CORRELATIONS OF SEVERAL MORPHOLOGICAL CHARACTERS AND DETERMINATION OF SOURCES OF VARIATION IN CORN PLANTED AT TWO LOCATIONS

By

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INTRODUCTION

Data concerning the correlation of the different vegetative characters of corn are limited. Although there have been many speculations as to the relationship between some of the characters such as ear height and date of maturity, few pertinent studies have actually been conducted. If certain of these vegetative characters could be shown to have a high correlation with maturity, yield, or other desirable agronomic characters, this information would be of considerable benefit to the corn breeder.

Much of the early corn breeding work was centered around various types of selection--the most prevalent of these types being mass selection and ear-to-row selection. Up to this time, little has been done to compare the relative efficiency of these two methods.

The purposes of this study are twofold. The first objective is to determine the relationship of certain vegetative characters to maturity in corn grown at two locations. In connection with this purpose, correlations will be presented which are concerned with morphological characters such as node number, plant height, and ear height as they relate to plant maturity and to each other. The second objective is to attempt to determine the size of the variation in regard to the characters mentioned above associated with families, progeny, and individual plants. It is hoped that information gained from this study utilizing data from two locations will give some basis for evaluating the efficiency of certain selection procedures.

REVIEW OF LITERATURE

Studies of Maturity and Certain Morphological Characters of Corn

Date of Pollen Shed and Date of Silk

According to Kiesselbach (12)[1] unfavorable climatic conditions have a greater effect upon delay of ear development than upon tassel development. Hayes and Johnson (9) using inbred lines, indicated that there was a strong correlation between date of silk and yield. It was further shown that silk date was correlated with plant height and ear height.

Plant Height

Hayes and Johnson (9) found plant height and ear height closely correlated. Kiesselbach (14) reported that late maturing varieties of corn tend to grow much taller than early maturing varieties. He showed that this added height was the result of long continued growth, rather than rapid growth. Smith (24) observed that high plants have more nodes and longer internodes than shorter plants. Morrow and Gardner (20) found that in general the height of both stalk and ear was increased with late maturity. In studies of variability of plant height in five open-pollinated varieties of corn, Russell (23) found that the

[1] Figures in parentheses refer to "Selected Bibliography", page 31.

coefficient of variation ranged from 8.39% to 11.15%. The standard deviation for this character ranged from 7.72 to 8.94.

Ear Height

According to Kiesselbach (12), several of the adaptive characters of corn seem to show close association. These characters are: small structure, ears low on the stalk, small leaf area, slender ears, and smooth shallow kernels. His five-year study of continuous selection in opposite directions, ears high on the plant versus ears low on the plant, resulted in a spread of 23% in ear height and a corresponding spread of 10% in stalk height.

Smith (24) using the Leaming variety of corn produced, by ear-to-row selection in opposite directions, two strains of corn which differed widely in ear height. One selected strain bore the ears three feet higher than the other. He also found low ears associated with early maturity. Conclusions from experiments conducted at the Ohio Agricultural Experiment Station were that low ears are associated with earliness, according to Williams and Welton (31). In studies on ear placement, Montgomery (18) noted that there was little association between ear placement and yield; however, the plants with lower ears were smaller and the corn matured earlier.

Eckhardt and Bryan (2) using crosses between several different inbred lines, showed that, when two inbred lines from the same variety were combined in each single cross parent, variances of ear height were significantly reduced. Stringfield (29) indicated that maturity of a corn variety can be changed by selecting for low or high ears. In studies on variability of ear height, Russell (23) found that the coefficient of variation for five open-pollinated corn varieties ranged from 15.90% to 18.13%. Correlation summaries of nodes below the ear and nodes above the ear indicated that the relative position of the ear did not affect the number of nodes per plant.

Number of Nodes

It was speculated by Leng (15) that there might be a correlation between leaf number and the time for a plant to begin tassel initiation. He noted that early strains of corn have a much lower leaf number than late ones. In studies with inbred lines R53, WF9, and L317, this speculation was not confirmed. R53, the earliest line, had the lowest leaf number; while WF9, the next earliest variety, had the highest leaf number and L317, the latest line, had an intermediate leaf number.

Kiesselbach (13) noted that the total number of leaves formed by an individual corn plant varies both within and between varieties. He also pointed out that one leaf is formed for each node on a plant. Stringfield (29) observed that ear-node height was not inherited as a dominant. Smith (24) indicated that plants with higher ears have more and longer internodes than plants with lower ears. Emerson and East (3) indicated that the number of nodes is greatly affected by heterozygosis. In F_1 families, the mean number of nodes was intermediate between the number of nodes of the two parents used. This mean number did not change greatly in the F_2. There was a lack of correlation between number of nodes and physiological characters, but there was an apparent genetic correlation between these characters.

Russell (23) found that for five varieties of corn, the coefficients of variation were nearly the same for number of nodes below the ear. Coefficients for all varieties ranged between 11.10% and 12.64%. The variation among the five coefficients for nodes above the ear ranged from 12.15% to 15.14%. This study showed that the number of nodes below the ear was negatively correlated with the number of nodes above the ear.

Morphological Characters in General

Emerson and East (3) emphasized that if an inert character could be determined by counting or weighing another visible character, it would be of great benefit to the plant breeder. Etheridge (4) stated that within limits there is no one character of a normal healthy plant which can be used as an index to determine the relative yielding ability of its progeny.

Ewing (5) in 1910 concluded that, "no experimental evidence is available regarding the effect of selection of one character on a correlated character." Tests by Hayes and Alexander (7) in 1924 indicated that the chief difference between high and low yielding rows in ear-to-row tests was dependent upon characters which in general were correlated with vigor of growth.

Evaluation of Certain Methods of Selection

Sprague and Brimhall (27) in a 1950 report, list the following as important items in determining the effect of selection: heritability, size of sample, and gene frequency. In studies made by Sprague (28), the differences recognized in two systems of selection, mass and ear-to-row, were as follows:

Mass Selection	Ear-to-row Selection
1. No isolation	1. Isolation
2. No progeny test	2. Progeny tests

3. Limited selection differential

3. Maximum selection differential

According to the information presented by Sprague (28), mass selection began with the domestication of corn. He reported that this practice was begun by selecting large ears for seed, and never has advanced much beyond that stage.

The ear-to-row selection procedure was begun by Hopkins (10) at the University of Illinois in 1896. This method involved the selection of several phenotypically desirable ears, and the evaluation of these ears by means of progeny tests.

Wallace and Bressman (30) observed that nearly all of the early work in corn breeding was accomplished by means of mass selection. They also emphasized the influence of the early corn shows upon mass selection goals. In this type of selection, the chief aim was toward uniformity without much consideration for yield. Montgomery (19) in his comparison of ear-to-row selection with mass selection found that more rapid results could be obtained by the ear-to-row selection method than with the general mass selection method. He stated that it might be possible that no increase in yield would result from mass selection, unless some vegetative character were closely associated with yield. Whereas in the ear-to-row method, the yield record could be obtained from previous years.

In tests involving ten years of selection, the following conclusion was reached by Smith and Brunson (25): "The simple method of mass selection, that is picking seed ears from standing stalks in the field, is just as effective in improving yield as the more complicated method of continuous ear-to-row selection." It was further stated by these workers that the improvement of a variety by selection is brought about by decreasing the low yielding strain. However, Hayes (8) reported that, as a rule, corn cannot be improved by mass selection methods.

In studies regarding ear placement of corn, Montgomery (18) noted that ear-to-row selection was effective in changing ear height; and that yields could be slightly increased by this method. Williams and Welton (31) also noted that ear height can be changed by this method. In experiments conducted by Smith (24), ear placement was changed as much as three feet by ear-to-row selection methods. It was concluded from these experiments that corn would give a definite response to selection.

Hartley (6) in work using the ear-to-row selection method, discovered that selected ears that look very similar, phenotypically can differ as much as 50-75% when their progeny are observed in separate plantings. Jenkins (11) reported in 1936 that ear-to-row selection was very effective in adapting a variety to a particular location, but that this method of selection seemed to have little effect over a long period of time.

Woodworth, Leng, and Jugenheimer (33) summarized the results of fifty years of selection for oil and protein content of corn. The basic design for their experiments was the ear-to-row selection method, although there were some modifications during the fifty years. The percentage of oil content began at a mean of 4.70%; and after fifty years of selection for high oil content, a resultant mean of 15.36% was obtained. As a consequence of selection in the opposite direction, oil content was reduced to 1.01%. The mean protein percentage started at 10.92% and was increased to 19.45% when selected for high content. The reverse selection procedure resulted in a protein content of 4.91%.

Little progress was made in this selection during the past ten to fifteen years, due to the accumulation of mutations in the low oil strains which caused germless seed. In 1948, reverse selection procedures on the high strains resulted in reducing the oil and protein content of the high strains, indicating that these lines may still possess some genetic variation.

Sprague (28) summarized the ear-to-row method of selection for yielding ability. He indicated that the method often had been discredited, not because of genetic limitations, but because of field plot technique.

MATERIALS AND PROCEDURES

Materials

The variety of corn designated as Accession 183 Single Cross was used exclusively in this study. This variety which originated at the Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma, was obtained by selfing the F_1 single cross of K4 X Ok.11, a corn belt line times an Oklahoma line. The actual material used was the selected progeny of the F_3 of the K4 X Ok.11 cross.

A duplicate planting of seed from fifty ears representing ten families and five progeny from each family was planted at each of two locations; so that seed from the original fifty ears would be equally represented at the two different locations. The fifty ears used in this study were derived by selecting five high yielding ears from each of twenty different maternal rows, which in turn had been selected from the F_2 of the above cross by simultaneous selection for ten characters. The progeny of only ten of these maternal rows was used; these ten were selected at random from the twenty.

The plants at location one were grown under irrigation on the Oklahoma Agricultural Experiment Station Agronomy Farm. The second series of plants was grown under dry land conditions at location two, near the Paradise Community nineteen miles southwest of Stillwater, Oklahoma. Provision was made for adequate border rows. The material for each location was planted on soil containing the maximum available uniformity. The plantings at Paradise were made on May 28, 1957, and the Stillwater plantings were made on June 17, 1957.

Procedures

Cultural Procedures

The plantings at each location were divided into two replications, each representing a randomized block. Each block contained a one row plot from each of the fifty ears being studied. The plantings at Stillwater were made in twenty foot, one row plots. The seeds were drilled at approximately six-inch intervals, and subsequently were thinned to average ten plants per plot.

At Paradise the plants were planted in rows fifteen hills long with the hills spaced forty inches apart. Three seeds were planted per hill, and later they were thinned to one plant per hill. The reason for the wider plant spacing used at Paradise in comparison with that described for Stillwater was that under dry land conditions, it was necessary to avoid interplant competition for moisture and nutrients and to give each plant the maximum opportunity for expressing its genotype.

Within each replication at each location the data were recorded on successive plants, so as to average about ten plants per plot. A total of 896 plants were studied at Stillwater; and 1,226 plants were studied at Paradise.

Measurements Taken

For the purposes of this study, individual plant observations on ten variable characters of corn were taken. These measurements were: date of pollen shed, date of silk, total actual leaf number, plant height, ear height, estimated number of nodes below the ear, number of nodes above the ear, plant score, actual number of nodes below the ear, and total estimated nodes. All observations of the the above mentioned characters, with the exception of the measurements concerning date of pollen shed and date of silking, were made when the plants had reached the stage of full vegetative development.

Date of pollen shed was determined when the central axis of the tassel first began to shed pollen. At this time a blue tag bearing the date of this observation was stapled around the top part of the plant. The date was recorded using a day number beginning with the first day of June as number one.

Date of silk was recorded as the time when silks first emerged from the shoot and were visible. A pink tag was stapled around the plant near the shoot. This tag was dated in the same manner as was described above for date of pollen shed.

Total leaf number is used in this study as the actual number of nodes for each plant. Since there is a leaf produced for each node, this total leaf count would give the total number of nodes per plant. In order to determine the exact number of leaves per plant, special procedures must be used since at the time the topmost leaf of the plant appears, the bottom four to six leaves have been destroyed by the growth of adventitious roots or by some climatic factor or cultural practice. The third leaf of the young seedlings used in this study was clipped about one and one-half inches from its tip with a common pair of household pinking shears. This procedure left a leaf with a jagged edge which could be seen easily. Each of the individual plants was successively clipped in the sixth and ninth leaf stage. Thus at the time of full vegetative development of the plant, by starting at the ninth leaf, one could determine the total leaf number for each plant.

Plant height was measured in inches from the ground level to the base of the tassel.

Ear height also was measured in inches from the ground level to the ear-bearing node. Where two or more ears appeared on one plant, height to the upper ear was measured.

Estimated number of nodes below the ear was determined by counting from the first leaf above the ground to the upper ear-bearing node.

Number of nodes above the ear was determined by counting the leaves above the top ear.

A plant score ranging from one to five was given to each plant, with one denoting the best possible score. This plant score was based upon general vigor, conformation of the plant, and freedom from disease.

Actual number of nodes below the ear was determined by subtracting the number of nodes above the ear from the total counted number of leaves.

Total estimated nodes was obtained by adding the estimated number of leaves or nodes below the ear and the actual number of leaves or nodes above the ear.

Climatic Conditions and Biotic Factors Prevalent

During the first part of the growing season the plants at Paradise were over supplied with moisture; however, by flowering time they showed the effects of dry weather stress. This dry condition resulted in near failure of grain production.

Plants at Stillwater were supplied with plenty of moisture throughout their growing season; but even with repeated applications of chemicals, their grain production was impaired by the corn ear worm and the fall army worm.

Method of Presentation of Data

After all data were recorded, a complete set of simple correlations was run for the ten variables previously mentioned. The two replications at each location were pooled resulting in two sets of correlations, one for each location.

Analysis of variation was computed for each replication within each location. The analyses of variance for the two replications at each location were pooled. The variances associated with the components--family, progeny, and individual plants--were separated according to procedures shown in Table I, page 14. Mean squares, standard deviations, and means were derived for each of the characters at each location.

TABLE I

FORM OF THE ANALYSIS OF VARIANCE

Stillwater

Source of Variation	D.F.	Component of Variance
Family	9	$s^2 + 8.96s^2p + 44.80s^2f$
Progeny	40	$s^2 + 8.96s^2p$
Individual Plant	796	s^2

Paradise

Source of Variation	D.F.	Component of Variance
Family	9	$s^2 + 12.26s^2p + 61.30s^2f$
Progeny	40	$s^2 + 12.26s^2p$
Individual Plant	1126	s^2

Key to Table

s^2 = variance between individual plants
s^2p = variance between progeny
s^2f = variance between families

RESULTS AND DISCUSSION

Correlations

Simple correlation coefficients were computed for the following ten characters of corn which are known to be variable:[2] date of pollen shed, date of silk, total actual leaf number, plant height, ear height, estimated nodes below the ear, nodes above the ear, plant score, actual nodes below the ear, and total estimated nodes. A complete set of correlation coefficients was computed relating each variable to each of the other variables. The resultant forty-five correlation coefficients for each location are tabulated in Table II, page 16. Only the correlation coefficients which seem to have direct bearing upon the purposes outlined for this study will be discussed. No distinction as to the cause of any correlation will be made.

Maturity as Determined by Date of Pollen Shed and Date of Silk

Data in Table II show a highly significant correlation between the date of pollen shed and the date of silk, .818 and .748 for the two locations. This correlation is to be expected, since both factors are measures of plant maturity and are physiologically closely associated.

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[2]Key to Characters for Table II, page 16.

1.	Date of Pollen Shed	6.	Estimated Nodes Below Ear
2.	Date of Silk	7.	Nodes Above Ear
3.	Total Actual Leaf Number	8.	Plant Score
4.	Plant Height	9.	Actual Nodes Below Ear
5.	Ear Height	10.	Total Estimated Nodes

TABLE II

SIMPLE CORRELATION COEFFICIENTS FOR TEN VARIABLE CHARACTERS OF CORN[3]

Vari-ables	2	3	4	5	6	7	8	9	10
1	.818 .748	.306 .206	-.019 .079	.007 -.096	.159 -.046	.036 .194	.149 .236	.287 .118	.253 .065
2		.290 .179	-.023 .052	-.038 -.149	.130 -.095	.102 .207	.161 .257	.238 .078	.247 .032
3			.272 .379	.323 .351	.265 .363	.259 .400	-.062 -.089	.873 .840	.501 .539
4				.712 .703	.111 .356	.230 .245	-.399 -.271	.156 .266	.326 .444
5					.272 .593	-.086 -.102	-.286 -.281	.367 .435	.376 .453
6						-.080 -.087	-.055 -.145	.305 .438	.437 .816
7							-.073 .075	-.235 -.149	.486 .500
8								-.027 -.137	-.131 -.082
9									.262 .288

The upper coefficient of each pair refers to the Paradise Location. The lower coefficient of each pair refers to the Stillwater Location.

.062 Significant at 5% Level
.081 Significant at 1% Level

[3] Key to Characters for Table II given in footnote [2], page 15.

There seems to be a slightly significant difference between the correlation values for date of pollen shed and date of silk at the two locations; but this difference could be attributed to delay of the silk appearance for plants at Stillwater by corn ear worm damage.

In contrast to the findings of earlier workers, Kiesselbach (14), and Smith (24), it was not demonstrated by this study that plant height is significantly correlated with date of maturity, using pollen shed date and silking date as an index to maturity. If plant height were correlated with date of maturity in Accession 183, it had ample conditions to be shown, since the range in plant height obtained through this study varied considerably between plants within each location.

A lack of correlation is shown between ear height and date of maturity, as measured by pollen shed and silk date. This again is contrary to what has been shown by early workers, Smith (24) and Montgomery (18). Although there is as much as ten days difference in the dates of maturity within each location, ear height does not seem to be closely associated with this factor. In fact at Stillwater, a small but significant negative correlation is indicated.

The correlation coefficient between the two maturity measures and total actual nodes is significantly positive. This correlation is of such degree that it could possibly be of some value in predicting maturity when the variable, total actual nodes, is used in conjunction with other characters.

Estimated total node count, the determination of which requires considerably less labor than the actual node count, also shows a significant correlation for both date of pollen shed and date of silk at the Paradise location. But at the Stillwater location, estimated node count was not significantly correlated with maturity. This low correlation value could be attributed to cultivation methods, since several of the bottom nodes at this location were covered in the process of making irrigation furrows. In any case, the number of leaves derived by estimation seems to be less reliable in predicting plant maturity than is the actual leaf or node count.

The actual number of nodes below the ear which is part of the total actual node count, also shows a positive correlation to the factors determining maturity. The estimated number of nodes below the ear which reflects part of the total estimated nodes, shows a significant positive correlation with date of maturity at the Paradise location; but this correlation does not hold true for the Stillwater planting.

Maturity, as measured by date of pollen shed and date of silk, is significantly correlated with nodes above the ear at Stillwater, but show some inconsistency at the Paradise location.

Plant Height

Plant height was found to be highly correlated with ear height at both locations, .712 for Paradise and .703 for Stillwater. This result is in agreement with others who have studied these two characteristics. In this study it also was observed that plant height is significantly correlated with both actual leaf number and estimated leaf number. Either the actual or estimated node number, therefore, should be an aid in the prediction of plant height. Plant height is correlated with the number of nodes below the ear, as well as with the number of nodes above the ear.

Ear Height

Ear height was found to be positively correlated with both actual and estimated total node number and with actual and estimated nodes below the ear, but it has a negative correlation with nodes above the ear.

Number of Nodes

Table II shows both actual and estimated number of nodes below the ear to be negatively correlated with nodes above the ear, which is in agreement with the findings of Russell (23). Other significant node correlations have been noted in connection with previously discussed characters.

Mean Values

Data in Table III, page 20, show a wide spread in the average date of maturity, as measured by date of pollen shed and silk date. This difference in means is attributed to the wide spread in planting date at the two locations. Seed were planted on May 28, 1957, at Paradise and on June 17, 1957, at Stillwater.

The mean total leaf number at both locations is almost the same, 21.74 for Stillwater and 21.58 for Paradise. This similar value is expected, since node number is thought to be independent of environmental influence and, therefore, would not be affected by a difference in planting dates or by other variations in growing conditions.

Plant height has a mean difference of 4.73 inches between the two locations, the Stillwater location having the tallest plants. This added height for Stillwater plants can be attributed to an enhancement of growing conditions through the use of irrigation.

TABLE III

POPULATION MEAN AND STANDARD DEVIATION

FOR TEN VARIABLES

Variable	Location			
	Stillwater		Paradise	
	Mean	σ	Mean	σ
1. Date of Pollen Shed	74.60**	3.13	66.58**	3.23
2. Date of Silk	76.72**	4.38	67.83**	3.28
3. Total Leaf Number	21.74	1.52	21.58	1.52
4. Plant Height	68.57*	9.81	63.84*	7.23
5. Ear Height	30.16*	6.66	32.27*	5.26
6. Estimated Nodes Below Ear	8.20	1.18	8.89	1.03
7. Nodes Above Ear	6.78	0.82	6.67	0.75
8. Plant Score	2.33***	0.77	2.05***	0.59
9. Actual Nodes Below Ear	14.96	1.41	14.91	1.51
10. Total Estimated Nodes	14.98	1.35	15.55	1.27

All measures are expressed in unit numbers, except the following:
* Inches
** Days, beginning with June 1, 1957, as number 1
*** Units ranging from 1 to 5, with 1 denoting the best possible score

The mean ear height for the two locations is very closely associated, the Paradise planting having a 2.11 inch higher average ear height than the Stillwater planting. This difference may be due to cultivation practices necessary for irrigation, which covered the first few inches of stalk at Stillwater.

The estimated number of nodes below the ear at Stillwater is .69 lower than the estimated node count at Paradise. This difference also can be explained by cultivation methods used at Stillwater which resulted in the covering of some of the bottom plant nodes.

Nodes above the ear has a variation of .11 between the two locations. This similarity is to be expected, since this value can be accurately determined and is less subject to environmental change.

The mean value for plant score is relatively similar for both locations; but since plant score is a largely subjective determination, it would vary considerably in other experiments conducted by other workers. For this reason, analysis of plant score data has not been considered at length in this discussion.

Actual nodes below the ear has a variation of only .05 between the two locations. This value was accurately determined by subtracting the number of leaves above the ear from the actual total leaf number.

The total estimated leaf number indicates some variation between the locations. This inconsistency can be attributed to cultivation factors already mentioned above.

Mean Squares

Data in Table IV, page 22, show a highly significant difference

TABLE IV

MEAN SQUARES FOR TEN VARIABLES

Character	Source	Location	
		Stillwater	Paradise
1. Date of Pollen Shed	Between Families	60.03**	79.62**
	Between Progeny	15.87*	28.91**
	Between Individuals	6.83	7.02
2. Date of Silk	Between Families	94.55**	77.25**
	Between Progeny	27.27	30.96**
	Between Individuals	14.40	7.50
3. Total Leaf Number	Between Families	13.43**	13.74**
	Between Progeny	4.13**	5.98**
	Between Individuals	1.60	1.68
4. Plant Height	Between Families	407.01**	126.25**
	Between Progeny	214.43**	161.12**
	Between Individuals	65.59	36.10
5. Ear Height	Between Families	211.10**	94.17**
	Between Progeny	92.16**	72.40**
	Between Individuals	30.39	21.04
6. Estimated Nodes Below Ear	Between Families	4.43**	4.38**
	Between Progeny	2.16*	2.21**
	Between Individuals	1.08	0.85
7. Nodes Above Ear	Between Families	0.78	0.95*
	Between Progeny	0.93	0.95*
	Between Individuals	0.56	0.47
8. Plant Score	Between Families	0.62	0.45
	Between Progeny	1.05*	0.51
	Between Individuals	0.47	0.30
9. Actual Nodes Below Ear	Between Families	12.48**	12.10**
	Between Progeny	2.60	5.47**
	Between Individuals	1.45	1.70
10. Total Estimated Nodes	Between Families	5.36**	6.41**
	Between Progeny	3.14*	4.21**
	Between Individuals	1.39	1.21

* Significant at 5% Level
** Significant at 1% Level

in mean squares between families at both locations for all of the ten variables being studied, except in the cases of number of nodes above the ear and plant score. With the exception of mean squares for number of nodes above the ear, plant score, and silk date, there also is shown a significant difference between progeny for the ten characters. The difference between progeny for silk date is significant at the 1% level at Paradise, but a significant difference is not shown for this character at Stillwater. It is indicated that the differences between families and between progeny used in this study are of such significance that progress could be made by selecting between families and between progeny.

Components of Variance

For each of two locations components of variance were computed between families, between progeny, and between individual plants. The ten variables studied are: date of pollen shed, date of silk, total leaf number, plant height, ear height, estimated number of nodes below the ear, number of nodes above the ear, plant score, actual number of nodes below the ear, and total estimated number of nodes. These components of variance are tabulated in Table V, page 24.

It was hoped that a study of the components of variance for these ten characters would yield some evidence as to the source of variation, whether highest between families, between progeny, or between individuals. It would be desirable if this information concerning the source of variation could be used to predict whether it is better to select by the ear-to-row method, or whether it is just as profitable to use the mass selection method.

TABLE V

COMPONENTS OF VARIANCE

FOR TEN CHARACTERS

Character	Source	Location	
		Stillwater	Paradise
1. Date of Pollen Shed	Between Families	0.99	0.83
	Between Progeny	1.01	1.79
	Between Individuals	6.83	7.02
2. Date of Silk	Between Families	1.50	0.76
	Between Progeny	1.44	1.91
	Between Individuals	14.40	7.50
3. Total Leaf Number	Between Families	0.21	0.13
	Between Progeny	0.28	0.35
	Between Individuals	1.60	1.68
4. Plant Height	Between Families	4.30	-0.57
	Between Progeny	16.60	10.20
	Between Individuals	65.59	36.10
5. Ear Height	Between Families	2.65	0.36
	Between Progeny	6.89	4.19
	Between Individuals	30.39	21.04
6. Estimated Nodes Below Ear	Between Families	0.05	0.03
	Between Progeny	0.12	0.11
	Between Individuals	1.08	0.85
7. Nodes Above Ear	Between Families	-0.03	0.00
	Between Progeny	0.04	0.39
	Between Individuals	0.56	0.47
8. Plant Score	Between Families	-0.01	-0.01
	Between Progeny	0.06	0.02
	Between Individuals	0.47	0.30
9. Actual Nodes Below Ear	Between Families	0.22	0.11
	Between Progeny	0.13	0.31
	Between Individuals	1.45	1.70
10. Total Estimated Nodes	Between Families	0.05	0.04
	Between Progeny	0.20	0.24
	Between Individuals	1.39	1.21

In general it is found that the greatest amount of variation lies between the individual plants. The second greatest amount of variation is found between progeny; and the least variation is found between families. Although the components of variance show family differences to be small, mean square values in Table IV, page 22, indicate that the differences between families are significant.

In order to understand fully the implications which are about to be made in regard to the amount of variation from each of the three sources, it is necessary again to review the history of the material from which the present population was grown. In 1952 the F_1 of the cross K4 X Ok.11 was self pollinated, and the seed thus produced were planted under isolation in 1953. The twenty most desirable plants from this planting were determined by simultaneous selection for ten plant and ear characters based on a selection score giving equal weight to each of the ten characters. In 1955 the twenty selected ears from the 1953 plants, which now will be referred to as families, were planted ear-to-row. The five high yielding ears were selected from each of these twenty families. The progeny of only ten of the possible twenty families were selected at random for use in the present study. By planting this material ear-to-row, it was possible to compare differences in families, progeny and individual plants.

In regard to total actual leaf number it is shown that at both locations, there is less variation between families than between progeny, and more variation between individuals than between either families or progeny. The amount of variance between the families measures the difference in the family means; the variation for progeny measures the amount of variation by which the progeny mean differs from the family mean. The variation between individual plants is a measure of the variance of the plant group of which the individual plant is a member.

It is not known what part of the variance found between individual plants is due to environment and what part of this difference is due to genetic differences in the plants. But since the mean and standard deviation for total actual leaf number for both locations (Table III, page 20) are practically the same, it is indicated that this character acts independently of its environment. If the total actual leaf number is independent of environment, then the differences between individuals must be genetic; also the progeny and family differences would of necessity be attributed to genetic variation.

Under the foregoing hypothesis the greatest selection differential could be gained by selecting desirable families, and from these families selecting desirable progeny, and from these progeny selecting desirable individual plants.

It also must be noted that the low variation between families as compared to the variation of progeny and of the individual plants must be the direct result of selection that was carried out in the previous generations of the variety being studied.

The variation for total estimated number of nodes follows a pattern similar to that of total actual number of nodes, showing the least variation between families and the most variation between individuals; while the mean and standard deviation for the two locations remain the same. This general pattern is indicated for actual number of nodes below the ear, estimated number of nodes below the ear, number of nodes above the ear, and plant score.

Plant height and ear height also have the prevalent pattern, that of the least variance falling between families and the most variance lying between individual plants; but the means and standard deviations for these characters vary, indicating environmental difference. However, the indication of environmental influence does not rule out the possibility that at least part of the difference shown between families, progeny, and individuals could be due to genetic influence--especially since plant height and ear height possess the same trend of variation as do the components for node count. Again the low amount of variation which is shown between families, in comparison to progeny variation and individual variation, can be attributed to previous selection of the F_2 material.

SUMMARY AND CONCLUSIONS

The objectives of this study were to determine the relationship of certain variable vegetative characters of corn to maturity; and also to determine the size of the variations associated with families, progeny, and individual plants in regard to these characters. In order to accomplish these objectives a variety of corn designated as Accession 183 Single Cross was planted at two locations.

Measurements were taken on ten variable characters of this corn. After all data were recorded, a complete set of simple correlations was run, relating the two locations in regard to the ten variables. Analysis of variation was computed for each location. The variances associated with the components--family, progeny, and individual plants--were separated. Mean squares, standard deviations, coefficients of variation, and means were derived for each character at each location.

It was found that there was a high correlation value indicated between date of pollen shed and date of silk. In contrast to conclusions of previous workers, it was found that plant height was not correlated with maturity, as measured by date of pollen shed and date of silk. A lack of correlation also was shown between ear height and date of maturity. A relatively large positive correlation coefficient was found between the total actual leaf number and date of maturity. It is possible that total leaf number could be used to predict date of maturity, especially if this factor were used in conjunction with other vegetative characters. Total estimated node count showed a significant correlation with both date of pollen shed and date of silk at the Paradise location; but at the Stillwater location, total estimated node count lacked significant correlation with these factors. It was shown that there was a significant correlation between both actual and estimated nodes below the ear and maturity; and also that there was a correlation between nodes above the ear and plant maturity.

The means for most of the characters were similar for the two locations, with comparable standard deviations. However, the mean for both date of pollen shed and date of silk at the two locations was quite different, due to the difference in planting dates. The mean total leaf number for the two locations was approximately the same, indicating that the environment has little to do with the total number of leaves which a plant develops. In general the mean square data showed a significant difference between families and between progeny, except for the values for number of nodes above the ear and plant score.

Generally it was found that the greatest amount of variation for each character lay between the individual plants. The second greatest amount of variation was found between progeny; and the least variation was found between families. By comparing the means and standard deviations for total actual nodes, total estimated nodes, nodes below the ear, and nodes above the ear at two locations, it is indicated that environment has little influence upon the expression of these characters. The major differences between individuals, progeny, and families may be attributed to genetic variation. The low amount of family variation found in this study is due to selection in previous generations. Since there is indicated a genetic difference between families, progeny, and individual plants, the greatest selection differential should be obtained by using the ear-to-row selection method and selecting desirable families, progeny, and individual plants.

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