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SOME CORRELATION STUDIES
IN MAIZE

by

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INTRODUCTION

The most common method of selecting seed corn has been for many years to pick the best ears from the crib, no consideration whatever being given to the stalks on which they were borne. Within the last few years, however, this method has been replaced largely by that of selecting the seed from the field, taking into consideration not only the ear, but the plant as well.

With this advance in the methods of selecting corn for seed a number of questions naturally arises: Are there any vegetative characters in the plant growth that may serve as indices to the yielding quality of the plant? Which of these seems to be indicative of a high yielding type of plant? Which of a low yielding type? If any such characters be present, to what extent may they be relied upon in making selections? In other words, does a correlation exist between the yielding quality of a plant and any of its vegetative characters? It is in an attempt to find an answer to some of these questions that the following studies are made.

BIOMETRY AND BIOMETRICAL CONSTANTS.

Such studies naturally resolve themselves into a biometrical problem. The fact that each character of a population varies more or less in the different individuals makes it necessary to find some means of expressing its value and its relation to other characters for the population rather than for each individual. The first step in securing such expressions

is the making of a frequency distribution of the individuals with reference to the character in question. The range of such character is divided into classes, then the individuals grouped according to the class into which they fall. To give each class its true significance, its value is multiplied by the number of individuals falling in it. (If there is a range within the class, the centre is taken as its value. For example, classes 0 to 1, 1 to 2, etc. are considered as .5, 1.5, etc. respectively in calculating.) The total of these products is divided by the total number of individuals, thus giving the average value of the character for the particular group of individuals. By such a procedure, the individualities of the variates are lost in that of the group, the result being a hypothetical individual whose value, with reference to the particular character, is the average for the group.

The next step in the problem is the making of a correlation table or figure. A frequency distribution such as described above, is made with reference to some particular character. A second distribution is made within the first, with reference to another character. The results of such grouping are recorded in a checker-board fashion, the horizontal lines being controlled by one character and the perpendicular lines by the other. Each of these distributions is handled in a manner similar to the one described in the preceding paragraph. Then by biometrical formulae, the coefficient of correlation is determined which shows the degree of relationship existing between the two characters.

Biometry may be defined as a statistical study of the behavior of measurable characters, or of the interaction of such characters in the plant or animal kingdom.

The Mean "M" is the average value of the character in question for the particular group of individuals. However, the mean should not be considered conclusive, as in exceptional cases it may be somewhat misleading. The following illustration of a case in which the mean would be misleading is cited by Davenport (1907), "In a community of paupers lives a millionaire. Now the mean wealth of this community would be fairly high. Still the prevailing type would be paupers."

The Average Deviation is an index to the variability of the individuals within the group. If the range of variation is wide, the average deviation will be large. On the other hand, if the range is narrow, the average deviation will be small. Stated in a mathematical way, the average deviation is the sum of the products of the differences between the different classes and their mean, times the number of individuals in each class; divided by the total number of individuals in the group. From this it is obvious that as the number of individuals increases the average deviation becomes relatively smaller.

The Standard Deviation is the same as the average deviation except that for mathematical reasons the difference between the classes and their mean is squared before being

multiplied by the frequency of the class. The sum of these products is then divided by the total number of individuals, and the square-root of the quotient taken. The standard deviation serves the same purpose as does the average deviation. However, the two cannot be compared. That is, the standard deviation of one group of individuals can be compared only with the standard deviation of another, and the average only with the average. Davenport (1907) has this to say about the standard deviation, " ----- It therefore affords a reliable basis for comparing the variability of one race with that of another character under consideration, or of one character with that of another either in the same or in different races."

In the following studies only the standard deviation is used.

The Coefficient of Variability "C" is an abstract expression of the variation among the individuals of a group as regards any particular character. This makes it possible to directly compare the variability of one frequency distribution with that of another; "no matter," as Davenport (1907) says, "what the character - whether in the same or different individuals, or between similar or unlike species."

The Coefficient of Correlation "r" is an index to the relationship that exists between two characters. This relationship may exist in any one of three ways: (1) They may go hand in hand, rise and fall together - one being dependent on the other. Such a relationship is known as a "positive

correlation" and expressed by 1. About the only perfect correlation that can be cited as an illustration is the presence or absence of some character as influencing some other character. For example, a perfect correlation must exist between the yield of a stalk of corn and the presence of an ear.

(2) They may act independent of each other. That is, one may have no apparent effect on the other. As an example of this might be cited the yielding quality of an ear as influenced by its color. In such a case no correlation exists and is expressed as 0.

(3) They may be opposing in nature. That is, the increase in one character is attended with a corresponding decrease in the other. Such a relationship is known as a negative correlation and expressed by -1. As an example of a perfect negative correlation might be cited the reverse of the illustration used for a perfect correlation: that is, the correlation between the yield of a stalk of corn and the absence of an ear.

In practical studies it is very improbable that a coefficient of correlation of either -1, 0, or 1 will ever be found. However, values ranging all the way from one of the extremes (-1) to the other (1) will be found, and the farther from 0, either way, the greater the correlation, positive or negative.

The Probable Error "E" is an index to how much confidence may be placed in the constants just explained. Expressing it in a general way, since only part of a population can be measured it is obvious that the results are not likely to be absolutely correct. However, as the number of measured individuals increases this likelihood of error decreases, till if the entire population could be measured, it should be zero. Since the value of a constant for a group of individuals may be either above or below that for the population, the probable error is written plus or minus ($\pm$), and the chances are even that the true value of such a constant lies within this range.

REVIEW OF LITERATURE

Very little work has been done in the studies of correlations of vegetative characters in the maize plant, and the literature on this subject is very meager. With the exception of two or three cases, the following reports have no direct bearing on the subject. However, most of them have indirect bearing.

With reference to the characters of the mother ears, Williams and Welton (1909) found that the long seed ears gave a marked increase in yield over that of the shorter ears. Their results were obtained from observations on three generations of selection from four varieties. The first gener-

ation the long ears gained 4.36 bushels per acre in yield and 2.0 inches in average length of ears over the short ones; the second generation the long ears gained 5.77 bushels in yield per acre and 2.05 inches in length; and the third generation the long ears gained 5.62 bushels in yield and 2.3 inches in length, the average being an increase of 5.18 bushels in yield per acre, and 2.2 inches in length, in favor of the long ears.

In the discussion of their results, the writers state that the greatest difference in yield was between groups showing the greatest difference in ear length and least between those showing the least difference, the highest yielders always being the longest ears. They go on to say that probably the weight of the ears has some effect on yield but less effect than does the length, since the shorter ears and lower yielders invariably exceed the longer ones in circumference.

They conclude by saying, "If a given quantity of seed corn be divided into two groups, one composed of ears below the average and the other of ears above, the longer ears will out-yield the shorter. We have no evidence that selection for extremely long ears increases the yield above those of medium length. The difference thus far seems to be due to a lessened yield resulting from the selection for the short ears rather than an increased yield from the selection for long ears."

The statement of these writers as regards the shorter

ears invariably exceeding the longer ones in circumference is not borne out by the results of Rietz and Smith (1910) who found correlations between the length of ear and the circumference ranging from $.128 \pm .035$ to $.623 \pm .016$. No case, at any rate being reported in which the correlation was negative. As to the weight of the ear as influenced by the length they found a correlation ranging from $.035 \pm .005$ to $.781 \pm .008$. However, as their results show, there seems to be a much closer correlation between the weight of the ear and the circumference; from $.721 \pm .011$ to $.840 \pm .007$, than there is between the weight and the length.

Montgomery (1909) is of the same opinion as the Ohio men, that is, that the long, slim type of ears probably yield best.

In eighteen tests covering a period of four years, Williams and Welton (1909) found that the tapering ears out-yielded the cylindrical ones on an average of .87 bushels. But the variations were so inconsistent that the results were not considered conclusive by the writers.

The same men carried on an experiment to test the effect of bare tips in the seed ears on the yield of their progeny. They state that bare tips tend to increase in proportion and at the same time the yield tends to decrease.

In respect to the size of the mother ears, Lyon (1905) found that the largest ears were not always the highest yielders. In fact, the largest eared varieties were very little above the average of the medium sized ears in yield and in a few cases they were below it.

A few years later Montgomery (1909) makes this statement regarding the question, "The size of the ear depends on the environment and is important only when the conditions under which it was grown are known."

Along this same line Williams and Welton (1909) experimented, using the weight of the ears as indicative of their size. For their studies, they selected four hundred good seed ears. Then these were each weighed. The 40% weighing the heaviest were selected for the heavy ears and the 40% weighing the least were selected for the light. After this selection, the group of heavy ears averaged 2.46 ounces per ear heavier than the light ones, and out-yielded them by 2.08 bushels per acre.

As regards the indentation, Williams and Welton (1909) found an average increase in yield of 2.84 bushels per acre in favor of the smooth ears. But they do not state how long the experiment was run. In the discussion of their results they have this to say, "It will be noted that the rough, dented ears exceeded the smooth in weight, length, circumference, and percent of grain. Several of these characters where studied under conditions in which they are dominant, have favored an increase in yield, but in a modified form and associated with the more pronounced character of roughness in indentation, they have given way to the smoother type."

Davenport and Rietz (1907) found that the chemical composition of the seed ears has some influence on both the chemical composition and on the yield of the progeny. Their re-

sults are from ten generations of a variety known as Burr's White. The principal object of the experiment was to change the oil and protein contents of different strains of this variety. After seven generations of selection for high protein content on the one hand and low protein content on the other, they have succeeded in changing the two protein contents till there is a wider gap between them than is covered by the strain from which they were originally selected. The same thing is true with reference to their selection for the high and low oil contents.

Along with these gradual chemical changes, there seem to have been some physical changes. According to their report, the low protein strain produced the longest ears while the high oil strain produced the shortest ears. The low oil strains produced ears averaging largest in circumference while the high protein strain produced the smallest.

The writers state that there also seemed to be some change with reference to the number of rows of kernels in the ear, the high oil strains having the highest number, while the low oil had the smallest number.

With reference to the correlation of plant characters with the yield, about the only studies that have been published are the studies of Ewing (1910) and of Montgomery (1911). Smith (1909) has also done some work along this line, but most of his work has been in connection with selection.

As regards the size of the plant Montgomery (1911) found a correlation of $.847 \pm .010$ between the weight of ear as subject and the weight of the plant, relative. In commenting on his results, he says a stout stalk has no advantage over a medium one. Though the medium is a little better than the slim in actual yield, it is slightly lower in proportional yield.

Using the diameter of the stalk as relative instead of the weight of plant, Ewing (1910) found a correlation of $.393 \pm .020$. "This" he says, "is equivalent to about forty percent of a perfect correlation and is obviously too small a degree of association to be of value for prediction."

As regards leaf area, the same writer found a correlation of $.292 \pm .021$ between the weight of grain and the length of the leaves, and $.314 \pm .021$ between the weight of grain and the breadth of the leaves.

Montgomery (1911) reports a correlation of $.386 \pm .032$ between the weight of ear as subject and the total leaf area, relative. As an explanation for this low correlation he says, "A low relative leaf area seems desirable as it requires less water."

In regard to height of stalk, relative to the yield, Ewing (1910) obtained a correlation of $.203 \pm .025$. Montgomery (1911) reports a very similar result, $.208 \pm .035$.

As to height of ear, Montgomery reports a correlation of $.211 \pm .035$ between the weight of ear and its height. Ewing (1910) found a correlation of $.025 \pm .024$ between the yield and the percent of internodes below the ear.

Smith (1909) reports similar results and conclusions. He says that he found no appreciable difference in the yielding ability of the two strains, but that the lower eared type flowered nearly a week earlier than did the higher eared one. He explains the increase in the height of ears as due to two factors; an increase in the number of internodes below the ear, and an increase in the length of the internodes. These two factors, according to him, also influence the height of stalk so that by increasing the height of the ear the height of the stalk is also gradually increased. By selection, he has modified this character (height of ear) to a very marked degree. Starting with an ordinary strain of corn, he selected the highest ears on the one hand and the lowest on the other. After six generations of such selection, he has produced a strain of corn bearing the ears at an average height of 72.4 inches and at the same time the other strain bearing its ears at an average height of only 33.2 inches.

It has also been shown by Smith (1909) that the angle of the ear can be greatly changed by selection. Within six generations of selecting for upright ears on the one hand, and declining ears on the other, he succeeded in changing the average angle of the ear 168.8 degrees. He found this mainly due to the difference in length of shank. In the declining ears, the shanks were longer, having more nodes and consequently a heavier covering of husks. The yield, according to him, was not markedly affected.

Along this same line Montgomery (1911) says that a long shank is associated with a high actual yield, but a low proportional yield. He found a correlation of $.223 \pm .035$ between the weight of ear, subject and the length of shank, relative.

Both Ewing (1910) and Montgomery (1911) have made more studies but have made very little comment on them. Their results, together with the ones already mentioned are shown in tabular form in the summary (Table XI).

In conclusion of his work along this line Ewing (1910) says: "Considerable study of the subject has forced upon the writer the belief that it is improbable that much use can be made of correlation in practical breeding." "There are" he continues, "rare cases in which the coupling of unit characters may assist the breeder in making selections at an early period, but the existence of correlation in the fluctuating variability of two different characters is not likely to prove of much assistance."

Montgomery (1911) holds very much the same view. In conclusion, he has this to say: "If either high actual yield or high relative yield is regarded as indicating a productive type, then none of the plant characters studied can be regarded as closely enough correlated with productiveness to justify the grower who wishes to select for increased yield in giving much attention to secondary characters of the plant."

MATERIAL

The material for these studies consisted of seventy ears selected from a crib on Boone County White corn. In selecting seven types, with reference to ear shape and indentation, were sought; namely: (a) Long, slim, smooth; (b) long, thick, smooth; (c) short, thick, smooth; (d) medium long, medium thick, medium rough; (e) long, slim, rough; (f) long, thick, rough; and (g) short, thick, rough. Each type or series being represented by ten ears. On being asked, the man from whom this corn was obtained stated that he usually practiced selecting medium ears with reference to size and shape, and slightly rough with reference to indentation, for seed. Other than this, no selection had been made prior to the one mentioned in the beginning.

These seven series were marked by letters - A, B, C, D, E, F, and G, respectively, and the ears numbered from 1 to 10 inclusive within each of the series. Fifteen characters on each ear were recorded as shown in the following tables. Photographs of the remnants of the ears accompany the tables.

Symbols Used in the Following Tables

With reference to "rows straight or twisted":

D - dodged

C - crooked

St. - straight

T. L. - turn to left (looking down ear from butt.)

T. R. - turn to right (looking down ear from butt.)

With reference to "ear shape":

Club. - clubbed

Cy. - cylindrical

P. Cy. - partly cylindrical

P. T. - partly tapering

Tap. - tapering

With reference to "space between rows":

Med. - medium

M. C. - medium close

M. O. - medium open

With reference to "indentation":

B. or Beak. - beaked

Chaf. - chaffy

Med. - medium

M. R. - medium rough

R. - rough

R.-C. - rough to chaffy

R.-B. - rough to beaked

M. S. - medium smooth

S. - smooth

With reference to "kernels per inch":

This refers to the thickness of the kernels as they stand on the cob.

With reference to "composition of the kernels":

H. - horny

M. H. - medium horny

Med. - medium

M. S. - medium starchy

S. - starchy

With reference to "size of germ":

L. - large

M. L. - medium large

Med. - medium

M. S. - medium small

S. - small

With reference to "size of shank":

L. - large

M. L. - medium large

Med. - medium

M. S. - medium small

S. - small

With reference to "shape of butt":

M. F. - medium flat

Med. - medium

M. P. - medium poor

M. R. - medium rounded

Round - rounded

* - shelled

With reference to "character of tip":

C. - covered

P. C. - partly covered

CHARACTER OF EARS IN SERIES "B" - LONG, THICK, SMOOTH TYPE

Ear No.	Length (inches)	Circum. (inches)	No. of rows	Rows at or twisted	Ear shape	Space between rows	Indentation	Kernel width (mm)	Kernel depth (mm)	Kernels per inch	Kernel composition	Size of germ	Size of shank	Shape of butt.	Character of tip.
1	12 $\frac{1}{2}$	6 $\frac{1}{2}$	18	C.	P.T.	M.C.	S.	8	9.5	6	H.	M.L.	M.L.	Poor	Bare
2	10 $\frac{1}{2}$	7	16	T.L.	P.Cy.	M.O.	S.	9	11.5	6	S.	M.S.	L.	Fair	P.C.
3	11 $\frac{1}{2}$	7	16	St.	P.Cy.	Open	Med.	9	12.2	6-7	M.H.	M.S.	L.	F.	P.C.
4	10	7 $\frac{1}{2}$	18	T.R.	Tap.	Open	M.R.	7.3	12.5	7	M.S.	M.S.	M.S.	M.R.	Bare
5	9 $\frac{1}{2}$	7 $\frac{1}{2}$	20	D.	P.T.	Med.	Med.	7.3	12.3	5-7	S.	Med.	Med.	R.	P.C.
6	9 $\frac{1}{2}$	7	22	D.	Tap.	Close	M.S.	7.6	11.4	5	M.S.	M.S.	Med.	*	P.C.
7	9 $\frac{1}{2}$	9	18	T.L.	P.Cy.	Med.	M.S.	7.4	11.3	6-7	M.S.	Med.	M.S.	*	P.C.
8	9 $\frac{1}{2}$	7 $\frac{1}{2}$	18	D.	Tap.	Med.	Med.	9.2	12.3	6	M.S.	Med.	L.	F.	P.C.
9	10	7	20	St.	Tap.	Close	M.S.	7.6	12.0	7	Med.	M.S.	S.	Med.	P.C.
10	8 $\frac{1}{2}$	7 $\frac{1}{2}$	18	T.R.	Tap.	M.O.	S.	9.0	11.4	6-7	S.	S.	Med.	M.R.	P.C.
Av.	10.2	7.1	18.4					8.14	11.6	6.25					

TABLE NO. II.

CHARACTER OF EARS IN SERIES "C" - SHORT, THICK, SMOOTH TYPE.

Ear No.	Length (inches)	Circum. (inches)	No. of rows.	Rows st. or twisted.	Bar shape.	Space between rows.	Indentation.	Kernel width (mm)	Kernel depth (mm)	Kernels per inch.	Kernel composition.	Size of germ.	Size of shank.	Shape of Butt.	Character of tip.
1	8	7 $\frac{1}{2}$	20	C.	P.Cy.	Med.	M.R.	7.8	10.8	6-8	S.	S.	L.	M.P.	Bare.
2	7 $\frac{1}{2}$	7 $\frac{1}{2}$	22	D.	Tap.	Close	M.R.	7.0	11.4	7	S.	M.S.	Med.	Round	C.
3	7 $\frac{1}{2}$	7 $\frac{1}{2}$	22	C.	Tap.	Close	S.	7.4	10.0	6-7	Med.	M.S.	M.L.	Round	C.
4	7 $\frac{1}{2}$	7 $\frac{1}{2}$	20	T.R.	P.Cy.	M.O.	S.	7.6	10.3	7	S.	M.S.	S.	*	Bare
5	7	7	18	T.R.	P.T.	M.O.	M.S.	8.5	11.0	6-7	Med.	M.L.	Med.	Flat	P.C.
6	7	7 $\frac{1}{2}$	20	St.	Cy.	M.O.	Med.	8.5	13.0	6-7	M.S.	S.	S.	Round	Bare
7	7 $\frac{1}{2}$	7 $\frac{1}{2}$	20	C.	P.T.	M.O.	Med.	7.7	12.1	7	S.	S.	S.	Round	Bare
8	7	7 $\frac{1}{2}$	20	D.	P.T.	M.O.	M.S.	8.0	11.4	6	M.H.	S.	S.	Round	Bare
9	6	7 $\frac{1}{2}$	20	St.	Cy.	M.O.	Med.	7.7	13.7	7-8	S.	M.S.	M.S.	M.R.	P.C.
10	6 $\frac{1}{2}$	6 $\frac{1}{2}$	18	St.	P.T.	Med.	S.	8.0	11.2	6-7	S.	M.S.	S.	*	P.C.
Av.	7.0	7.4	20.0					7.82	11.5	6.75					

TABLE NO. III

CHARACTER OF EARS IN SERIES " D " - MEDIUM LONG, MEDIUM THICK, MEDIUM ROUGH TYPE.

Ear No.	Length (inches)	Circum. (inches)	No. of rows	Rows st. or twisted.	Bar Shape.	Shape between rows.	Indentation.	Kernel width (mm)	Kernel depth (mm)	Kernels per inch.	Kernel composition.	Size of germ.	Size of shank.	Shape of Butt.	Character of tip.
1	9½	7	16	St.	P.T.	M.O.	R.	9.0	12.3.	7	S.	M.S.	M.S.	M.F.	P.C.
2	8½	7½	18	T.L.	Tap.	M.O.	R.	8.9	12.7	7	M.S.	S.	L.	M.F.	P.C.
3	9½	7½	18	St.	Tap.	Med.	R.	9.0	11.9	7-8	M.S.	Med.	L.	Round	C.
4	9½	7½	18	St.	P.T.	Close	R.	8.7	12.0	6-7	S.	M.S.	Med.	M.R.	C.
5	9½	7	16	St.	Tap.	M.O.	R.	9.0	12.8	7	M.S.	S.	S.	M.F.	C.
6	9½	7	18	T.R.	P.Cy.	M.O.	M.R.	8.0	11.1	6-7	Med.	M.S.	S.	Flat	P.C.
7	9½	7	16	St.	P.Cy.	M.O.	Med.	8.7	12.9	6-7	Med.	Med.	Med.	M.F.	P.C.
8	9	7½	20	St.	Tap.	M.C.	Med.	7.5	13.0.	6-7	S.	M.L.	Med.	Round.	C.
9	9	7½	16	St.	P.T.	Med.	M.R.	9.4	12.7	7	Med.	M.S.	S.	M.R.	P.C.
10	9½	7	18	T.L.	P.T.	Med.	M.S.	8.2	12.1	7	Med.	M.S.	S.	M.P.	P.C.
Av.	9.2	7.15	17.4					8.6	12.35	6.85					

TABLE NO. IV.

CHARACTER OF EARS IN SERIES "E" - LONG, SLIM, ROUGH TYPE.

Ear No.	Length (inches)	Circum. (inches)	No. of rows.	Rows st. or twisted.	Ear Shape.	Space between rows.	Indentation.	Kernel width (mm)	Kernel depth (mm)	Kernels per inch.	Kernel composition.	Size of germ.	Size of shank.	Shape of butt.	Character of tip.
1	11	7 $\frac{1}{4}$	20	St.	P.T.	M.C.	Beak.	7.5	11.4	6	S.	S.	S.	*	P.C.
2	10 $\frac{1}{2}$	7	14	T.L.	P.T.	M.O.	R.	9.6	11.4	7	M.S.	M.S.	I.	Flat	Bare
3	10 $\frac{1}{2}$	7 $\frac{1}{4}$	18	T.L.	Tap.	Med.	R.-B.	8.0	11.5	6-7	H.	Med.	S.	*	P.C.
4	10 $\frac{1}{2}$	7	20	C.	P.Cy.	Close	R.	8.0	10.0	6-7	M.S.	S.	Med.	Flat	P.C.
5	10 $\frac{1}{2}$	6 $\frac{3}{4}$	16	St.	P.T.	Med.	Med.	9.4	10.3	6	M.S.	S.	M.L.	Poor	Bare
6	10 $\frac{1}{2}$	7 $\frac{3}{4}$	18	T.R.	Tap.	Med.	R.	8.0	9.9	6	S.	Med.	M.S.	M.R.	P.C.
7	10 $\frac{1}{2}$	6 $\frac{3}{4}$	18	St.	P.Cy.	Med.	R.-B.	7.8	10.3	5-6	S.	S.	M.S.	Flat	P.C.
8	10 $\frac{1}{2}$	6 $\frac{3}{4}$	18	T.R.	Tap.	M.O.	R.	7.5	11.8	6	M.S.	Med.	M.S.	*	P.C.
9	10	6 $\frac{3}{4}$	18	T.L.	P.Cy.	Med.	R.-B.	7.6	12.6	6	M.S.	M.S.	S.	Med.	P.C.
10	10	6 $\frac{1}{4}$	16	T.L.	P.Cy.	Med.	R.	8.5	11.5	7	Med.	M.S.	S.	Flat	P.C.
Av.	10.5	7.0 $\frac{3}{8}$	17.6					8.2	11.1	6.25					

TABLE NO. V

CHARACTER OF EARS IN SERIES "F" - LONG, THICK, ROUGH TYPE

Ear No.	Length (inches)	Circum. (inches)	No. of rows.	Rows st. or twisted.	Ear Shape.	Space between rows.	Indentation.	Kernel width (mm)	Kernel depth (mm)	Kernels per inch.	Kernel composition.	Size of germ.	Size of shank.	Shape of butt.	Character of tip.
1	10 $\frac{1}{2}$	7 $\frac{1}{2}$	20	D.	P.Cy.	Med.	R.	8.0	12.0	6-7	M.H.	Med.	M.L.	Round	P.C.
2	10 $\frac{1}{2}$	7 $\frac{1}{2}$	18	T.L.	P.Cy.	M.O.	R.-B.	9.5	12.7	6-7	Med.	S.	Med.	*	P.C.
3	10 $\frac{1}{2}$	7 $\frac{1}{2}$	18	T.L.	P.T.	M.O.	R.	9.0	13.0	7	Med.	S.	Med.	Flat	P.C.
4	10	8 $\frac{1}{2}$	22	T.R.	P.T.	Open	Chaf.	8.8	13.0	6-7	M.H.	Med.	L.	*	P.C.
5	10 $\frac{1}{2}$	8	22	C.	P.T.	M.O.	R.-B.	8.0	12.4	7	S.	S.	L.	M.R.	P.C.
6	9 $\frac{3}{4}$	8	18	T.L.	P.Cy.	Open	R.-B.	9.6	12.6	5-6	M.S.	M.L.	L.	M.F.	P.C.
7	10	7 $\frac{3}{4}$	24	T.R.	Tap.	Clos.	R.-B.	7.0	10.0	6-7	S.	S.	L.	M.F.	P.C.
8	9 $\frac{3}{4}$	7 $\frac{3}{4}$	20	St.	P.T.	Med.	R.-B.	7.5	11.0	7	S.	Med.	Med.	M.R.	P.C.
9	9 $\frac{1}{2}$	8	20	St.	P.T.	M.C.	R.-B.	8.0	12.5	6	M.S.	L.	L.	*	P.C.
10	9 $\frac{1}{2}$	8	16	D.	Tap.	M.O.	Chaf.	9.0	10.3	7-8	S.	Med.	L.	M.R.	Bare
Av.	10	8	19.8					8.4	11.95	6.55					

TABLE NO. VI

CHARACTER OF EARS IN SERIES "G" - SHORT, THICK, ROUGH TYPE.

Ear No.	Length (inches)	Circum. (inches)	No. of rows.	Rows st. or twisted.	Ear Shape.	Space between rows.	Indentation.	Kernel width (mm)	Kernel depth (mm)	Kernels per inch.	Kernel composition.	Size of germ.	Size of shank.	Size of butt.	Character of tip.
1	8½	8½	22	T.L.	P.Cy.	Med.	Chaf.	8.0	11.0	8-9	S.	S.	S.	Round.	Bare
2	8½	8	24	T.L.	P.Cy.	M.C.	Chaf.	7.0	11.6	8	S.	M.S.	M.L.	*	C.
3	8½	7½	20	St.	Tap.	M.O.	R.-C.	7.7	11.7	7	S.	S.	M.L.	Round	P.C.
4	7½	8½	22	D.	Club.	Open	Chaf.	8.0	12.0	7	S.	S.	Med.	Flat	C.
5	7½	8½	20	St.	Tap.	Open	R.	9.0	14.0	5	S.	Med.	M.L.	*	P.C.
6	8	7½	20	St.	Tap.	Med.	R.	8.5	11.5	7	S.	M.S.	M.L.	M.R.	Bare
7	8	7½	20	St.	Tap.	M.O.	R.	7.8	12.5	7-8	S.	M.L.	M.L.	Round	P.C.
8	7½	8	24	St.	P.Cy.	Close	R.-C.	7.0	11.4	7-8	S.	S.	Med.	Round	Bare
9	7½	7½	22	C.	Tap.	M.C.	R.-C.	8.5	11.0	5-8	S.	M.S.	L.	Round	Bare
10	7	7½	18	St.	Tap.	M.O.	R.-C.	8.0	12.4	7	S.	Med.	M.L.	M.R.	Bare
Av.	7.8	7.95	21.2					7.9	11.91	7.10					

TABLE NO. VII

On May 16, 1914 seed from these ears was planted by the ear-to-row method in hills 3 feet 8 inches apart. From 4 to 6 kernels were dropped in a hill, then later thinned to two stalks.

Each row was marked with the same series letter and number as its mother ear. They were planted in the order of the series, that is, series A, 10 rows; B, 10 rows, and so on; every fifth row being a check. These checks were all planted with seed from the same source and used as an index of the unevenness in the character of the soil. (See figure No.1)

During the growing season this corn received ordinary, good cultivation, being harrowed twice and plowed twice each way.

Just about tasseling time a numbered tag was tied on each of forty plants in each row. (Unfortunately this was begun a little too late as some of the plants had tasseled out before the dates could be taken, so the correlations with reference to date of tasseling are omitted.) For this purpose only healthy, uninjured plants growing in a hill with another healthy plant and surrounded on the four sides by healthy hills were selected. Other than this, no selection was practiced so the results are from all kinds of healthy plants under normal conditions. The total number of plants labeled for measurement was 2,800. Each was labeled to show:- (1) its individual number, (2) its row or mother ear number, and (3) the series or type to which its mother ear belonged. For example, A - 1 - 32 indicated stalk number 32, from ear number

1, of series A.

After the stalks were labeled 13 characters on each were recorded as follows: 1, date of tasseling, 2, date of silking, 3, number of tillers, 4, leaf area above the ear, 5, leaf area below the ear, 6, total leaf area, 7, height of upper ear, 8, upper ear node, 9, height of stalk, 10, number of nodes in stalk, 11, circumference of first internode above the ground, 12, circumference of internode above the ear, 13, total tassel length.

The methods of determining the values of these characters are clear with the probable exception of leaf area and total tassel length.

In determining the leaf area of a plant the length of each leaf and its width at the widest point were measured. The area was then calculated by taking $\frac{3}{4}$ of the product of the width and the length, according to the method suggested by Montgomery. This result was then multiplied by 2 to give the area of both sides of the leaf. The area of a leaf as determined by this method may be expressed by the formula,

$$\text{Area} = 2 \times \frac{3}{4}(\text{width} \times \text{length})$$

The total leaf area of the plant was obtained by adding together the area of each leaf.

The tassel length was obtained by finding the sum of the length of five average lateral branches, dividing this sum by five and multiplying the quotient by the number of laterals, then adding to the product the length of the central spike.

$$\left(\frac{\text{Sum of 5 average branches}}{5} \times \text{No. of branches} \right) \text{ plus Central spike}$$

The object of finding the value of this character was to obtain a measure of the relative pollen producing area of the different plants and then determine what effect if any, it has on the yielding quality of the plant.

As soon as the corn was mature the ears from these stalks were gathered and each labeled with a tag, the number corresponding to that of the mother plant. After about six weeks of drying these ears were weighed separately and the shelled corn from each again weighed, thus obtaining the exact yield of grain of each of the stalks measured.

After these data were all collected and all calculations like leaf area, tassel length, etc., were made, they were arranged on 3 x 5 inch cards as is shown below, each card representing a stalk and each number on the card a certain character measurement on that stalk.

Row No. _____		Stalk No. _____		1	2
3	4	5	6	7	
8	9	10	11	12	
13	14	15	16	17	
18	19	20	21	22	
23	24	25	26	27	

The cards were first grouped according to the weight of shelled corn in ounces, one ounce being the factor. Undamaged ears were secured from only about 1750 of the 2800 plants and it is only these plants that are used in the following calculations. The biometrical constants for the frequency distribution within the different types are shown in table No. IX.

The groups for the different series (wts) were then combined and each group again divided with reference to the other characters regardless of the type to which they belonged. The number of individuals falling into the different classes were recorded in the ordinary biometrical way, and the calculations were made by biometrical methods.

In calculating, the decimals were carried to the fourth place. If the fifth place exceeded 5, the fourth was raised one, if it (5th) was 5 or less it was dropped.

DATA

Before proceeding with the discussion of the data, attention is called to the diagram (figure 1) showing the irregularities in the field on which the corn was grown. These are shown by the yields of the different checks, in pounds, the average for all the checks being 36.2 lbs. per row.

The diagram also shows the relative position of the rows over the field. For example, between checks No. 1 and 2 are the four rows, A - 1, A - 2, A - 3, and A - 4, respectively.

Figure 1.

Progeny Compared with Mother Ears.

To get a fair estimate of the influence of the mother ears on the progeny, a man who knew nothing about the character of the mother ears was sent to the field to pick out 25 or 30 representative ears from each series. The following table No. VIII shows how these ears compared with their mother ears in the two measurable characters, length and circumference.

In both cases the progeny behaved very much in accordance with Galton's law of regression. "Average parents tend to produce average offspring; minus parents tend to produce minus offspring; plus parents tend to produce plus offspring; but the progeny of extreme parents, whether plus or minus, inherit the parental peculiarities to a less marked degree than the latter were manifested in the parents themselves."

Figures 2 and 3 show graphically how the progeny ears compare with their mother ears with reference to length and circumference. In figure 2, it will be noted that only in one case - series B - are the average length of the progeny and that of their mother ears on opposite sides of the mean length for the different series. With the exception of series D, the average ear length of the progeny lies closer to the mean than does that of their mother ears.

Comparison of Progeny with the Mother Ears with Reference to Circumference and Length of Ear.

Mother Ears				Progeny			
Series	Number of Ears	Average Length	Average Circum.	Ratio Circum. Length	Number of Ears	Average Length	Average Circum. Ratio Circum. Length
A	10	10.70	6.20	.579	25	8.64	6.36 .736
B	10	10.20	7.10	.696	26	8.01	7.03 .878
C	10	7.00	7.40	1.057	28	7.75	6.95 .897
D	10	9.20	7.15	.777	25	7.97	6.73 .844
E	10	10.50	7.00	.667	25	9.25	6.98 .754
F	10	10.00	8.00	.800	25	8.74	7.21 .825
G	10	7.80	7.95	1.019	26	8.30	7.10 .855
Average				9.34	7.26	8.37	6.91

TABLE NO. VIII

Figure 2

As shown in figure 3, the circumference follows the law of regression about as closely as does the length. In this case there are two series, B and E, in which the average circumferences of the progeny and those of their mother ears are on opposite sides of the mean, but no case where the average circumference of the progeny is as far from the mean as is the average circumference of their mother ears.

The reason for the double curve in each of these graphs is the difference in indentation. As stated earlier in this paper, there were three extreme types with reference to ear shape - long, slim; long, thick; and short thick; and two extreme types with reference to indentation - smooth, and rough.

As regards the indentation, it to some extent, seems to follow the same law. But not being a measurable character, it is hard to state just how near. However, using the two extremes, it can safely be said that the smooth ears generally produced smoother progeny than did the rough ones. But the progeny of the rough type did not vary as much toward the smooth as did that of the smooth toward the rough. This may have been due partially to previous selection practiced by the breeder, from whom the mother ears were secured, his selection being for the medium rough type.

A Frequency Distribution of the weight of shelled corn in ounces per stalk was made for each of the series. The biometrical constants for these distributions are shown in table No. IX and the means graphically shown in figure 4.

Figure 3.

CONSTANTS FOR FREQUENCY DISTRIBUTIONS.

Subject, weight of shelled corn in ounces.

Series	Number of Ears	Mean	Standard Deviation	Coefficient of Variability
A	195	7.7400 ± .1409	2.916 ± .0996	37.67% ± 1.4577
B	228	7.7150 ± .1169	2.619 ± .0827	33.95% ± 1.1898
C	256	8.1836 ± .1209	2.868 ± .0855	35.05% ± 1.3014
D	264	7.9924 ± .1100	2.651 ± .0778	33.17% ± 1.0753
E	256	8.7740 ± .1182	2.803 ± .0836	31.95% ± 1.0451
F	270	8.2741 ± .1190	2.900 ± .0842	35.05% ± 1.1354
G	292	8.2363 ± .1111	2.814 ± .0785	34.17% ± 1.0593
Composite	1761	8.1525 ± .0452	2.815 ± .0320	34.53% ± .4367

TABLE NO. IX

Figure 4.

The highest mean, $8.7740 \pm .1182$ ounces, was found in series E, the long, slim, rough type; and the lowest mean, $7.7150 \pm .1169$ in series B, the long, thick, smooth type. However, these differences follow so closely the variations in the yield of the checks that it seems probable that the soil variations are partially, if not wholly responsible for them.

As to the range of variation there is very little difference, the narrowest being from .5 ounces to 12.5 ounces in series A, the long, slim, smooth type, and B, the long, thick, smooth type. And the widest being from .5 ounces to 16.5 ounces in series E, long, slim, rough type; and F, long, thick, rough type. But this difference is too small to be of any significance.

On the other hand, the highest coefficient of variability, 37.67 ± 1.4577 , is in series A, the long, slim smooth type; and the lowest 31.95 ± 1.0451 in series E, the long, slim, rough type.

The mean for the composite of all the series is $8.1525 \pm .0452$ ounces, the standard deviation $2.8150 \pm .0320$ and the coefficient of variability $34.53 \pm .4367$. If the relatives had been present in all the individuals, these values should have remained unchanged throughout the following correlations. But since from every correlation, a few individuals had to be dropped on account of the lack of a relative value, they vary somewhat as shown in table No. X.

In this table, the first column, headed "Fig. No.", refers to the number of the correlation table to which these values belong.

CONSTANTS FOR SUBJECT FREQUENCIES IN THE FOLLOWING FIGURES:

Figure No.	Number of Bars	Mean	Standard Deviation	Coefficient of Variability
5	1754	8.1585 ± .0451	2.8048 ± .0319	34.3789% ± .4352
6	1609	8.3366 ± .0454	2.7005 ± .0321	32.3933% ± .4236
7	1613	8.3394 ± .0453	2.7005 ± .0321	32.3824% ± .4229
8	1746	8.1609 ± .0455	2.8190 ± .0322	34.5428% ± .4388
9	1741	8.1628 ± .0453	2.8061 ± .0321	34.3767% ± .4369
10	1737	8.1621 ± .0455	2.8130 ± .0322	34.4642% ± .4387
11	1758	8.1474 ± .0453	2.8138 ± .0320	34.5400% ± .4373
12	1759	8.1623 ± .0453	2.8175 ± .0320	34.5184% ± .4274
13	1759	8.1492 ± .0453	2.8141 ± .0320	34.5322% ± .4370
14	1753	8.1503 ± .0453	2.8127 ± .0320	34.5100% ± .4374
15	1519	8.1392 ± .0486	2.8102 ± .0344	34.5267% ± .4702
16	1757	8.1528 ± .0453	2.8182 ± .0321	34.5673% ± .4377
Composite	1761	8.1525 ± .0452	2.8150 ± .0320	34.5300% ± .4367

TABLE NO. X

CORRELATIONS

The discussions of the following figures will be confined mainly to the relatives as the subject, "weight of shelled corn in ounces per stalk," has been pretty thoroughly worked over in the preceding paragraph. The values of the constants of the subject for the various figures are recorded in table No. X.

Weight of Shelled Corn and Date of Silking (figure 5). With the exception of two Sundays and one rainy day, daily observations were made on each stalk during the silking period and the exact date of the appearance of the silks recorded. These dates range from 59 to 83 days after the time of planting, the mean being $67.8962 \pm .0614$ days. The standard deviation and coefficient of variability are: $3.8156 \pm .0434$ and $5.6197 \pm .0640\%$ respectively.

A coefficient of correlation of $-.4181 \pm .0133$ was found, this means a negative correlation of from 40 to 45%. Between the same pair of characters, Ewing (1910) reports a correlation coefficient of $-.202 \pm .-23$. These, to some extent at least, seem to indicate that the earlier silking stalks are likely to produce more corn than are the later ones.

The Weight of Shelled Corn and the Leaf Area Above the Ear (figure 6). In general, the leaf area above the ear ranges from 300 to 2300 square inches (both sides of the leaf) however, one individual out of the 1609 showed an area of 3700 square inches. The mean for this character is 1354.32

0 -	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
59	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	34
60	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	34
61	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	42
62	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	66
63	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	87
64	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	87
65	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	281
66	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	201
67	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	130
68	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	222
69	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	209
70	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	101
71	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	182
72	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	88
73	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	73
74	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	11
75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
76	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10
77	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
78	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
79	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
80	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
81	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
82	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
83	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2

Weight of shelled corn in ounces, subject.
Days to silking, relative.
 $r = -.4181 \pm .0133$

Figure 5

[illegible]

Weight of shelled corn in ounces, subject
Leaf area above the ear in hundreds square inches, relative
 $r = .0885 \pm .0167$.

Figure 6

± 5.03 square inches; the standard deviation, $2.9942 \pm .0356$; and the coefficient of variability, $22.1085 \pm .2754\%$. The coefficient of correlation, $.0885 \pm .0167$, is too small to be of any practical value.

Between the Weight of Shelled Corn and the Leaf Area Below the Ear (figure 7), the coefficient of correlation is less than between the weight of corn and leaf area above the ear, being $.0565 \pm .0167$. The range of leaf area per stalk is about the same as that above the ear, running from 400 to 3200 square inches, one individual out of the 1613 going as high as 3900 square inches, the mean being 1609.73 ± 6.04 square inches which is $255.41 \pm .0101$ square inches greater than the leaf area above the ear. The coefficient of variability was found to be $22.3671 \pm .2786\%$ and the standard deviation $3.6005 \pm .0427$, both of which are very close to the values of the same constants for the leaf area above the ear.

In measuring the leaf area below the ear, there is a much greater chance of error than in measuring that above it, due to the drying, shriveling and whipping off of the lower leaves.

As would be expected, the value of the correlation coefficient between the Weight of Shelled Corn and the Total Leaf Area (figure 8) falls between those of the two preceding correlations. The constants in this case are : Mean 2975.56 ± 7.14 square inches, the coefficient of variability $14.8602 \pm .1733\%$, (the range being from 1500 to 5500 square inches), and the standard deviation $4.4218 \pm .0322$,

	4	6	8	10	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	38-40	Total
0 - 1	1	1	2	4	1	6	2												19
1 - 2			1	4	3	5	7	2	3	1		2							28
2 - 3			1	4	7	6	8	4	3	1									34
3 - 4			1	2	5	11	11	2	3	1	1			1					38
4 - 5			2	6	11	18	11	9	6	2									65
5 - 6			5	7	23	24	16	19					1						95
6 - 7	1	1	4	16	20	35	31	24	15	4	1							1	153
7 - 8	1	1	4	23	46	38	41	35	15	4	2			1					211
8 - 9			6	22	41	63	53	32	24	6	9								256
9 - 10		1	5	22	36	56	51	38	22	7	1								239
10 - 11			6	20	44	45	47	51	26	10	3	1	1						254
11 - 12			1	17	25	22	35	17	7	7	1	1							133
12 - 13				7	4	9	16	7	7	5									55
13 - 14			1	2	4	6	5	2	3	1									24
14 - 15					1		1	1	2	1									6
15 - 16									1										1
16 - 17																			2
Total	2	4	38	154	274	340	340	245	137	50	20	4	2	2	2		1	1	1613

0 -	1 -	2 -	3 -	4 -	5 -	6 -	7 -	8 -	9 -	10 -	11 -	12 -	13 -	13 - 14	14 - 15	15 - 16	16 - 17	Total
14-16	1																	1
16-18				1	1	1	2			1				1				5
18-20				2	1	2	3	4	4	2								18
20-22	1	2	1	2	4	3	3	5	4	2	2	2		1				30
22-24	3	2	3	1	5	9	14	11	13	11	11	3						90
24-26		4	4	3	9	14	25	30	31	27	11	3	3	1				183
26-28	7	3	6	8	10	6	19	43	54	37	28	7		3				280
28-30	5	7	6	10	14	25	21	53	45	51	30	9	1	1				328
30-32	5	4	12	8	10	17	31	34	53	53	23	13	4					309
32-34	6	6	5	6	13	12	23	23	41	32	19	14	3	3		1	1	236
34-36	5	2	4	1	2	2	12	8	26	28	11	6	7	7	2			130
36-38	2	1	4	4	3	7	13	9	9	10	2	3	3	2	1	1		77
38-40	1	1	1			2	2	1	3	5	7	1		1	1			33
40-42	1	1		2		2		1	2	4	4							17
42-44		1					1		2	1								5
44-46								1	1									2
46-48																		
48-50																		
50-52																		
52-54																		
54-56										1								2
Total	36	34	42	45	76	104	170	223	274	254	264	135	56	24	6	1	2	1746

Weight of shelled corn in ounces, subject
 Total leaf area in hundreds square inches, relative.
 $r = .0702 \pm .0161$

Figure 8.

with a coefficient of correlation of $.0702 \pm .0161$. Between these same characters, Montgomery (1911) reports a correlation of $.386 \pm .032$. Along this same line, Ewing (1910) found a correlation of $.292 \pm .021$ between the yield and the length of leaf and $.314 \pm .021$ between the yield and the width of leaf.

Weight of Shelled Corn and the Height of the Stalk (figure 9). A correlation of $.1109 \pm .016$ was found to exist between these two characters. This result is lower than those of either Ewing (1910) or Montgomery (1911) who report a correlation of $.203 \pm .025$ and $.208 \pm .035$ respectively.

The range of the relative in this case is from 85 to 160 inches, the mean being $126.1933 \pm .155$ inches. These measurements are from the ground to the tip of the central spikelet of the tassel. The coefficient of variability was found to be $7.6004 \pm .0869\%$, and the standard deviation $9.5912 \pm .0196$.

Weight of Shelled Corn and Number of Nodes in the Stalk (figure 10). The number of nodes per stalk range from 11 to 19 the mean being $14.916 \pm .0198$, the coefficient of variability $8.2267 \pm .0942\%$ and the standard deviation $1.2271 \pm .0104$. The coefficient of correlation, $.0843 \pm .0161$, obtained from this data is again lower than those reported by Ewing (1910) $.228 \pm .023$ and Montgomery (1911) $.248 \pm .034$.

Weight of Shelled Corn and the Height of the Ear (figure 11). Where there was more than one ear on a stalk, only the height of the upper one was recorded. The range in ear height is from 25 to 85 inches (two stalks produced ears between 110

	85-90	90-95	95-100	100-105	105-110	110-115	115-120	120-125	125-130	130-135	135-140	140-145	145-150	150-155	155-160	Total
0 - 1				1		1	7	6	8	10	2					35
1 - 2					3	2	7	6	6	5	4					33
2 - 3					1	3	4	11	8	10	4					41
3 - 4			1		2	4	5	12	9	7	3	2				45
4 - 5			2		5	3	16	22	10	14	2	1				75
5 - 6		1		1	5	12	20	15	21	17	7	8	2			109
6 - 7		1	2		4	12	26	33	41	30	9	8	3			169
7 - 8				3	6	21	30	38	48	43	13	13	6			221
8 - 9		1	1	4	6	21	33	53	52	45	35	15	7			273
9 - 10		1	2	3	2	21	23	50	45	58	29	13	6	2		255
10 - 11	1		1	1	6	21	29	64	49	55	18	10	7			262
11 - 12				1	2	10	13	26	21	33	13	5	10		1	135
12 - 13					1	2	4	9	9	22	4	4	1			56
13 - 14					1	2	4	3	7	4	2		1			24
14 - 15								1	1	2			1			5
15 - 16										1						1
16 - 17										2						2
Total	1	4	9	14	44	135	221	349	335	358	145	79	44	2	1	1741

Weight of shelled corn in ounces, subject
Height of stalk in inches, relative.
 $r = .1109 \pm .016$

Figure 9

	11	12	13	14	15	16	17	18	19	Total
0 - 1			7	6	13	7	2			35
1 - 2			7	7	7	10	1	1		33
2 - 3		1	7	12	9	10	3			42
3 - 4	1	1	2	18	9	11	2		1	45
4 - 5		1	8	24	17	16	7	1		74
5 - 6		3	9	34	32	25	6			109
6 - 7	1	7	8	51	48	41	8	3		167
7 - 8	1	5	17	65	72	46	13	1		220
8 - 9	1	4	26	70	88	56	24	2	1	272
9 - 10	4	6	18	60	80	64	21	3	1	257
10 - 11	2	4	17	61	94	56	21	6		261
11 - 12		1	8	29	50	28	16	2		134
12 - 13			5	11	19	17	4			56
13 - 14		1	2	3	12	1	5			24
14 - 15					2	3				5
15 - 16							1			1
16 - 17					1	1				2
Total	10	34	141	451	553	392	134	19	3	1737

Weight of shelled corn in ounces, subject
 Number of nodes in stalk, relative.
 $r = .0843 \pm .0161$

Figure 10.

and 115 inches high), the mean being $60.2010 \pm .1352$ inches. The coefficient of correlation, $-.0006 \pm .0161$, is about as near no correlation as one can expect to get. Montgomery (1911) reports a positive correlation of $.211 \pm .035$ between this pair of characters.

The Coefficient of variability is $13.9600 \pm .1618$ and the standard deviation $8.4061 \pm .0956$.

Weight of Shelled Corn and the Ear-node (figure 12). The ear-node ranges from the 7th to the 11th node above the ground, the mean being $7.5406 \pm .0152$. The coefficient of variability is $12.5415 \pm .1783\%$ and the standard deviation $.9457 \pm .017$. The coefficient of correlation, $.0340 \pm .0161$ in this case is too low to be considered of any value at all. Montgomery (1911) reports a correlation of $.205 \pm .035$ between this pair of characters.

Weight of Shelled Corn and the Circumference of the First Internode Above the Ground (figure 13). To get a fair estimate of the size of the stalk the circumferences of the first internode above the ground and above the ear were measured. The circumference of the first internode above the ground varies from 1.75 to 5.25 inches, the mean being $3.7167 \pm .0089$ inches. The coefficient of variability is $11.6474 \pm .1342\%$ and the standard deviation, $.4329 \pm .0049$. The coefficient of correlation is $.1846 \pm .0155$.

The Weight of Shelled Corn and the Circumference of the Internode Above the Ear (figure 14). The correlation existing between the weight of shelled corn and the circumference

0 - 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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Weight of shelled corn in ounces, subject
Height of upper ear in inches, relative.
 $r = -.0006 \pm .0161$

Figure 11.

	4	5	6	7	8	9	10	11	Total
0 - 1		1	5	11	16	3			36
1 - 2	1		4	15	9	4	1		34
2 - 3		1	1	15	23	2			42
3 - 4		3	4	18	15	3	1	1	45
4 - 5			9	31	25	8	3		76
5 - 6		1	15	45	39	12	1		113
6 - 7		4	19	58	62	23	3	1	170
7 - 8		3	22	82	74	38	4		223
8 - 9		2	31	105	97	32	7		274
9 - 10		1	31	87	100	37	1		257
10 - 11	1	1	24	116	86	32	5		265
11 - 12			19	35	65	15	1		135
12 - 13			4	16	32	4			56
13 - 14			2	13	5	4			24
14 - 15				2	2	2			6
15 - 16							1		1
16 - 17				1	1				2
Total	2	17	190	650	657	219	28	2	1759

Weight of shelled corn in ounces, subject
 Ear-node, relative.
 $r = .034 \pm .0161$

Figure 12.

	1.75-2.00	2.00-2.25	2.25-2.50	2.50-2.75	2.75-3.00	3.00-3.25	3.25-3.50	3.50-3.75	3.75-4.00	4.00-4.25	4.25-4.50	4.50-4.75	4.75-5.00	5.00-5.25	Total
0 - 1					2	4	5	7	12	4	1	1			36
1 - 2						5	7	9	7	4	2				34
2 - 3			2		5	4	9	10	6	4	2				42
3 - 4				1	4	2	8	6	13	5	1	3	1		44
4 - 5					9	10	12	17	18	7	2	1			76
5 - 6					7	17	23	27	21	12	3	2		1	113
6 - 7				1	3	23	50	27	25	27	9	3	1	1	170
7 - 8					8	23	58	42	55	20	11	3	2	1	223
8 - 9				2	14	22	60	54	60	37	16	9	1		275
9 - 10					7	14	54	54	59	41	16	10	1		256
10 - 11	1				3	14	44	58	69	36	25	14	4		265
11 - 12					3	6	26	22	36	23	11	7	1	1	136
12 - 13			1			2	8	10	13	10	10	1		1	56
13 - 14						3	2	3	5	6	3	1	1		24
14 - 15									3		2	1			6
15 - 16												1			1
16 - 17									1			1			2
Total	1	3	4	65	149	363	346	403	236	114	58	12	5		1759

Weight of shelled corn in ounces, subject
Circumference of internode above ground in inches,
relative.
 $r = .1846 \pm .0155$

Figure 13.

of the internode above the ear, $.0893 \pm .016$, is less than that existing between the first internode above the ground and the yield. The range of variation is also somewhat less, being from 1.75 to 4.50 inches with a mean of $2.8167 \pm .0057$ inches. The coefficient of variability is $12.5785 \pm .1455$ and the standard deviation $.3543 \pm .0040$.

The Weight of Shelled Corn and the Tassel Length (figure 15). If the spikelets of the tassel were fastened end to end, the length would vary from 40 to 520 inches, with a mean of $240.9546 \pm .2838$ inches. The standard deviation, $16.3961 \pm .1920$ is the largest of all the characters measured. The coefficient of variability is $6.0464 \pm .0740$. There seems to be a slight negative correlation between the pollen producing and the corn producing qualities of a stalk of corn. The coefficient of correlation found from this data is $-.1251 \pm .017$. This result agrees favorably with that of Ewing (1910 who found a correlation of $-.009 \pm .048$ between the number of branches in the tassel and the yield.

The Weight of Shelled Corn and the Number of Tillers (figure 16). The number of tillers seemed to be rather small this year, ranging from 0 to 4 with a mean of $.4320 \pm .0113$. This obviously lowers the standard deviation $.7049 \pm .0080$ very much, and at the same time the low mean causes an exceedingly large coefficient of variability, $163.1713 \pm 4.6692\%$. The coefficient of correlation $-.1060 \pm .0160$ shows an exceedingly small negative correlation.

	1.75-2.00	2.00-2.25	2.25-2.50	2.50-2.75	2.75-3.00	3.00-3.25	3.25-3.50	3.50-3.75	3.75-4.00	4.00-4.25	4.25-4.50	Total
0 - 1	1	4	8	10	8	3	2					36
1 - 2			3	7	11	7	1	2	1	1		33
2 - 3		2	11	11	7	6	3	1	1			42
3 - 4		2	10	8	12	6	1	3	2	1		45
4 - 5	1	3	18	17	23	7	6	1				76
5 - 6	3	6	18	37	26	16	2	4				112
6 - 7		8	27	45	55	17	16	1		1		170
7 - 8	3	13	29	77	62	23	10	4	2			223
8 - 9	3	9	42	71	77	47	21	3	2			275
9 - 10	3	6	24	73	76	42	14	12	4			254
10 - 11		4	27	65	81	58	22	6	1			264
11 - 12		2	13	30	43	31	10	4	2			135
12 - 13			4	8	18	17	4	3	1			55
13 - 14			2	6	11	3	1	1				24
14 - 15				2	2	2						6
15 - 16					1							1
16 - 17					1	1						2
Total	13	56	232	465	516	291	114	47	16	2	1	1753

Weight of shelled corn in ounces, subject
Circumference of internode above ear in inches,
relative.
 $r = .0893 \pm .016$

Figure 14.

Weight of shelled corn in ounces, subject
 Total tassel length in inches, relative.
 $r = -.1251 \pm .017$.

0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13	13 - 14	14 - 15	15 - 16	16 - 17	Total	
1	1	1	1	1	2	1	1	2	1	3	1	1	2	1			1	1519
1																	1	
1																	1	
1																	1	
1																	3	
1	1																7	
1																	13	
2			1														23	
2	1		1														44	
2	3		1														63	
3	1	1	1														96	
3	1	4	6														127	
5	3	7	6														160	
2	8	2	8														184	
4	3	5	7														218	
2	1	6	3														199	
3	2	3	4														148	
3	3	2	1														103	
1	1																73	
1	1	1	1														30	
1																	13	
																	8	
																	3	
																	1	
																	2	
																	1519	

Figure 15.

	0	1	2	3	4	Total
0 - 1	25	5	6			36
1 - 2	24	4	4	2		34
2 - 3	30	11	1			42
3 - 4	29	8	7	1		45
4 - 5	51	21	4			76
5 - 6	86	18	8	1		113
6 - 7	115	34	16	3	1	169
7 - 8	139	59	20	4		222
8 - 9	172	74	23	6		275
9 - 10	180	59	14	1	1	255
10 - 11	183	65	15		2	265
11 - 12	87	35	11	3		136
12 - 13	43	12	1			56
13 - 14	17	5	2			24
14 - 15	4	1	1			6
15 - 16	1					1
16 - 17		1	1			2
Total	1186	412	134	21	4	1757

Weight of shelled corn in ounces,
subject

Number of tillers, relative.

$r = -.0160 \pm .0160$

Figure 16.

SUMMARY

1. The object of the experiment was to find what, if any, vegetative characters are correlated with the yield.

2. The problem was handled by the biometrical method.

3. In the seed ears, four types - long, slim; long, thick; medium long, medium thick; and short thick types were represented with reference to ear shape; and three types - smooth, medium, and rough - with reference to indentation.

4. Nineteen characters were recorded on each of 2800 plants from these ears.

5. The progeny ears of these ears behaved very much in accordance with Galton's law of regression with reference to their length and circumference, and to some extent with reference to their indentation.

6. The weight of shelled corn per stalk ranged from 0 to 16.5 ounces, the mean being $8.1525 \pm .0452$ ounces.

7. The mean values for the following characters were found to be:

Character	Mean
Days to silking	$67.8962 \pm .0614$ days
Leaf area above the ear	1354.32 ± 5.03 square inches.
Leaf area below the ear	1609.73 ± 6.04 square inches.
Total leaf area	2975.56 ± 7.14 square inches.
Height of stalk	$126.1933 \pm .1550$ inches.
Ear-node	$7.5406 \pm .0152$
Number of nodes in stalk	$14.916 \pm .0198$
Height of ear	$60.201 \pm .1352$ inches

Character	Mean
Circumference of inter-node above ground	3.7167 ± .0089 inches.
Circumference of inter-node above the ear	2.8167 ± .0057 inches.
Length of tassel	240.9546 ± .2838 inches.
Number of tillers	.4320 ± .0113

8. Using the weight of shelled corn as subject, the following correlations were found:

Relative	Coefficient of Correlation
Days to silking	-.4181 ± .0133
Leaf area above ear	.0885 ± .0167
Leaf area below ear	.0565 ± .0167
Total leaf area	.0702 ± .0161
Height of stalk	.1109 ± .0160
Number of nodes in stalk	.0843 ± .0161
Height of ear	-.0006 ± .0161
Ear-node	.0340 ± .0161
Circumference of inter-node above ground	.1846 ± .0155
Circumference of inter-node above ear	.0893 ± .0160
Length of tassel	-.1251 ± .0170
Number of tillers	-.0160 ± .0160

9. The following table, No. XI, shows how the results obtained here compare with those of Ewing (1910) and Montgomery (1911).

TABLE NO. XI

RESULTS OF THREE STATIONS - CORNELL, NEBRASKA, & MISSOURI.

(Yield of grain subject in each case.)

Relative	Cornell (1910)	Nebraska (1911)	Missouri (1915)
Diameter of stalk	.393 ± .020		
Length of leaf	.292 ± .021		
Breadth of leaf	.314 ± .021		
Height of stalk	.203 ± .025	.208 ± .035	.1109 ± .016
No. of internodes	.228 ± .023	.248 ± .034	.0843 ± .0161
Av. length of "	-.004 ± .027		
% of internodes below ear	.025 ± .024		
Days to tasseling	-.153 ± .023		
Days to pollen	-.090 ± .024		
Days to silk	-.202 ± .023		-.4181 ± .0133
Branches on tassel	-.009 ± .048	(length)	-.1251 ± .017
Total leaf area		.386 ± .032	.0702 ± .0161
Leaf area below ear			.0885 ± .0167
Leaf area above ear			.0565 ± .0167
Weight of plant		.874 ± .010	
Height of ear		.211 ± .035	-.0006 ± .0161
Ear-node		.205 ± .035	.0340 ± .0161
Length of shank		.223 ± .035	
Circumference of internode above ground			.1846 ± .0155
Circumference of internode above ear			.0893 ± .0160
No. of tillers			-.0160 ± .0160

CONCLUSION

From the results obtained here and those of other men who have investigated the subject, the answer to the question, "Are there any vegetative characters in the plant growth that may serve as indices to the yielding quality of the plant?" must undoubtedly be answered in the negative, for the characters so far studied.

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5-18-1915.

Dean Walter Miller,
Chairman Graduate Committee,
Academic Hall.

My dear Dean Miller:-

In accordance with your request,
I have carefully examined the dissertation of Mr. C. E. Neff
on "Some Correlation Studies on Maize". In my opinion, this
dissertation meets the established standard for the Master's
dissertation.

Very truly yours,

I. F. Lewis

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