EXPERIMENT STATION

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CHEMICAL DEPARTMENT.

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*ANALYSES OF CORN, WITH REFERENCE TO ITS IMPROVEMENT.**

CORN, from any point of view, is interesting. Its sturdy plants, with flowing, rippling leaves, shining silk, and nodding tassels, possess individually and collectively a beauty, grace and symmetry that have won the admiration of artists. For its priceless worth it was held in the highest esteem by the Indians, its development being eagerly watched, and its arrival at a stage suitable for food celebrated by religious ceremonies. Its foliage is appetizing and nourishing to beast, and its grain a delicacy as well as an aliment to both man and beast. It surpasses the biblical superlative, and yields not only a hundredfold, but five-hundred and even a thousandfold, and more. Its plant is easily cared for, its ear large, handled with a minimum of trouble, and readily stored. Subjected to the disintegrating, analytical and transforming power of modern chemistry and mechanics, it yields a variety of special foods for man—starch for dozens of purposes, sugar for the school-girl's confectionery, syrup for the breakfast table, mucilage, alcohol, oil for paint, a rubber substitute, and a variety of feeds

*The analyses recorded in this bulletin have extended over four years. Those made in 1898 were by Miss Maud Gardiner, a graduate student, and J. T. Willard; those of the crop of 1899 were made by Mr. R. W. Clothier, and Mr. A. G. Adjemian; those of the crop of 1900 were made by Mr. Clothier, and those of last season's crop by Mr. F. C. Weber.

for stock. It is worthy of the brush of the painter and the pen of the poet, the voice of the orator, and the thought of the philosopher; it is a royal plant indeed.

The corn of to-day is very different from that of the aborigines. Its plasticity is great, no other crop so readily showing transformation under climatal influences. Even where climate has apparently ceased to effect changes, a variety exhibits inner differences of great magnitude among its millions of individuals. Differences among individuals constitute the means of progress in all things. Homogeneity is an index of changelessness and of mediocrity. In its variableness we have in corn the means for its improvement both in yield and in composition; for, kingly as corn is, it is not perfect.

The principal nutritive substances of feeds are included in the three groups: crude protein, carbohydrates, and fats. The last two contain the elements carbon, hydrogen and oxygen only. Crude protein includes a number of classes of compounds which agree in containing nitrogen in addition to the three elements named, but which differ among themselves materially in other respects. The most important class of substances in the crude protein is the proteids. The proteids constitute nearly all of the nitrogenous portion of grains, but in the growing parts of plants other nitrogenous substances are present, sometimes to an even greater extent than the proteids. The proteids are the most valuable of all the food principles; not that others are not necessary, but the others occur more abundantly in most feeds; and hence our attention must be more especially directed toward the proteids, in order to secure them in the amount which the animal body requires.

The study of feeding standards does not come within the scope of this bulletin, and it must suffice to say that, as the result of much observation and experiment, it has been learned that in animal nutrition, whether the object be power, growth, milk, or mere maintenance, a fairly definite proportion of the energy of the food must be furnished by proteids in order that the object may be accomplished with the least amount of feed, and that the proportion of proteids required varies with the object of the feeding. Carbohydrates and fats, consisting of the same elements, can replace each other to a great extent in a ration, but as they do not contain nitrogen they cannot replace proteids. Fats, it must be noted, while containing the same elements as carbohydrates, contain them in quite a different proportion, the percentage of oxygen being much less in fats. Fats have been found to yield rather more than two and one-fourth times as much energy as carbohydrates; so that, within reasonable limits, the larger the percentage of fat in feed the more valuable it is. To increase, then, the percentage of proteids and of fats in a feed at the expense of the carbohydrates is to increase the value per pound.

TABLE showing the percentage of nitrogen in the dry matter of certain varieties of corn.

No.	Color.	Varieties of corn.	Nitrogen.	Grower.
3	White.	Shull's White	1.56	C. W. Shull, Manhattan.
33	"	Clothier's White	1.58	N. S. Clothier, Vera.
9	"	Champion White Pearl	1.63	J. W. Babbitt, Hiawatha.
16	Yellow.	Gold Standard	1.63	J. W. Babbitt, Hiawatha.
32	White.	Haney's White	1.74	E. D. Haney, Courtland.
2*	"	Kansas King	1.79	D. W. Matsler, Chanute.
27	Mixed.	Buehler's Calico	1.80	Fred. Buehler, Hiawatha.
5	White.	Large and Early	1.80	A. J. Achenbach, Washington.
4	"	White Pearl	1.83	A. A. Cottrell, Wabaunsee.
23	Yellow.	Leaming	1.86	Sam'l Detwiler, Hiawatha.
11	White.	Early White Dent	1.88	J. D. Ziller, Hiawatha.
31	"	Warner's White	1.88	John Warner, Manhattan.
14	"	Cooper's White	1.90	J. D. Cooper, Delphos.
30†	"	Zimmerman's White	1.91	Zimmerman Bros., Moray.
7	"	St. Charles (smooth kernels),	1.92	Sam'l Detwiler, Hiawatha.
24‡	Mixed.	Chester County Mammoth	1.92	A. J. Achenbach, Washington.
1§	White.	Boone County White	1.93	A. J. Achenbach, Washington.
12	"	Normandy Giant	1.96	J. D. Ziller, Hiawatha.
21	Yellow.	Mammoth Yel. Dent, Ziller.	1.96	J. D. Ziller, Hiawatha.
15	"	Cooper's Yellow	1.98	J. D. Cooper, Delphos.
8	White.	Babbitt's White	1.99	J. W. Babbitt, Hiawatha.
19	Yellow.	Babbitt's Mammoth Dent	1.99	J. W. Babbitt, Hiawatha.
25	Mixed.	Shull's Mix. (3 & 22 crossed),	2.03	C. W. Shull, Manhattan.
6	White.	St. Charles (rough kernels)	2.06	Sam'l Detwiler, Hiawatha.
18	Yellow.	Missouri Dent	2.06	J. W. Babbitt, Hiawatha.
20	"	Babbitt's Sweepstakes	2.07	J. W. Babbitt, Hiawatha.
22	"	Shull's Yellow	2.13	C. W. Shull, Manhattan.
26	"	Gardner	2.14	A. A. Cottrell, Wabaunsee.
13	White.	Early White Dent	2.18	
17	Yellow.	Ziller's Yellow	2.21	J. D. Ziller, Hiawatha.
28	Red.	Red	2.22	J. W. Babbitt, Hiawatha.
29	Yellow.	Haney's Yellow	2.23	E. D. Haney, Courtland.
10	White.	Buehler's White	2.26	Fred. Buehler, Hiawatha.

*A blend of four varieties raised in the vicinity of Chanute for ten or twelve years.
†Raised for thirty years on the same farm without admixture.
‡Obtained by mixing a number of other varieties.
§Raised from seed obtained from James Riley, Thornton, Ind.

ORIGIN OF THE EXPERIMENTS.

In the fall of 1897, the chemist of the Experiment Station, at a joint meeting of the Faculty and the Board of Regents, proposed, as a part of the work of the chemical department of the Station, the analysis of varieties of corn, with a view to ascertaining which are highest in nutritive value, and a cooperation between the chemical, the farm and the botanical departments in efforts to improve this cereal. This met the approval of the Board, and the next spring this work was begun, the three departments named cooperating. In the spring of 1899 the agriculturist of the Station asked to be relieved from further connection with the work, and since then it has been entirely in charge of the botanist and chemist and their assistants.

ANALYSES OF VARIETIES.

The first year varieties were analyzed as to percentage of nitrogen. Most of these were show samples which were secured at a corn exhibit in connection with a farmers' institute at Hiawatha. The table on page 59 shows the percentages of nitrogen in the several varieties, and the name and color of the corn. The varieties are arranged in the order of their nitrogen content. We had but small samples of most of the varieties, so that the figures given may not fairly represent the relative value of them, but they bring out in striking contrast the very great variations in composition exhibited by corn, and suggest wonderful possibilities in the way of selection and improvement.

ANALYSES OF SINGLE EARS.

We did not stop with ascertaining that there were great differences among varieties, but analyzed individual ears of two or more varieties. One of these was Zimmerman's White, a variety that has been grown by the Zimmerman family for over thirty years without the introduction of other seed. It would seem that if uniformity of type could be secured by mere continuity of cultivation this variety should have acquired it. Ten ears were analyzed, with the following results, the figures being percentages of nitrogen in the dry grain:

Zimmerman's White:	Ear	a	1.53	per cent. nitrogen.
	"	f	1.55	" "
	"	d	1.69	" "
	"	h	1.77	" "
	"	c	1.98	" "
	"	b	2.00	" "
	"	e	2.05	" "
	"	g	2.09	" "
	"	i	2.24	" "

These results show that there are as great differences in the nitrogen content of different ears of the same variety as were found between the different varieties, and this in a variety that would seem to

have had every opportunity to become uniform. Here, again, we see in even more striking form the possibilities of improvement by proper seed selection.

A mixed corn, the result of a cross between a white and a yellow variety made by Mr. C. W. Shull, was analyzed in a similar manner, to observe the variations in a corn that might be supposed to have no fixity of type as yet. The result of these analyses follows:

Shull's Mixed:	Ear h	1.35	per cent. nitrogen.
	" i	1.47	" "
	" g	1.57	" "
	" d	1.75	" "
	" b	1.83	" "
	" c	1.85	" "
	" a	1.88	" "
	" i	2.05	" "
	" f	2.22	" "

Here we see even greater differences, the ear with the least amount of protein having but 8.44 per cent., while the best contained 13.87 per cent., or 64.5 per cent. more when calculated on the protein itself.

ANALYSES OF SINGLE KERNELS.

Having found these large variations in individual ears of these varieties, the question arose, "Are there differences in the individual kernels from the same ear?" Analyses of seventeen separate kernels from ear *i* of Zimmerman's White, the ear found to be richest in nitrogen, were made, with the following results: 1.72, 1.95, 1.97, 1.98, 2.01, 2.02, 2.02, 2.04, 2.06, 2.10, 2.10, 2.10, 2.11, 2.11, 2.14, 2.16 and 2.30 per cent., respectively.

Many other analyses of single kernels were made later, in studying the relation of specific gravity to nitrogen content. The results show that, while the variation is much less than that exhibited by different ears of the same variety, the differences are by no means insignificant. This observation seems to be contrary to the published opinion of some other experimenters in this line.

RELATION OF SIZE OF GERM TO NITROGEN CONTENT.

It is thus evident that much better seed could be selected, if in any way ears of high nitrogen content could be chosen, and that it would be still better if the best kernels could be taken from such ears. Analyses of the several parts of the corn kernel made at the New Jersey station having shown that the germ of the grain is much richer in fat and in protein than the other parts of the kernel; the thought was but natural, that, by selecting corn with a large germ for seed, the quality of the seed must necessarily be improved. Examination of the different ears analyzed in the studies previously made showed that the differences in the size of the germs were very readily ob-

served, and that there was not the slightest difficulty in distinguishing between those high in nitrogen and those low in nitrogen by making sections of a number of kernels from each ear.

The importance of the facts in respect to composition of corn, the ease with which corn high in nitrogen may be selected by means of the germ and the financial advantage that would accrue by such selection were set forth in Press Bulletin No. 20, issued December 27, 1898, and largely copied by the agricultural press. This press bulletin was included in Bulletin No. 86. Similar considerations were presented in a mimeograph bulletin sent to the agricultural papers February 20, 1900, and from which the following is extracted:

"There is no reasonable doubt that, by intelligent and persistent seed selection, a considerable increase in the proteids of existing varieties may be made, but how is this selection to be guided? Chemical analysis cannot be applied by every farmer, yet every farmer must be able to join in the work if it is to be effective. Chemical analysis of the several parts of the corn kernel has shown that the germ is the richest in proteids. Therefore, choosing a corn in which the germ is in larger proportion is all that is necessary to insure getting that which is richer in proteids.

"Selecting corn with a large germ is not as difficult as might be supposed. Take a few grains from the ear, neglecting the butt and tip, where they are more or less distorted in form. With a sharp pocketknife, begin at the tip of the kernel, where it was attached to the cob, and make several cross-sections from one-thirty-second to one-sixteenth of an inch in thickness, and observe the relative proportion of germ that the section shows. Repeat this on a number of kernels, and make longitudinal sections of other kernels also. These sections can be made in less time than it takes to tell how to make them, and by means of them a very useful judgment can be passed upon the corn. The relatively small amount of seed required for corn-planting makes it feasible to give special attention to the selection of the seed, and if the method indicated above be persisted in there can be no serious doubt that improvement would result. At the same time attention should be given to the various factors that combine to produce a large yield. A variety satisfactory in these respects should be chosen as the basis upon which to develop an improvement in the percentage of proteids."

To ascertain more fully the bearing of the size of the germ upon the composition of corn, as to its amount of nitrogen, a number of analyses were made in which the germs were separated from the kernels, and the germs and the remainders analyzed separately. The results given below show that in every case the germs are much richer

in nitrogen than the remainder of the kernels from which they were taken, and that selecting corn with large germs cannot fail to secure corn richer in nitrogen than corn of the same variety with smaller germs, other things being equal.

Serial number.	VARIETY.	No. of kernels.	Per cent. of nitrogen in--	
			Germs.	Kernels minus germs.
K 542 B	Red crossed with Chester County Mammoth.....	6	3.89	2.91
K 557 B	Haney's Yellow crossed with Shull's Yellow.....	5	3.13	1.22
30	Zimmerman's White.....	5	2.91	1.98
K 519 B	Shull's Mixed crossed with Zimmerman's White.....	4	3.98	2.30

To make a practical test of examination of corn with reference to the size of the germs, selections were made from two lots grown by farmers near Manhattan. One of these was a white dent corn grown by Mr. Chas. Thompson; the other was a yellow dent grown by Mr. Wm. Deibler.

In the case of the white corn, thirteen ears were chosen as having larger germs than the average, and fourteen as having smaller. The former were found to contain 1.94 per cent. of nitrogen in the dry corn, the latter to have but 1.76 per cent., making a very appeciable difference in their feeding value.

Of the yellow corn, twelve ears were selected with the larger germs, and thirteen with the smaller. The former contained 1.81 per cent. of nitrogen; the latter, 1.68 per cent.—not as great a difference as in the other case.

There are undoubtedly great differences in the nitrogen content of the part of the kernel exclusive of the germ, and it is conceivable, and not improbable, that a large germ, though in itself tending to produce high nitrogen content, might be overcome by the low nitrogen of the remainder of the kernel. Nevertheless the selection of seed-corn with large germs is the most practical means available for securing an increase in the protein. It is worthy of note, too, that the germs are very rich in oil; in fact, contain most of the oil of the grain. By increasing the germ we increase the percentage of fat, a constituent worth about two and one-fourth times as much as starch for feeding, and a very valuable principle in corn sent to the glucose factories, where the oil is extracted on a large scale.

CAN SEED-CORN RICH IN NITROGEN BE SELECTED BY MEANS OF THE SPECIFIC GRAVITY OF THE GRAIN?

The possibility of a separation of kernels of corn richer in nitrogen from those less rich by means of differences in specific gravity suggested itself at an early date. Some preliminary analyses were made of individual kernels taken from the richest ear of Zimmerman's White, in which the relative specific gravity of the several kernels was determined, but not the specific gravity itself, apparatus for that purpose not being at hand then. The percentages of nitrogen obtained follow, and are given in the order of increasing specific gravity. They are: 2.06, 2.11, 2.04, 2.30, 2.11, 2.16, 2,10, 2.02, 1.72, 1.97. It will be noticed that there is not a corresponding direct variation in the nitrogen content.

At a later date determinations of nitrogen were made in kernels from the same ear, in which their exact specific gravity was ascertained by means of the Westphal balance and a solution of calcium chloride. A solution of common salt cannot be used, since it cannot be made of sufficient density to suit all cases. The results were as follows, being arranged in the order of the specific gravity of the grain:

Percentage of nitrogen.	Specific gravity.
1.95	1.278
2.01	1.285
2.10	1.2885
1.98	1.294
2.10	1.294
2.14	1.296
2.02	1.296

Here, again, we have no regular connection between the specific gravity and the nitrogen content.

These results did not lend much encouragement to the hope that selection of seed-corn could be made by means of specific gravity, but further study of the question was delayed until the spring of 1901, when a much greater number of analyses were made. A large number of single kernels were examined in a somewhat comprehensive manner. The specific gravity was taken, and in many cases that of the germ and of the remainder of the kernel were separately ascertained; also, in many cases, the weights of the germ and the remainder of the kernel. Seven different varieties of corn were used in this work. The results of these studies in their various aspects follow. In considering these, it must be borne in mind that a single kernel of corn affords a smaller amount of material than is usually taken for an analysis, and none for a duplicate determination. Analyses ordinarily are made in duplicate, and the average taken as true, if the two agree well enough. In these analyses of single kernels we have but the one

ANALYSES of individual kernels of corn to show relation between specific gravity and percentage of nitrogen.

Serial number.	VARIETY.	No. of kernel.	Weight of kernel.	Specific gravity of kernel.	Nitrogen in kernel.
			grams.		*per ct.*
K 542 B	Red crossed with Chester County Mammoth,	2	.1784	Not taken.	2.99
		3	.1850	1.1496	2.77
		5	.1728	1.1960	2.93
		7	.1984	1.1960	2.82
		8	.1760	1.2130	2.756
		4	.1374	1.2160	3.15
		6	.1430	1.2350	2.804
K 557	Haney's Yellow crossed with Shull's Yellow,	7	.1730	1.1765	1.286
		6	.1624	1.1797	1.27
		5	.2690	1.2414	1.37
		1	.2896	1.2523	1.49
		2	.2596	1.2640	1.50
		4	.2698	1.2900	1.564
		3	.2698	1.2960	1.564
30	Zimmerman's White, ear (i),	11	.4154	1.2730	2.18
		2	.4224	1.2810	2.12
		15	.3986	1.2850	2.02
		9	.3886	1.2870	2.14
		1	.3880	1.2870	2.24
		4	.4080	1.2880	2.17
		10	.3952	1.2890	2.16
		13	.3674	1.2895	2.26
		16	.3654	1.2940	2.16
		14	.3724	1.2960	2.204
		5	.3942	1.2963	2.24
		8	.4166	1.2980	2.15
		3	.3940	1.2990	2.07
		12	.3458	1.3047	2.28
		7	.4006	1.3047	2.01
K 519 B	Shull's Mixed crossed with Zimmerman's White,	4	.2744	1.2020	2.53
		3	.2996	1.2020	2.29
		5	.2970	1.2044	2.41
		1	.2974	1.2044	2.58
		6	.3150	1.2193	2.34
		2	.2904	1.2390	2.466
K 447 Cy	Mammoth Dent crossed with Babbitt's Sweepstakes,	5	.2858	1.1800	2.18
		8	.3046	1.2050	2.03
		9	.2934	1.2070	2.00
		6	.2716	1.2080	2.16
		1	.3430	1.2150	2.21
		4	.2600	1.2230	2.17
		10	.2740	1.2280	2.06
		7	.2890	1.2340	2.03
		3	.3398	1.2400	2.14
K 92 A	Normandy Giant crossed with Gardner,	3	.3842	1.0980	2.40
		2	.3320	1.1060	2.384
		5	.4400	1.1550	2.17
		1	.3996	1.1815	2.413
		4	.3814	1.1900	2.19
		6	.3704	1.1960	2.254

determination, which is necessarily subject to more or less error, and it is too much to expect to exhibit perfectly the application of a general principle, under such conditions, without making a great number of analyses. We think the results are fully sufficient for some deductions to be made, however.

In the table (page 65) the analyses are arranged by varieties, and in the order of increasing specific gravities within the varieties. If there were any general law connecting specific gravities with percentages of nitrogen, it would appear in the column showing the latter; but no such connection appears.

Owing to the difficulty of operating on the somewhat small weight of single kernels, a trial was made in which samples consisting of several kernels each were analyzed. The specific gravity of a number of kernels of a given variety having been taken, they were divided into two lots, one including those of the higher specific gravity, and the other those of the lower specific gravity. The results as exhibited below show the same lack of uniformity of relation between specific gravity and percentage of nitrogen. In fact, almost identical results were obtained with those of lower specific gravity and those of higher.

Serial number.	Name of Variety or Cross.	No. of kernels.	Average specific gravity.	Per cent. of nitrogen.
30	Zimmerman's White	9	1.2843	2.25
30	Zimmerman's White	9	1.2988	2.20
K 92 A	Normandy Giant crossed with Gardner,	5	1.1200	2.385
K 92 A	Normandy Giant crossed with Gardner,	5	1.1736	2.425
K417Ax	Gold Standard crossed with Mammoth Yellow Dent	14	1.2162	1.900
K417Ax	Gold Standard crossed with Mammoth Yellow Dent	12	1.2403	1.882

From all of the foregoing, the conclusion seems inevitable that, however unfortunate the fact may be, we cannot use the specific gravity of the kernels of maize as a means of separating those of low nitrogen content from those of high nitrogen content.

In connection with the study of the relation of specific gravity to composition in corn, a considerable number of determinations of the specific gravity of the entire kernel, the germ and the remainder of the kernel were made. In every case the germ was very much lighter in specific gravity than the remainder of the kernel. This shows that, while there is no regular law connecting specific gravity and nitrogen content, an increase in the size of the germ must decrease the specific

gravity of the kernel as a whole, and the qualities conferred by large germs must tend to accompany low specific gravity. As the germs are richer in both fat and protein than the rest of the grain, low specific gravity must tend to accompany richness in these principles. The following table gives the detailed comparison of the specific gravities of the two parts and of the whole grains:

TABLE comparing specific gravities of whole kernels, germs, and kernels minus germs.

Serial number.	VARIETY.	No. of kernel.	Specific gravity of whole kernels.	Specific gravity of germs.	Specific gravity of kernels minus germs.
K 542 B	Red crossed with Chester County Mammoth,	1	Not taken.	1.0855	1.2850
		2	1.2050	1.1384	1.2474
		3	1.1496	Lost.	1.2286
		4	1.2160	1.0900	1.2650
		5	1.1960	1.1090	1.2780
K 557 B	Haney's Yellow crossed with Shull's Yellow,	1	1.2523	1.1085	1.3110
		2	1.2640	1.0860	1.3120
		3	1.2960	1.0880	1.3400
		4	1.2900	1.0885	1.3344
30	Zimmerman's White, ear (i),	1	1.2870	1.1620	1.3480
		2	1.2810	Lost.	1.3410
		3	1.2990	1.1290	1.3405
		4	1.2880	1.1060	1.3413
		5	1.2963	1.1145	1.3480
		11	1.2730	1.1097	1.3310
		12	1.3047	1.1496	1.3550
		13	1.2895	1.1235	1.3400
		14	1.2960	1.1130	1.3400
		15	1.2850	1.1220	1.3480
		16	1.2940	1.1150	1.3500
K 519 B	Shull's Mixed crossed with Zimmerman's White,	1	1.2044	1.0744	1.2865
		2	1.2390	Lost.	1.3110

ANALYSES OF CROSSED VARIETIES.

Of the thirty-three varieties analyzed at the beginning of the work in breeding, twenty-one were selected for use, and were planted by the Botanical Department. The details of the work of that department will be left to its officers for description, sufficient being given here to make the analytical figures intelligible. The season of 1898 these varieties were systematically cross-fertilized, but analyses of the crosses obtained were not made, as this was not regarded as worth while until the type had become at least slightly fixed. This fixing of type in the many crosses obtained the first year has been going on since by preventing all mixture of a given cross with others. Each cross is fertilized artificially by pollen of its own kind, but, as a rule, from a different stalk from that bearing the ear. The product of the

first year of close fertilization, 1899, was analyzed in respect to its content of nitrogen—558 samples in all. Of these, only those showing two per cent. of nitrogen, or very nearly so, were reserved for further propagation. The crop of 1900 was analyzed, in many cases two ears being taken, marked **x** and **y** in the table. The crop obtained from these in 1901 was analyzed, in many cases a large-, a small- and a medium-sized ear being taken. These are indicated by l, s and m in the table.

It will be seen that we now have in many cases six ears analyzed of the crop of 1901 that trace back to the original cross made in 1898, and first analyzed in 1899. While this system of lettering enables one to trace the ancestry of the various ears readily, it is obvious that it does not admit of indefinite extension in time. It is possible that in future we will be obliged to content ourselves with the original numerical designation, which is prefixed by the letter K, to show its Kansas origin.

In the table of analyses of crosses, each analysis is of a sample from a single ear, and shows the percentage of nitrogen in the dry substance. The female parent—that is, the one upon which the ear grew—is named first. The sign × signifies "crossed by," and the name following is that of the male or pollinating parent. The mean for three years is shown for all crosses that are still being grown. This is obtained by averaging the results for all of the ears of a given cross analyzed during the three years, excepting those ears which are not represented by descendants in the crop of 1901. For the convenience of such as prefer to compare protein rather than nitrogen, a table is introduced for the conversion of percentage of nitrogen into percentage of protein. The figures as given are exact equivalents, protein being assumed to contain sixteen per cent. of nitrogen.

TABLE for converting percentage of nitrogen into percentage of protein.

Nitrogen.	Protein.	Nitrogen.	Protein.	Nitrogen.	Protein.	Nitrogen.	Protein.
1.920	12.0	2.224	13.9	2.528	15.8	2.832	17.7
1.936	12.1	2.240	14.0	2.544	15.9	2.848	17.8
1.952	12.2	2.256	14.1	2.560	16.0	2.864	17.9
1.968	12.3	2.272	14.2	2.576	16.1	2.880	18.0
1.984	12.4	2.288	14.3	2.592	16.2	2.896	18.1
2.000	12.5	2.304	14.4	2.608	16.3	2.912	18.2
2.016	12.6	2.320	14.5	2.624	16.4	2.928	18.3
2.032	12.7	2.336	14.6	2.640	16.5	2.944	18.4
2.048	12.8	2.352	14.7	2.656	16.6	2.960	18.5
2.064	12.9	2.368	14.8	2.672	16.7	2.976	18.6
2.080	13.0	2.384	14.9	2.688	16.8	2.992	18.7
2.096	13.1	2.400	15.0	2.704	16.9	3.008	18.8
2.112	13.2	2.416	15.1	2.720	17.0	3.024	18.9
2.128	13.3	2.432	15.2	2.736	17.1	3.040	19.0
2.144	13.4	2.448	15.3	2.752	17.2	3.056	19 1
2.160	13.5	2.464	15.4	2.768	17.3	3.072	19.2
2.176	13.6	2.480	15.5	2.784	17.4	3.088	19.3
2.192	13.7	2.496	15.6	2.800	17.5	3.104	19.4
2.208	13.8	2.512	15.7	2.816	17.6	3.120	19.5

Table of Analyses of Crosses. 1899, 1900, 1901.

		1899	1900	1901	Mean
K 1	Boone County White × Shull's White.....	1.98	Discarded.		
K 2	Boone County White × St. Charles (rough)....	1.96	Discarded.		
K 4	Boone County White × Normandy Giant.....	A 1.72 B 1.65	Discarded. Discarded.		
K 6	Boone County White × Mammoth Yellow Dent,	2.09	2.07	l 2.49 s 2.17	2.21
K 9	Boone County White × Gardner.....	A 1.83 B 1.98	Discarded. Discarded.		
K 10	Boone County White × Red...	2.12	x 2.23 y 2.33	xl 2.22 xs 2.05 xm 2.27 yl 2.08 ys 2.22	2.19
K 13	Shull's White × Boone County White...	A 1.65 B 2.04 C 1.81	Discarded. Bx 1.87 By 2.26 Discarded.	Bxl 2.26 Bxs 1.76 Byl 2.22 Bys 2.17	2.08
K 14	Shull's White × Babbit's White.....	1.95	Discarded,		
K 15	Shull's White × Buehler's White.....	A 1.52 B 1.67 C 1.47	Discarded. Discarded. Discarded.		
K 16	Shull's White × Cooper's Yellow.....	2.02	x 2.30 y 2.08	xs 2.56 xl 1.90 yl 2.23 ys 2.46 ym 2.38	2.24
K 17	Shull's White × Mammoth Dent.....	A 1.47 B 1.73	Discarded. Discarded.		
K 18	Shull's White × Shull's Mixed,	1.82	Discarded.		
K 19	Shull's White × Gardner.....	A 1.87 B 1.82 C 1.55	Discarded. Discarded. Discarded.		
K 21	St. Charles (rough) × Shull's White.....	1.49	Discarded.		

Table of Analyses of Crosses — *Continued.*

		1899	1900	1901	Mean
K 23	St. Charles (rough) × Normandy Giant.....	A 1.47 B 1.83	Discarded. Discarded.		
K 24	St. Charles (rough) × Cooper's Yellow.....	A 1.53 B 1.84	Discarded. Discarded.		
K 25	St. Charles (rough) × Gold Standard	2.22	Discarded.		
K 26	St. Charles (rough) × Ziller's Yellow	A 1.72 B 2.03	Discarded.	 Bl 2.74 Bs 2.22 B 2.37 Bxl 1.84 Bxs 2.50 Bxm 2.38 Byl 1.96 Bys 2.12 Bym 2.34	2.23
			Bx 1.99		
			By 2.17		
K 28	St. Charles (rough) × Mammoth Dent	1.81	Discarded.		
K 29	St. Charles (rough) × Babbit's Sweepstakes...	1.60	Discarded.		
K 30	St. Charles (rough) × Mammoth Yellow Dent,	2.02	x 2.45 y 2.38		
K 31	St. Charles (rough) × Shull's Yellow	A 1.85 B 1.58	Discarded. Discarded.		
K 33	St. Charles (rough) × Shull's Mixed.....	1.53	Discarded.		
K 34	St. Charles (rough) × Gardner	1.17	Discarded.		
K 35	St. Charles (rough) × Red....	A 1.95 B 2.14	Discarded. Discarded.		
K 37	St. Charles (smooth) × Shull's White.....	1.70			
K 39	St. Charles (smooth) × Babbit's White	A 2.06		Al 2.09 As 2.53	2.00
			Ax 2.04	Axl 1.47 Axs 1.76	
			Ay 1.73	Ayl 1.96 Ays 2.26 Aym 2.54	
		B 2.02		Bl 1.73 Bs 1.65 Bm 2.15	
			Bx 2.02 By 2.16		

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 40	St. Charles (smooth) × Buehler's White..	A 1.88 B 2.35	Discarded. Discarded.		
K 42	St. Charles (smooth) × Cooper's Yellow.....	1.47	Discarded.		
K 52	St. Charles (smooth) × Red ..	A 1.97 B 1.78	Discarded. Discarded.		
K 56	Babbit's White × St Charles (rough).....	2.19	Discarded.		
K 58	Babbit's White × Buehler's White.....	1.42	Discarded.		
K 62	Buehler's White × Boone County White...	A 1.07 B 1.47	Discarded. Discarded.		
K 65	Buehler's White × St. Charles (smooth)...	1.34	Discarded.		
K 68	Buehler's White × Cooper's Yellow.....	1.67	Unsuccessful.		
K 76	Buehler's White × Gardner.....	A 2.06 B 2.19 C 1.80	Ax 2.37 Ay 2.28 B 2.71 Discarded.	Axl 2.38 Axs 2.43 Ayl 2.56 Ays 2.69 Bl 1.93 Bs 2.61 Bm 2.44	2.39
K 77	Buehler's White × Red.....	A 2.05 B 1.76	A 1.91 Discarded.	Al 2.18 As 2.36 Am 1.96	2.09
K 78	Buehler's White × Haney's Yellow	1.54	Discarded.		
K 82	Normandy Giant × Babbit's White	2.03	1.98	l 2.13 s 2.02	2.04
K 83	Normandy Giant × Buehler's White.....	1.68	Discarded.		
K 85	Normandy Giant × Gold Standard.....	1.51	Discarded.		
K 87	Normandy Giant × Mammoth Dent.....	1.80	Discarded.		
K 88	Normandy Giant × Mammoth Yellow Dent,	1.81	Discarded.		

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 89	Normandy Giant × Shull's Yellow.....	1.67	Discarded.		
K 90	Normandy Giant × Chester Co. Mammoth,	1.43	Discarded.		
K 91	Normandy Giant × Shull's Mixed.....	1.85	Discarded.		
K 92	Normandy Giant × Gardner ..	A 2.02	A 2.52	Al 1.85 As 2.07 Am 2.53	2.25
		B 2.13	Bx 2.11	Bxl 2.44 Bx2 2.69 Bx3 2.23 Bx4 2.75	
			By 1.93	Byl 2.18 Bys 2.36 Bym 1.92	
K 93	Normandy Giant × Red.....	1.89	Discarded.		
K 94	Normandy Giant × Haney's Yellow.....	A 1.57 B 1.90	Discarded. Discarded.		
K 95	Cooper's Yellow × Boone County White...	1.94	Discarded.		
K 96	Cooper's Yellow × Shull's White.....	A 1.32 B 1.84	Discarded. Discarded.		
K 97	Cooper's Yellow × St. Charles (rough)....	1.92	Discarded.		
K 98	Cooper's Yellow × St. Charles (smooth)...	1.93	Discarded.		
K 106	Cooper's Yellow × Mammoth Yellow Dent,	2.03	x 2.13	xl 2.35 xs 2.08	2.29
			y 2.40	yl 2.24 ys 2.75 ym 2.35	
K 116	Gold Standard × Buehler's White	A 2.03	A 2.43	Al 2.00 As 2.53 Am 2.44	2.29
		B 1.63	Discarded.		
K 117	Gold Standard × Normandy Giant.....	1.69	Discarded.		
K 118	Gold Standard × Cooper's Yellow.....	A 1.72 B 1.84 C 1.77 D 1.97	Discarded. Discarded. Discarded. Discarded.		

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 119	Gold Standard × Ziller's Yellow.....	1.64	Discarded.		
K 122	Gold Standard × Mammoth Yellow Dent,	1.70	Discarded.		
K 123	Gold Standard × Shull's Yellow.....	2.20	Discarded.		
K 125	Gold Standard × Shull's Mixed.....	1.72	Discarded.		
K 128	Gold Standard × Haney's Yellow.....	1.68	Discarded.		
K 132	Ziller's Yellow × St. Charles (smooth)..	1.56	Discarded.		
K 133	Ziller's Yellow × Babbit's White.....	A 1.92 B 1.55	Discarded. Discarded.		
K 134	Ziller's Yellow × Buehler's White.....	A 1.39 B 2.10	Discarded. Discarded.		
K 135	Ziller's Yellow × Normandy Giant.....	A 1.99 B 2.23	Discarded. Lost.		
K 138	Ziller's Yellow × Missouri Dent.....	A 1.89 B 2.11	Discarded. Bx 2.41 By 2.34	Bxl 1.88 Bxs 2.60 Bxm 2.36 Byl 2.81 By2 2.59 By3 2.64 By4 2.44 By5 2.47	2.42
K 139	Ziller's Yellow × Mammoth Yellow Dent,	1.67	Discarded.		
K 140	Ziller's Yellow × Shull's Yellow.....	A 2.07 B 1.89	A 2.31 Discarded.	Al 1.89 As 2.37 Am 2.16	2.10
K 141	Ziller's Yellow × Chester Co. Mammoth,	A 1.46 B 2.11	Discarded. Bx 2.32 By 2.35	Bxl 2.24 Bxs 2.19 Byl 2.71 Bys 2.36	2.33
K 143	Ziller's Yellow × Red.....	A 1.87 B 2.03	Discarded. Bx 2.52 By 2.24	Bxl 2.32 Bxs 2.20 Bxm 2.78 Byl 2.18 Bys 2.46	2.34

Table of Analyses of Crosses—*Continued.*

		1899	1900	1901	Mean
K 145	Missouri Dent × Boone County White...	A 2.02 B 1.60	Unsuccessful. Discarded.		
K 149	Missouri Dent × Gold Standard.....	1.80	Discarded.		
K 151	Missouri Dent × Haney's Yellow	A 1.79 B 2.12	Discarded. Bx 2.21 By 2.09	 Bxl 1.72 Bxs 2.52 Bxm 2.35 Byl 2.34 Bys 2.38 Bym 2.10	2.20
K 154	Mammoth Dent × St. Charles (rough)....	1.89	Discarded.		
K 155	Mammoth Dent × Babbit's White	1.77	Discarded.		
K 157	Mammoth Dent × Normandy Giant.....	2.16	Discarded.		
K 158	Mammoth Dent × Gold Standard.....	A 1.81 B 2.03	Discarded. Unsuccessful.		
K 171	Babbit's Sweepstakes × Gold Standard.....	2.24	x 2.43 y 2.24	xl 1.88 xs 2.66 yl 242 ys 2.52 ym 2.23	2.33
K 176	Babbit's Sweepstakes × Shull's Mixed.....	1.51	Discarded.		
K 181	Mammoth Yellow Dent × Shull's White.....	1.85	Discarded.		
K 183	Mammoth Yellow Dent × St. Charles (Smooth)..	1.52	Discarded.		
K 184	Mammoth Yellow Dent × Babbit's White	1.73	Discarded.		
K 188	Mammoth Yellow Dent × Ziller's Yellow.....	1.97	Discarded.		
K 191	Mammoth Yellow Dent × Babbit's Sweep. Yellow,	A 1.85 B 1.95	Discarded. Discarded.		
K 193	Mammoth Yellow Dent × Chester Co. Mammoth,	1.49	Discarded.		
K 196	Mammoth Yellow Dent × Red Corn.....	1.72	Discarded.		

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 198	Mammoth Yellow Dent × Zimmerman White.....	A 1.46	Discarded.		
		B 1.54	Discarded.		
K 199	Shull's Yellow × Boone County White...	A 2.07	Ax 2.06	Axl 2.10	2.05
				Axs 2.26	
				Axm 2.37	
			Ay 1.97	Ayl 1.53	
				Ays 2.29	
				Aym 1.76	
		B 1.90	Discarded.		
K 205	Shull's Yellow × Gold Standard.....	2.14	Unsuccessful.		
K 206	Shull's Yellow × Missouri Dent	A 1.63	Discarded.		2.29
		B 2.23	Bx 2.26		
			By 2.08	Byl 2.11	
				Bys 2.50	
K 207	Shull's Yellow × Babbit's Sweepstakes ..	1.15	Discarded.		
K 209	Shull's Yellow × Chester Co. Mammoth,	A 2.28	Ax 2.15	Axl 2.03	2.18
				Axs 2.44	
			Ay 1.88	Ayl 1.86	
				Ays 2.63	
				Aym 2.18	
		B 1.64	Discarded.		
K 211	Shull's Yellow × Gardner.....	A 1.54	Discarded.		
		B 1.81	Discarded.		
K 212	Shull's Yellow × Red.....	2.01	Unsuccessful.		
K 213	Shull's Yellow × Haney's Yellow.....	A 1.99	Discarded.		2.29
		B 2.17	Bx 2.20	Bxl 2.20	
				Bxs 2.50	
				Bxm 2.46	
				By 2.19	
K 214	Shull's Yellow × Zimmerman's White ...	1.53	Discarded.		
K 217	Chester County Mammoth × Normandy Giant.....	1.90	Discarded.		
K 218	Chester County Mammoth × Gold Standard.....	A 2.37	Ax 1.93	Axl 2.00	2.14
				Axs 2.80	
				Axm 2.08	
			Ayl 1.80	Ayl 2.29	
				Ay2 1.86	
				Ay3 2.24	
				Ay4 2.23	
		B 2.00	Bx 2.14	Bx 1.86	
			By 2.30	Unsuc'sful.	

Table of Analyses of Crosses —*Continued.*

		1899	1900	1901	Mean
K 219	Chester County Mammoth × Ziller's Yellow.....	1.73	Discarded.		
K 220	Chester County Mammoth × Babbit's Sweepstakes..	A 1.79 B 1.58 B (sweet) 1.76	Discarded. Discarded. Discarded.		
K 222	Chester County Mammoth × Shull's Mixed.....	2.01	x 1.86 y 1.95	yl 2.27 ys 2.19	2.11
K 223	Shull's Mixed × Shull's White,	2.03	x 2.29 y 2.24	xl 2.30 xs 2.94 yl 2.07 ys 2.41 ym 1.95	2.28
K 224	Shull's Mixed × St. Charles (rough)....	1.62	Discarded.		
K 227	Shull's Mixed × Buehler's White.....	2.05	Unsuccessful.		
K 230	Shull's Mixed × Gold Standard.....	1.97	Discarded.		
K 231	Shull's Mixed × Mammoth Dent.....	2.31	Lost.		
K 233	Shull's Mixed × Mammoth Yellow Dent,	2.22	Lost.		
K 238	Shull's Mixed × Zimmerman's White....	1.805	Discarded.		
K 240	Gardner × St. Ch. (rough)....	1.45	Discarded.		
K 241	Gardner × St. Ch. (smooth)...	A 1.60 B 1.83	Discarded. Discarded.		
K 242	Gardner × Babbit's White....	1.85	Discarded.		
K 243	Gardner × Buehler's White...	A 1.79 B 2.41	Discarded. Lost.		
K 245	Gardner × Gold Standard	A 1.93 B 2.02	Discarded. Lost.		
K 246	Gardner × Babbit's Sweeps Yellow,	1.58	Discarded.		
K 247	Gardner × Mammoth Yellow Dent,	1.84	Discarded.		
K 248	Gardner × Shull's Yellow.....	A 1.82 B 1.84	Discarded. Discarded.		
K 249	Gardner × Chester Co. Mammoth,	1.93	Discarded.		

Table of Analyses of Crosses — *Continued.*

		1899	1900	1901	Mean
K 250	Gardner × Shull's Mixed	1.58	Discarded.		
K 252	Red × Boone County White...	A 1.95 B 2.10	Discarded. Lost.		
K 254	Red × St. Charles (rough)....	2.48	Unsuccessful.		
K 255	Red × St. Charles (smooth)...	1.66	Discarded.		
K 256	Red × Babbit's White.....	2.15	Lost.		
K 259	Red × Cooper's Yellow	A 1.45 B 1.90			
K 265	Red × Shull's Yellow.....	1.45	Discarded.		
K 275	Haney's Yellow × Buehler's White	1.28	Discarded.		
K 281	Haney's Yellow × Mammoth Yellow Dent,	1.52	Discarded.		
K 296	Zimmerman's White × Mammoth Dent.....	1.72	Discarded.		
K 298	Zimmerman's White × Mammoth Yellow Dent,	1.68	Discarded.		
K 301	Zimmerman's White × Gardner.....	1.58	Discarded.		
K 304	Boone County White × St. Charles (rough)....	A 1.85 B 2.03 A(d) 2.03 B(d) 1.69	Discarded. Lost. Lost. Discarded.		
K 305 K 305½	Boone County White × St. Charles (smooth)....	A 1.43 A 2.11	Discarded. Unsuccessful.		
K 306	Boone County White × Babbit's White.....	1.70	Discarded.		
K 307	Boone County White × Missouri Dent.....	1.78	Discarded.		
K 308	Boone County White × Cooper's Yellow.....A(d)	2.14	Unsuccessful.		
K 309	Boone County White × Gold Standard.....	2.01	Unsuccessful.		
K 310	Boone County White × Ziller's Yellow.....	2.01	Unsuccessful.		
K 311	Boone County White × Missouri Dent.....	1.82	Discarded.		
K 312	Boone County White × Mammoth Dent.....	Not rec.	a 2.32		

Table of Analyses of Crosses—*Continued.*

		1899	1900	1901	Mean
K 313	Boone County White × Babbit's Sweepstakes..	1.72	Discarded.		
K 314	Boone County White × Mammoth Yellow Dent,	2.39	1.92	l 2.63 s 2.29	2.31
K 315	Boone County White × Shull's Yellow	1.84	Discarded.		
K 316	Boone County White × Chester Co. Mammoth,	1.59	Discarded.		
K 317	Boone County White × Shull's Mixed	1.75	Discarded.		
K 319	Shull's White × Boone County White ..	1.86	Discarded.		
K 320	Shull's White × Shull's Mixed	1.75	Discarded.		
K 321	St. Charles (rough) × Boone County White...	1.69	Discarded.		
K 322	St. Charles (rough) × Shull's White.....	A(d) 2.22	A(d) 2.34	adl 2.67 ads 2.44 adm 2.49	2.43
		B(d) 2.14	Discarded.		
K 323	St. Charles (rough) × St. Charles (smooth)...	2.13	Unsuccessful.		
K 331	St. Charles (rough) × Mammoth Yellow Dent,	1.84	Discarded.		
K 332	St. Charles (rough) × Shull's Mixed.....	A 1.88 B 1.90 A(d) 1.70 B(d) 2.11	Discarded. Discarded.		
K 333	St. Charles (rough) × Red....	1.85	Discarded.		
K 335	St. Charles (rough) × Zimmerman's White...	A 2.05 B 1.95	Unsuccessful. Unsuccessful.		
K 338	St. Charles (smooth) × St. Charles (rough).. .Dup.	1.80	Discarded.		
K 340	St. Charles (smooth) × Buehler's White	1.98	Discarded.		
K 341	St. Charles (smooth) × Normandy Giant.....	A(d) 2.21 B(d) 2.10	Discarded. Discarded.		
K 342	St. Charles (smooth) × Gold Standard.....	1.84	Discarded.		

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 344	St. Charles (smooth) × Missouri Dent	A 2.13	Unsuccessful.		
		B 1.73	Unsuccessful.		
K 345	St. Charles (smooth) × Mammoth Dent	A(d) 1.65	Disacrded.		
		B(d) 1.80	Discarded.		
K 347	St. Charles (smooth) × Mammoth Yellow Dent,	A 1.70	Discarded.		
		B 1.54	Discarded.		
K 348	St. Charles (smooth) × Shull's Yellow	(d) 2.10	Lost.		
K 350	St. Charles (smooth) × Shull's Mixed	A 1.87	Discarded.		
		B 2.05	Unsuccessful.		
K 351	St. Charles (smooth) × Red	A 1.92	Discarded.		
		B 2.01	Unsuccessful.		
K 352	St. Charles (smooth) × Haney's Yellow	A 2.33	A 216	A1 2.38	2.26
				A2 2.36	
				A3 2.33	
				A4 2.02	
		B 1.39	Discarded.		
K 353	St. Charles (smooth) × Zimmerman's White	A(d) 2.17	Adx 2.06	Discarded.	
			Ady 2.20	Discarded.	
		B(d) 2.04	Discarded.		
K 354	Babbit's White × Boone County White	(d) 1.48	Discarded.		
K 355	Babbit's White × Shull's White	1.87	Discarded.		
K 356	Babbit's White × St. Charles (rough)	1.94	Discarded.		
		A 1.65	Discarded.		
		B 2.03	Lost.		
		C 2.13	Lost.		
K 358	Babbit's White × Buehler's White	1.69	Discarded.		
		(d) 2.07	Lost.		
K 360	Babbit's White × Cooper's Yellow	A 1.92	Discarded.		
		B 1.51	Discarded.		
K 361	Babbit's White × Gold Standard	A(d) 1.89	Discarded.		
		B(d) 1.85	Discarded.		
K 362	Babbit's White × Mammoth Dent	A 2.04	Unsuccessful.		
		B 1.91	Discarded.		
		C 1.79	Discarded.		

Table of Analyses of Crosses — *Continued.*

		1899	1900	1901	Mean
K 364	Babbit's White × Haney's Yellow	A 1.94 B 1.93	Discarded. Discarded.		
K 365	Buehler's White × Boone County White	1.88	Discarded.		
K 366	Buehler's White × Shull's White	1.86 A(d) 1.89 B(d) 1.89	Discarded. Discarded. Discarded.		
K 367	Buehler's White × (?)		A 2.29	Lost.	
K 368	Buehler's White × St. Charles (rough)	A 1.85 B 2.09	Discarded. Unsuccessful.	Discarded.	
K 369	Buehler's White × Babbit's White	A 2.18 B 2.12	Unsuccessful. Unsuccessful.	al 2.07 as 2.28	2.18
K 371	Buehler's White × Cooper's Yellow	A 1.82 B 2.15	Discarded. Unsuccessful.		
K 372	Buehler's White × Gold Standard	A 1.82 B 2.05	Discarded. Unsuccessful.		
K 373	Buehler's White × Ziller's Yellow	A 1.97 B 2.04	Discarded. Unsuccessful.		
K 374	Buehler's White × Babbitt's Sweepstakes,	A(d) 2.05 B(d) 2.26 C(d) 2.22	Unsuccessful. Bdx 2.03 Bdy 2.06 Cd 2.27	Bdx 2.23 Discarded. Cd 2 87	2.31
———	K 374 × K 383	1.91	Discarded.		
K 375	Buehler's White × Shull's Yellow	1.97	Discarded.		
K 376	Buehler's White × Chester Co. Mammoth	1.95	Discarded.		
K 379	Buehler's White × Gardner	———	———	———	
———	K 377 × K 375	A 2.01 B 2.31	Lost. Lost.		
K 379	Normandy Giant × Shull's White	1.95	Discarded.		
K 380	Normandy Giant × St. Charles (rough)	A 1.98 B 1.93	Discarded. Discarded.		

Table of Analyses of Crosses —*Continued.*

		1899	1900	1901	Mean
K 381	Normandy Giant × St. Charles (smooth)...	2.01	Unsuccessful.		
K 383	Normandy Giant × Buehler's White	A 1.90 B 2.05 C 2.04	Discarded. Unsuccessful. Unsuccessful.		
K 385	Normandy Giant × Gold Standard.....	1.85	Discarded.		
K 386	Normandy Giant × Mammoth Dent	1.82	Discarded.		
K 387	Normandy Giant × Chester Co. Mammoth,	A 1.99 B 1.91	Discarded. Discarded.		
K 388	Normandy Giant × Gardner..	A 1.91 B 1.98 C 1.63 D 1.82	Discarded. Discarded. Discarded. Discarded.		
K 390	Cooper's Yellow × Boone County White...	A 1.98 B 1.74	Discarded. Discarded.		
K 392	Cooper's Yellow × St. Charles (rough)....	A(d) 2.08 B(d) 1.89	Lost. Discarded.		
K 394	Cooper's Yellow × Babbit's White.....	1.54	Discarded.		
K 396	Cooper's Yellow × Normandy Giant.....	2.24	2.46	l 2.29 s 2.45	2.36
K 397	Cooper's Yellow × Gold Standard.....	1.97	Discarded.		
K 398	Cooper's Yellow × Missouri Dent	A 2.14 B not rec.	Unsuccessful. Discarded.		
K 399	Cooper's Yellow × Babbit's Sweepstakes..	2.20	Discarded (acc.)		
K 400	Cooper's Yellow × Mammoth Yellow Dent,	——		——	——
——	K 400 × K 398	2.13	——	2.83	2.48
K 401	Cooper's Yellow × Shull's Yellow	A 2.16	A 2.59	Al 2.23 As 2 50 Am 2.32	2.36
		B 2.13	Unsuccessful.		

Table of Analyses of Crosses—*Continued.*

		1899	1900	1901	Mea
K 402	Cooper's Yellow × Chester Co. Mammoth,	1.81	Discarded.		
		A 1.78	Discarded.		
		B 2.02	Unsuccessful.		
		C missing.			
		D 1.98	Discarded.		
K 403	Cooper's Yellow × Shull's Mixed.....	A 2.36	A 2.01	Al 2.26	2.29
				As 2.53	
				Am 2.31	
		B 2.13	Discarded.		
		C 2.06	Discarded.		
K 404	Cooper's Yellow × Gardner....	2.00	Discarded.		
K 405	Cooper's Yellow × Haney's Yellow	2.24	1.59	l 2.17	2.28
				s 2.30	
				m 2.46	
				('99) 2.87	
K 407	Gold Standard × Boone County White...	1.75	Discarded.		
K 408	Gold Standard × Shull's White.....	2.04	Discarded.		
K 411	Gold Standard × Normandy Giant.....	A 2.35	Unsuccessful.		
		B 1.72	Discarded.		
———	K 411 × K 407.....	1.59	Discarded.	2 45	2.02
K 412	Gold Standard × Cooper's Yellow.....	1.80	Discarded.		
K 414	Gold Standard × Mammoth Dent.....	1.96	Discarded.		
K 415	Gold Standard × Mammoth Dent.....	A 1.71	Discarded.		2.25
		B 2.16	B 2.41	Bl 2.23	
				Bs 2 20	
				(B '99) 2.25	
K 416	Gold Standard × Babbit's Sweepstakes..	2.30	Unsuccessful.		
K 417	Gold Standard × Mammoth Yellow Dent,	A 2.23	Ax 1.83	Discarded.	2.35
			Ay 1.99	Discarded.	
		B 2.30	B 2.58	Bl 2.57	
				Bs 2.41	
				Bm 2.16	
		C 2.16	C 2.53	C 2.06	
				C ('99) 2.38	
K 419	Gold Standard × Shull's Mixed.....	2.07	Discarded.		

Table of Analyses of Crosses — *Continued.*

		1899	1900	1901	Mean
K 420	Gold Standard × Zimmerman's White ...	2.10	Discarded.		
K 422	Ziller's Yellow × Shull's White.....	1.92	Discarded.		
K 424	Ziller's Yellow × Buehler's White	2.11	Discarded.		
K 426	Ziller's Yellow × Cooper's Yellow.....	1.72	Discarded.		
K 427	Ziller's Yellow × Gold Standard.....	A 2.22 B 2.13 C 2.25	Unsuccessful. Discarded. C 2.19	 C 2.66	2.36
K 428	Ziller's Yellow × Missouri Dent	A 2.29 B 2.06	A 2.05 Discarded.	Al 2.22 As 2.23	
K 429	Ziller's Yellow × Mammoth Dent.....	A 1.89 B 2.02 C 2.23	Discarded. Discarded. C 2.36	 C 2.76	2.45
K 430	Ziller's Yellow × Babbit's Sweepstakes ..	2.64	2.26	2.26	
K 431	Ziller's Yellow × Mammoth Yellow Dent,	2.38	Unsuccessful.		
K 432	Ziller's Yellow × Shull's Yellow	A 1.85 B 2.13	Discarded. Discarded.		
K 434	Ziller's Yellow × Red.....	A 1.86 B 2.36	Discarded. B 2.34	 Bl 2.62 Bs 2.20 Bm 1.78	2.26
K 435	Ziller's Yellow × Haney's Yellow.....	2.15	2.11	2.35	2.20
K 436	Ziller's Yellow × Zimmerman's White ...	2.13	Discarded.		
K 437	Missouri Dent × Gold Standard.....	A(d) 2.11 B(d) 1.88	Discarded. Discarded.		
K 441	Missouri Dent × Zimmerman's White ...	1.98	Discarded.		
K 442	Mammoth Dent × Shull's White	B 2.33 C 2.05	Unsuccessful. Discarded.		
K 443	Mammoth Dent × Babbit's White	B 1.83 C 2.10 D 1.85	Discarded. Discarded. Discarded.		

Table of Analyses of Crosses — *Continued.*

		1899	1900	1901	Mean
K 444	Mammoth Dent × Buehler's White	A 2.04	Discarded.		
		B 1.85	Discarded.		
		C 2.03	Discarded.		
K 445	Mammoth Dent × Gold Standard.....	A 2.06	Discarded.		
		B 1.91	Discarded.		
K 447	Mammoth Dent × Babbit's Sweepstakes ..	A 2.23	Unsuccessful.	Al 2.36	2.10
				As 2.41	
		B 2.23	Unsuccessful.		
		C 1.68	Cx 1.74	Cxl 2.26	
				Cxs 2.01	
			Cy 2.19	Cyl 2.38	
				Cys 2.41	
K 448	Mammoth Dent × Mammoth Yellow Dent,	A 1.66	Discarded.		
		B 1.86	Discarded.		
K 450	Mammoth Dent × Chester Co. Mammoth,	2.13	Discarded.		
K 451	Mammoth Dent × Shull's Mixed.....	A 1.95	Discarded.		
		B 2.10	Discarded.		
		C 1.77	Discarded.		
		C (thin) 1.79	Discarded.		
		C (well filled) 1.78	Discarded.		
		D 2.04	Discarded.		
K 454	Mammoth Dent × Zimmerman's White ...	A 1.97	Discarded.		
		B 2.08	Discarded.		
		C 1.95	Discarded.		
K 455	Babbit's Sweeptakes × Buehler's White	A 1.92	Discarded.		
		B 1.65	Discarded.		
K 456	Babbit's Sweepstakes × Normandy Giant.....	A 2.15	Unsuccessful.		
		B 2.00	Discarded.		
K 457	Babbit's Sweepstakes × Cooper's Yellow.....	A 1.64	Discarded.		
		B 2.05	Discarded.		
		C 1.85	Discarded.		
K 458	Babbit's Sweepstakes × Mammoth Dent.....	A 1.90	Discarded.		
		B 1.77	Discarded.		
K 459	Babbit's Sweepstakes × Mammoth Yellow Dent,	A 1.80	Discarded.		
		B 1.91	Discarded.		
		B1l 1.94	Discarded.		
		B2l 1.90	Discarded.		
		B3l 1.89	Discarded.		
		B4l 1.83	Discarded.		
		C 2.02	Discarded.		
		D 1.62	Discarded.		

Table of Analyses of Crosses. 1899, 1900, 1901.

		1899	1900	1901	Mean
K 460	Babbit's Sweepstakes × Shull's Mixed	A 1.49	Discarded.		
		B 2.27	B 2.61		
		A(d) 1.86	Discarded.		
		B(d) 1.83	Discarded.		
K 461	Mammoth Yellow Dent × Boone County White	A 1.79	Discarded.		
		B 1.87	Discarded.		
K 462	Mammoth Yellow Dent × Shull's White	A 1.87	Discarded.		2.28
		B 2.00	Discarded.	B 2.56	
K 463	Mammoth Yellow Dent × St. Charles (rough)	A 1.55	Discarded.		
		B 1.86	Discarded.		
		C 1.87	Discarded.		
K 464	Mammoth Yellow Dent × St. Charles (smooth)	1.96	Discarded.		
K 466	Mammoth Yellow Dent × Buehler's White	A 2.24	Ax 1.73?	Ax 1.86	2.01
			Ay 2.05	Ayl 1.99	
				Ays 2.20	
		B 1.93	Discarded.		
		C 1.88	Discarded.		
		D 2.09	Discarded.		
K 467	Mammoth Yellow Dent × Normandy Giant	A 1.87	Discarded.		2.41
		B 1.84	Discarded.		
		C 2.17	Not rec.	Cl 2.52	
				Cs 2.53	
K 470	Mammoth Yellow Dent × Ziller's Yellow	2.12	Discarded.		
K 471	Mammoth Yellow Dent × Missouri Dent	A 2.05	Discarded.		
		B 1.69	Discarded.		
K 472	Mammoth Yellow Dent × Mammoth Dent	2.14	Discarded.		
K 475	Mammoth Yellow Dent × Chester Co. Mammoth.	A 1.84	Discarded.		
		B 2.09	Discarded.		
K 476	Mammoth Yellow Dent × Shull's Mixed	2.23	2.44	L 2.46	2.32
				S 2.13	
K 478	Mammoth Yellow Dent × Red	A 2.10	Discarded.		
		B 1.70	Discarded.		

Table of Analyses of Crosses — *Continued.*

		1899	1900	1901	Mean
K 479	Mammoth Yellow Dent × Haney's Yellow.....	2.03	x 2.01	xl 1.98	2.22
				xs 2.47	
				xm 2.54	
			y 2.34	yl 1.87	
				ys 2.48	
K 481	Shull's Yellow × Boone County White...	A 2.21	Lost.		
		B 2.07	Discarded.		
K 483	Shull's Yellow × Babbit's White.....	A 1.75	Discarded.		
		B 1.64	Discarded.		
		C 2.12	Discarded.		
K 485	Shull's Yellow × Normandy Giant.....	2.32	x 2.31	xl 1.84	2.35
				xs 2.39	
			y 2.52	yl 2.49	
				ys 2.36	
				('99) 2.52	
K 487	Shull's Yellow × Gold Standard.....	A 2.18	Ax 2.11	Axl 2.33	2.19
				Axs 2.43	
				Axm 2.06	
			Ay 2.13	Ayl 2.07	
				Ay2 2.06	
				Ay3 2.23	
				Ay4 2.38	
		B 2.24	Unsuccessful.	A'99l 2.22	
				A'99s 2.24	
K 488	Shull's Yellow × Ziller's Yellow	2.42	2.08	2.46	2.36
				('99) 2.48	
K 491	Shull's Yellow × Chester Co. Mammoth,	A(d) 2.33	Discarded.		2.21
		B(d) 2.06	Discarded.		
		A 2.13	Discarded.		
		B 2.45	B 1.92	B1 2.28	
				B2 2.26	
				B3 2.02	
				B4 2.30	
K 492	Shull's Yellow × Shull's Mixed.....	1.98	Discarded.		
K 493	Shull's Yellow × Gardner.....	A 2.45	Ax 2.16	Ax 2.50	2.35
			Ay 2.11	Ayl 2.64	
				Ay2 2.40	
				Ay3 2.52	
				Ay4 2.49	
		B 2.46	B 2.14	Bl 2.37	
				Bs 2.17	
				Bm 2.13	
K 495	Shull's Yellow × Haney's Yellow	A 2.07	Discarded.		

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 497	Chester County Mammoth × Boone County White...	A 1.78 B 2.02	Discarded. Discarded.		
K 498	Chester County Mammoth × Shull's White.....	1.88	Discarded.		
K 499	Chester County Mammoth × Babbit's White	A 1.71 B 1.71	Discarded. Discarded.		
K 500	Chester County Mammoth × Cooper's Yellow.....	2.08	Discarded.		
K 502	Chester County Mammoth × Missouri Dent	2.27	Lost.		
K 505	Chester County Mammoth × Mammoth Yellow Dent,	1.93	Unsuccessful.		
K 507	Chester County Mammoth × Haney's Yellow	2.21	Unsuccessful.		
K 508	Chester County Mammoth × Zimmerman's White ...	1.92	Discarded.		
K 512	Shull's Mixed × Babbit's Sweeps. Yellow,	2.26 A 2.19 B 2.15	Lost. Lost. B 1.99 B (dup) 2.30	 B1 2.37 Bs 2.44 B (dup) 2.36	2.27
K 513	Shull's Mixed × Mammoth Yellow Dent,	2.17	2.73	l 2.51 s 2.44	2.46
K 514	Shull's Mixed × Shull's Yellow	2.18	2.34	2.28	2.26
K 515	Shull's Mixed × Chester Co. Mammoth,	2.29	x 2.28 y 1.72	x 2.18 y1 2.02 y2 2.29 y3 2.12 y4 2.73	2.21
K 516	Shull's Mixed × Gardner	2.09	Lost.		
K 417	Shull's Mixed × Red	A 2.26 B 2.16	a 2.08 Unsuccessful.	al 1.88 as 2.28	2.13
K 518	Shull's Mixed × Haney's Yellow	2.18	x 2.87 y 2.24	 y 2.68	2.49
K 519	Shull's Mixed × Zimmerman's White....	A 2.11 B 2.30	Discarded. B 2.59	 B1 2.08 B2 2.36 B3 2.57 B4 2.78	2.45

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 520	Gardner × Shull's White.....	2.21	Unsuccessful.		
K 521	Gardner × Mammoth Dent....	2.24	2.25	2.31	2.26
K 522	Gardner × Babbit's Sweepstakes ..	A 2.16	Ax 1.99	Ax1 2.64 Ax2 2.17 Ax3 2 05 Ax4 2.19	2.26
			Ay 1.96	Ayl 2.44 Ays 2.73	
		B 1.98	Discarded.		
K 525	Gardner × Haney's Yellow....	2.10	Discarded.	2.66	2.38
		A 1.81	Unsuccessful.		
		B 1.95	Discarded.		
K 528	Red × Shull's White.....	2.17	2.12	l 2.01 s 2.02	2.08
K 529	Red × St. Charles (rough)....	1.94	Discarded.		
K 530	Red × St. Charles (smooth) ..	1.84	Discarded.		
K 531	Red × Babbit's White.....	2.03	Discarded.		
K 532	Red × Buehler's White.....	2.09	Discarded.		
K 533	Red × Normandy Giant.....	A 2.16	Unsuccessful.		
		B 2.25	Unsuccessful.		
K 534	Red × Cooper's Yellow.....	A 1.93	Discarded.		
		B 2.04	Discarded.		
		C 1.99	Discarded.		
K 535	Red × Gold Standard	2.15	x 2.18	xl 2.20 xs 2.15 xm 2.61	2.31
			y 2.47	yl 2.36 ys 2.18 ym 2.48	
K 536	Red × Ziller's Yellow.....	A 2.04	Discarded.		
		B 2.09	Discarded.		
K 537	Red × Missouri Dent.....	2.03	Discarded.		
K 538	Red × Mammoth Dent	A 2.44	Ax 2.21	Axl 2.17 Axs 2.29	2.31
			Ay 2.18	Ayl 2.92 Ays 1.98	
		B 1.91	Discarded.		
K 539	Red × Babbit's Sweepstakes..	A 2.10	Discarded.		
		B 2.05	Discarded.		
K 540	Red × Mammoth Yellow Dent,	A 1.67	Discarded.		
		B 1.71	Discarded.		

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 541	Red × Shull's Yellow.....	2.24	2.45	1 2.50 s 2.65	2.46
K 542	Red × Chester Co. Mammoth..	A 2.24 B 2.19	A 2.38 B 2.96	A 2.22 Bl 2.26 Bs 2.32	2.37
K 543	Red × Shull's Mixed.....	A 1.99 B 2.28	Discarded. B 2.56	 Bl 2.11 Bs 2.53	2.37
K 544	Red × Gardner.....	A 1.71 B 1.91 C 2.10	Discarded. Discarded.		
K 545	Red × Haney's Yellow.....	A 1.90 B 2.19 C 1.95	Discarded. Bx 2.42 By 2.20 Discarded.	 Bx 2.68	2.43
K 546	Red × Zimmerman's White...	A 2.00 B 2.00 C 1.88	Discarded. Discarded. Discarded.	A1 1.64 A2 1.98 A3 1.64	
K 547	Haney's Yellow × Boone County White...	A Lost. B 2.39	Discarded. Bx 2.15 By ——	 Bx 2.18 Byl 2.47 Bys 2.55 Bym 2.37	2.35
K 549	Haney's Yellow × Babbit's White	A Lost. B 2.09	Discarded. Unsuccessful.		
K 550	Haney's Yellow × Buehler's White	A 1.88 B 2.15	Discarded. Unsuccessful.		
K 551	Haney's Yellow × Cooper's Yellow.....	A 1.81 B Lost.	Discarded. Discarded.		
K 552	Haney's Yellow × Gold Standard.....	1.99 A 1.78 B 2.36	Discarded. Discarded. Unsuccessful.		
K 553	Haney's Yellow × Ziller's Yellow	A(d) 1.83 B(d) 1.99 A 2.04 B 2.06 C 2.04	Discarded. Discarded. Discarded. Discarded. Discarded.		

Table of Analyses of Crosses— *Continued.*

		1899	1900	1901	Mean
K 554	Haney's Yellow × Missouri Dent	A 2.22	Ax 2.49	Axl 2.29 Axs 2.76	2.46
			Ay 2.47	Ayl 2.02 Ays 2.42	
		B 2.16	B 2.47	Bl 3.02 Bs 2.70	
K 555	Haney's Yellow × Babbit's Sweeps. Yellow,	A 2.07 B 2.26	Discarded. Unsuccessful.		
K 556	Haney's Yellow × Mammoth Yellow Dent,	1.68	2.79	Lost.	
K 557	Haney's Yellow × Shull's Yellow	A 1.84 B 2.18	Discarded. 1.39	 Bl 2.44 Bs 2.34	2.08
K 559	Haney's Yellow × Shull's Mixed.....	2.17	2.13	2.64	2.31
K 560	Haney's Yellow × Red.....	A 2.05 B 2.30	Discarded. Bx 2.05 By 2.61	 Bx 2.45 Byl 2.94 Bys 2.49	2.47
K 561	Haney's Yellow × Zimmerman's White ...	A 1.94 B 2.04 C 2.06	Discarded. Discarded. Discarded.		
K 562	Zimmerman's White × Boone County White...	A 2.23	Ax 2.10	Axl 1.93 Axs 1.85 Axm 2.68	2.19
			Ay 1.97	Ay 2.59	
K 563	Zimmerman's White × Shull's White.....	A 1.98 B 2.07	Discarded. Discarded.		
K 564	Zimmerman's White × St. Charles (rough)....	A 2.06 B 2.19 C 1.93 D 2.13	Discarded. B 2.15	 B 2.12	2.15
K 565	Zimmerman's White × St. Charles (smooth)...	A 2.13 B 2.17 C 2.23	Discarded. B 2.02 Lost.	 B 2.16	2.12
K 568	Zimmerman's White × Normandy Giant.....	A 1.94 B 2.11	Discarded. Discarded.		
K 569	Zimmerman's White × Cooper's Yellow.....	2.14	Discarded.		

Table of Analyses of Crosses —*Concluded.*

		1899	1900	1901	Mean
K 570	Zimmerman's White × Gold Standard.....	A 1.92	Discarded.		
		B 2.20	Unsuccessful.		
K 571	Zimmerman's White × Ziller's Yellow.....	A 2.43	Unsuccessful.		
		B 2.28	Unsuccessful.		
		C 2.19	Unsuccessful.		
K 572	Zimmerman's White × Missouri Dent.....	A (d) 1.90	Discarded.		
		B (d) 2.00	Discarded.		
K 573	Zimmerman's White × Mammoth Dent.....	2.14	Discarded.		
K 574	Zimmerman's White × Babbit's Sweepstakes..	A 1.78	Discarded.		
		B 1.95	Discarded.		
K 575	Zimmerman's White × Mammoth Yellow Dent,	A 1.94	Discarded.		
		B 2.05	Discarded.		
		C 1.73	Discarded.		
K 576	Zimmerman's White × Shull's Yellow.....	2.11	Discarded.		
K 579	Zimmerman's White × Gardner.....	A 2.13	Discarded.		
		B 2.12	Discarded.		
K 580	Zimmerman's White × Red...	A 1.99	Discarded.		
		B 2.19	1.95	Discarded.	
K 581	Zimmerman's White × Haney's Yeilow.....	1.88	Discarded.		

The preceding pages exhibit a mass of analytical data that may be studied from various points of view. It will be seen that, of the nearly 600 ears analyzed the first year, only about eighty have been retained to the present. The crosses analyzed in 1899 showed wide variations in nitrogen content. Average corn contains 1.84 per cent. of nitrogen, or 11.5 per cent. of protein in the dry substance. In selecting the crosses for further propagation in 1890, 2 per cent. of nitrogen was taken as the minimum. Some having that amount or more were not included. It will be seen that if varieties containing no more than 2 per cent. of nitrogen—that is, 12.5 per cent. of protein can be firmly fixed—the cereal would be very much improved. Calculating the increase on the protein itself instead of on the whole substance, the increase would be nearly nine per cent. This was set as our minimum. In following from year to year the nitrogen con-

tent exhibited by the several crosses kept under culture, one cannot but be struck by the persistence with which the original high nitrogen content is maintained. Examination of the detailed results shows that there is a certain tendency to variation, with the production of some ears low in nitrogen, but the great preponderance of ears high in nitrogen is very striking and encouraging.

TABLE showing average composition for three years, including all those grown in 1901, and their ancestors.

Cross number.	Ears analyzed.	Per cent. nitrogen.	Cross number.	Ears analyzed.	Per cent. nitrogen.
K 39	16	2.00	K 106	8	2.29
K 466	6	2.01	K 116	5	2.29
K 411 × K 407	2	2.02	K 206	5	2.29
K 82	4	2.04	K 213	6	2.29
K 199	9	2.05	K 403	5	2.29
K 528	4	2.08	K 314	4	2.31
K 557	4	2.08	K 374	6	2.31
K 13	7	2.08	K 535	9	2.31
K 77	5	2.09	K 538	7	2.31
K 447	7	2.10	K 559	3	2.31
K 222	4	2.11	K 476	4	2.32
K 565	3	2.12	K 141	7	2.33
K 517	4	2.13	K 171	8	2.33
K 218	14	2.14	K 143	8	2.34
K 564	3	2.15	K 417	9	2.35
K 140	5	2.16	K 485	8	2.35
K 209	8	2.18	K 493	13	2.35
K 369	3	2.18	K 547	6	2.35
K 10	8	2.19	K 396	4	2.36
K 487	10	2.19	K 401	5	2.36
K 562	7	2.19	K 427	3	2.36
K 151	9	2.20	K 488	4	2.36
K 435	3	2.20	K 542	7	2.37
K 6	4	2.21	K 543	4	2.37
K 491	6	2.21	K 430	3	2.38
K 515	8	2.21	K 525	2	2.38
K 479	8	2.22	K 76	12	2.39
K 26	12	2.23	K 467	3	2.41
K 16	8	2.24	K 138	11	2.42
K 92	15	2.25	K 322	5	2.43
K 415	5	2.25	K 545	3	2.43
K 352	6	2.26	K 429	3	2.45
K 434	5	2.26	K 519	6	2.45
K 514	3	2.26	K 513	4	2.46
K 521	3	2.26	K 541	4	2.46
K 522	9	2.26	K 554	11	2.46
K 512	6	2.27	K 560	6	2.47
K 223	8	2.28	K 400 × K 398	2	2.48
K 405	6	2.28	K 518	4	2.49
K 462	2	2.28			

For more ready comparison, we have compiled the above table showing average composition for three years. This is not a picked table, but includes all that have been grown continuously. The crosses are designated by number only, and are arranged in the order of nitrogen

content. It will be seen that of the seventy-nine, not one falls below 2 per cent. of nitrogen. The fact that we are in possession of seventy-nine varieties that, as an average for three years, exceed 2 per cent. in nitrogen is certainly of great significance. When we see further that an even dozen of them contain over 2.40 per cent. of nitrogen—that is, over 15 per cent. of protein, which is nearly as much as average wheat bran—the possibilities in the way of corn improvement become fairly luminous, and the existence of ears with nearly or quite 3 per cent. of nitrogen adds still more to the brightness of the prospect. It should be stated, however, that in many cases the ears showing very high percentages of nitrogen were small or the grains were scattering on the cob, and we cannot hope to secure such nitrogen content with a maximum development of grain. We have, notwithstanding, many very good ears containing a high percentage of nitrogen. In K 554 we have a cross of Haney's Yellow and Missouri Dent, in which, in analyses of eleven ears, not one fell below 2 per cent. of nitrogen, and one exceeded 3 per cent., the average of all being 2.46 per cent. K 138 B has an almost equal record. It is a cross of Ziller's Yellow and Missouri Dent, and among eleven analyses only one fell below 2 per cent. of nitrogen, the maximum was 2.81 per cent., and the average 2.42. K 560 B averages still higher, but its record rests on but six analyses, ranging from 2.05 per cent. to 2.95. It is a cross of Haney's Yellow and Red. The four ears analyzed of K 518 average 2.49 per cent., and range from 2.24 to 2.87 per cent. It is a cross of Shull's Mixed and Haney's Yellow. Space forbids calling special attention to further notable examples, all of which may be easily traced by means of the tables.

We have compiled a table which shows the number of times each of the original varieties was used in the production of the crosses still under cultivation. It also shows the crosses in which each was used as the female parent, and those in which it was used as the male, the average per cent. of nitrogen contained in each of these groups, and in all the crosses in which a given variety was used as either parent. In this table the varieties have been arranged in the order of the nitrogen content of the original ears. It is evident that certain of the varieties rich in protein have impressed this characteristic upon their offspring. The mean given in the last column is the average of all crosses in which the variety named was used—not simply the average of the averages of the crosses in which it was used as the female parent and those in which it was used as the male parent. These final means, each involving as it does a number of varieties, tend to the same value, as might have been anticipated.

TABLE showing the crosses in which each of the original varieties was used, and the average per cent. of nitrogen of these crosses, and the same for the crosses in which they were used as the female parent, and in which they were used as the male parent, separately shown:

	Times used.	Percentage of nitrogen.	
Shull's White	6	....	2.23
As female parent, K 13, K 16	2	2.16	
As male parent, K 223, K 322, K 462, K 528	4	2.27	
Gold Standard	8	....	2.28
As female parent, K 116, K 415, K 417	3	2.29	
As male parent, K 171, K 218, K 427, K 487, K 535	5	2.27	
Zimmerman's White	5	....	2.15
As female parent, K 562, K 564, K 565	3	2.15	
As male parent, K 519, K 546	2	2.14	
St. Charles (smooth kernels)	3	....	2.13
As female parent, K 39, K 352	2	2.13	
As male parent, K 565	1	2.12	
Chester County Mammoth	6	....	2.23
As female parent, K 218, K 222	2	2.22	
As male parent, K 141, K 209, K 491, K 515	4	2.23	
Boone County White	6	....	2.22
As female parent, K 6, K 10, K 314	3	2.24	
As male parent, K 199, K 547, K 562	3	2.20	
Normandy Giant	5	....	2.28
As female parent, K 82, K 92	2	2.15	
As male parent, K 396, K 467, K 485	3	2.37	
Mammoth Yellow Dent	10	....	2.27
As female parent, K 462, K 466, K 467, K 476, K 479	5	2.25	
As male parent, K 6, K 106, K 314, K 417, K 513	5	2.32	
Cooper's Yellow	6	....	2.30
As female parent, K 106, K 396, K 401, K 403, K 405	5	2.32	
As male parent, K 16	1	2.24	
Babbit's White	3	....	2.07
As female parent	0	0.00	
As male parent, K 39, K 82, K 369	3	2.07	
Mammoth Dent	5	....	2.37
As female parent, K 447	1	2.10	
As male parent, K 415, K 429, K 521, K 538	4	2.32	
Shull's Mixed	13	....	2.32
As female parent, K 223, K 512, K 513, K 514, K 515, K 517, K 518, K 519	8	2.32	
As male parent, K 222, K 403, K 476, K 542, K 559	5	2.32	
St. Charles (rough kernels)	3	....	2.27
As female parent, K 26, K 322	2	2.33	
As male parent, K 564	1	2.15	
Missouri Dent	4	....	2.34
As female parent, K 151	1	2.20	
As male parent, K 138, K 206, K 554	3	2.39	
Babbit's Sweepstakes	5	....	2.24
As female parent, K 171	1	2.33	
As male parent, K 374, K 447, K 512, K 522	4	2.24	
Shull's Yellow	14	....	2.26
As female parent, K 199, K 206, K 209, K 213, K 485, K 487, K 488, K 491, K 493	9	2.25	
As male parent, K 140, K 401, K 514, K 541, K 557	5	2.26	

Table showing the crosses.—*Concluded.*

	Times used	Percent.	Nitrogen
Gardner	6	....	2.32
As female parent, K 521, K 522, K 525	3	2.30	
As male parent, K 76, K 92, K 493	3	2.33	
Ziller's Yellow	10	....	2.31
As female parent, K 138, K 140, K 141, K 143, K 427, K 429, K 434, K 435	8	2.32	
As male parent, K 26, K 488	2	2.29	
Red	14	....	2.30
As female parent, K 528, K 535, K 538, K 541, K 542, K 543, K 545, K 546	8	2.34	
As male parent, K 10, K 77, K 143, K 434, K 517, K 560	6	2.25	
Haney's Yellow	14	....	2.32
As female parent, K 547, K 554, K 557, K 559, K 560	5	2.33	
As male parent, K 151, K 213, K 352, K 405, K 435, K 479, K 518, K 525, K 545	9	2.31	
Buehler's White	6	....	2.21
As female parent, K 76, K 77, K 369, K 374	4	2.24	
As male parent, K 116, K 466	2	2.15	

The experiments with crosses during the last four years have been carried out in spite of the two seasons of protracted drought. This would not have been possible had we not had the Manhattan water-supply available for irrigation, and our work would have been entirely lost, or, at best, set back two years.

A COOPERATIVE EXPERIMENT.

In the spring of 1889, when Professor Cottrell withdrew from further connection with the work in seed breeding, he suggested an experiment growing out of the experience of one or two farmers of the state, and arrangements were made to carry it out. Its object was to test the alleged fact that seed-corn, the product of cross-fertilization, yields much better than that fertilized in the ordinary way. A number of farmers in the vicinity were induced to cooperate with the station, and arrangements were made by correspondence with several in other parts of the state. The experiment was clearly explained to them, and was essentially as follows: The Station furnished each farmer making the trial with seed-corn enough to plant two rows across the middle of the field. The tassels were to be completely removed from these rows as they appeared, so that any corn on them must be the result of cross-fertilization. This corn was to be gathered by itself and used to seed at least an acre the next year, so that its yield could be compared with that of the field grown from seed obtained in the usual manner.

For various reasons, not one of the twenty-four farmers beginning this experiment carried it through to its conclusion. Only four planted the crossed corn the following season, and they obtained no result because of the almost total failure of the corn crop from drought in this vicinity in 1900. The accompanying table gives a summary statement of the outcome in each case.

RESULTS of a cooperative experiment with farmers, in crossing corn for the production of seed, 1899 and 1900.

Names.	Addresses.	Results.
Birch	Manhattan, R. F. D. No. 2.	Corn was poor, small, hard, flinty; abandoned at end of first season.
Bills, C	Manhattan, R. F. D. No. 2.	No report.
Cunningham, J. S.	Manhattan, R. F. D. No. 1.	Corn was poor; abandoned at end of first year.
Huse, Ansel	Manhattan, R. F. D. No. 2.	Corn was poor; abandoned at end of first year.
Huse, Corliss	" "	Corn was poor; abandoned at end of first year.
Kean, J. A	Holland, R. F. D. No. 2.	Hired man destroyed (poor anyhow).
Kimball, Richard	Manhattan, R. F. D. No. 1.	Detasseling was neglected by the Station.
Knipe, Rev	" "	Crossed corn too poor for use as seed the following year.
Koppenheffer, S.	Manhattan, R. F. D. No. 2.	Crop failed the first year.
Maintz, R. W	Linn	No report.
Miller, T. B	Manhattan, R. F. D. No. 2.	Crossed corn good; abandoned second year on account of leaving the farm.
Schuler, A. J	Junction City	Crossed corn good; planted half his field with it the next year, but corn crop was a failure.
Steustrom, C. A.	White City	Crossed corn inferior, yield, 25 bus. per acre; other corn 60 bus. per acre; abandoned second year.
Stowell, C. W	Sabetha	First planting washed out.
Swingle, J. F	Manhattan, R. F. D. No. 1.	Nothing done the second season on account of rush of work.
Thorpe, F	Chapman	Second year a total failure of corn crop.
Toy, John	Manhattan, R. F. D. No. 2.	Crossed corn cut with rest of field by hired man.
Tully, M. J	" "	Washed out the first year.
Westgate, H	" "	Corn poor; abandoned at end of first year.
Westgate, E. W	" "	Second year a total failure of corn crop.
Westgate, P. E.	Manhattan, R. F. D. No. 1.	Second year a total failure of corn crop. (Some of this seed made 10 bus. per acre on College farm.)
Whitney, Will	Manhattan, R. F. D. No. 1.	Corn poor; abandoned at end of first year.
Yenawine, Rollin.	Manhattan, R. F. D. No. 2.	No report.
Yenawine, S. J.	" "	Bugs killed corn first year.

The outcome of this cooperative test as tabulated above ought not to occasion surprise. It is the experience of stations generally that cooperative experiments with farmers are seldom satisfactorily carried out. The farmer has too much else to attend to of greater moment to him individually. Our experience with farmers

growing sugar-beets furnishes ample illustration of the same difficulty. Even when they were definitely hired to do the work, results were not obtained. All such experiments must be under the immediate control of a station officer from start to finish. The experiment also indicates that the product of the crossing is apt to be rather unpromising in appearance. Whether or not it really was poor will not be known, since no one finished the test successfully. It is not unlikely that a part of the unfavorable results of the first year's work was due to the injury that the corn received in detasseling it. In our opinion, care should be taken to avoid unnecessary injury in this part of the process. The liability of failure, even when experiments have been conducted according to plans laid out, on account of drought or other untoward climatic conditions, is strongly brought out in this experiment.

SOME ANALYSES OF COMMERCIAL SEED-CORN.

In view of the probability that many farmers in the state would be obliged to purchase seed-corn this year, it seemed desirable to make analyses of some of the seed offered, and, if material differences were found, to publish recommendations. Accordingly, all the varieties offered by the leading seed firm of the state were purchased, and their nitrogen content determined. The results are published in the succeeding table, and make a striking contrast to those that have preceded. The seed was apparently of good quality, and its low content of nitrogen simply shows the deficiency of this important element that corn ordinarily exhibits:

Brazilian Flour Corn	1.39	Forsythe's Favorite	1.63
Iowa Gold Mine	1.47	Iowa Silver Mine	1.69
Early Mastodon	1.53	King of the Earliest	1.70
Hickory King	1.54	Kansas Sunflower	1.72
Champion White Pearl	1.59	Golden Beauty	1.74
Improved Leaming	1.62	Pride of the North	1.81

SUMMARY.

Corn is deficient in protein, and in 1898 experiments were begun which are still in progress, having for their object the origination of varieties that should be richer in protein. Thirty-three varieties were analyzed, and these showed percentages of nitrogen ranging from 1.56 to 2.26. Analyses of single ears of each of two varieties showed great differences in the nitrogen content of different ears of the same variety, the percentages ranging from 1.53 to 2.24 in a variety that had been grown for thirty years on the same farm without admixture, and from 1.35 to 2.22 in a cross originated the year previous. Analyses of single kernels from the same ear showed considerable differences in nitrogen content, though not as great as among different ears of the same variety.

Analyses of a large number of single kernels, the specific gravity of which had been determined, showed that, while there seems to be a tendency toward higher nitrogen content with lower specific gravity, there is no uniform connection between these factors, and therefore corn richer in nitrogen cannot be separated from that poorer in nitrogen by means of specific gravity.

From the original 33 varieties 21 were selected, and used in making crosses by the botanical department. Each ear saved was pollenized by hand, and all other fertilization prevented. The crosses originated in 1898 in this way were planted in 1899, and each close-fertilized. The ears obtained that year were analyzed, and the next season those showing 2 per cent. or more of nitrogen were planted, as a rule. These were again close-fertilized, the crop of each analyzed, and the same ones, in general, planted in 1901. They were again close-fertilized, and the ears produced analyzed. These crosses show remarkably high percentages of nitrogen in many cases, and all contain 2 per cent. or more of nitrogen as the average for three years. In 12 cases the average is above 2.40 per cent. of nitrogen, or 15 per cent. of protein.

The unsatisfactory outcome of a cooperative experiment is detailed, and analyses are given of a number of varieties of corn offered on the market, which show how inferior the seed-corn now available is in nitrogen content. The selection of seed-corn richer in nitrogen, by choosing ears in which examination shows that the kernels possess relatively large germs, is strongly urged upon farmers as a practicable method of increasing the percentage of both protein and fat in corn.