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Inheritance of ear height and associated characters of corn (Zea mays L.)

Bobby Gerald Harville

To the Graduate Council:

I am submitting herewith a dissertation written by Bobby Gerald Harville entitled "Inheritance of ear height and associated characters of corn (Zea mays L.)." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Plant, Soil and Environmental Sciences.

Leonard M. Josephson, Major Professor

We have read this dissertation and recommend its acceptance:

R. R. Shrode, Fred L. Allen, J. D. Caponetti, Vernon H. Reich

Accepted for the Council:

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(Original signatures are on file with official student records.)

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INHERITANCE OF EAR HEIGHT AND ASSOCIATED CHARACTERS OF CORN (ZEA MAYS, L.)

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Bobby Gerald Harville

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ABSTRACT

A phenotypic recurrent selection program for low-ear placement in corn (Zea mays L.) was begun in 1961 in an early and a late maturing population involving several low-ear inbreds. Approximately 250 plants were grown in each generation of selection. The plants were divided into two equal size groups. Bulk pollen was collected from phenotypically low-ear plants of one group and used to pollinate phenotypically low-ear plants of the other group. Reciprocal pollinations were made in a similar manner. Minimum plant heights were imposed and plants flowering within a specific time span were pollinated. The total number of plants selected in each generation ranged from 15 percent to 25 percent of the total number of plants.

The generations of selection were tested by regression analysis in a diallel set of crosses and in testcrosses to both high- and low-ear single cross testers. In addition, generation mean analysis was performed for two crosses involving high- and low-ear inbreds of white and yellow endosperm type.

Data from the studies were obtained at Knoxville and Crossville, Tennessee during 1974 and 1975. Data obtained were ear and plant heights, plant/ear height ratio, number of leaves below and above the ear, number of days to silking and tasselling, and yield.

Ear height was reduced approximately 1.25 inches per generation for both the early and late maturing synthetics. Plant height decreased only slightly resulting in an overall increase of plant/ear height ratios.

There was a significant increase in the number of leaves below the ear and a significant increase in the number of leaves above the ear. The number of days from planting to silking and tasselling did not change throughout the generations of selection. Yield reductions were observed in the later generations.

Significant general combining ability effects were noted for all characters indicating that selecting for lower ear placement was effective. The testcrosses showed less differences among the generations than did the generations of selection per se.

Significant additive effects occurred for ear height, number of leaves below and above the ear, and plant/ear height ratio for the cross E199 × Mo18W. Significant dominance effects were noted in both crosses for plant height. Significant additive and dominance effects occurred for plant/ear height ratio in the cross T232 × T458R.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Many southern corn inbreds and hybrids grow tall and have a high ear placement. With modern corn production methods of close spacing and heavy fertilization high-ear placement causes considerable lodging. One means of reducing lodging would be to lower the ear placement on the stalk in order to decrease the leverage on the stalk.

A program of selecting for low ear placement was begun in 1961 in Tennessee with populations involving several low-ear inbreds of early and late maturity. Two maturity ranges were maintained by selecting plants which flowered in 60-62 days in the early synthetics and 68-70 days in the late synthetics. In order to maintain vigorous plants, only plants with plant/ear height ratios of 3:1 or 4:1 were selected. A preliminary evaluation of the first 10 generations of selection for lower ear placement was made by Josephson and Kincer in 1972 (22). In their study it was shown that ear height was reduced 25.9 cm in the early synthetics and 18.3 cm in the late synthetics from the first to the tenth generations of selection. Plant height changed little in either synthetic. Total number of leaves remained almost constant, with the number reduced by one below the ear and one leaf added above the ear over the ten generations of selection.

Similar studies of ear height have previously been conducted. In studies conducted at the Illinois Agricultural Experiment Station, involving 24 cycles of selection for high- and low-ear placement, the low-eared plants had ears only eight inches above the ground level while high-eared plants had ears 120 inches above ground level (4). Vera and Crane (42) selected for lower ear placement in synthetic populations of corn and found a reduction of 4.5 percent per cycle with only a slight reduction in yield. In a later study, Acosta and Crane (1) were able to reduce the ear height by 6.0 percent per cycle of selection with plant height being reduced to a lesser degree. The selected subpopulations yielded progressively less than the control with each additional cycle of selection.

Other researchers studied ear heights in relation to yield. Kiesselbach (25) found that "low-ear" selections yielded 3.9 percent more grain than "high-ear" selections but 3.0 percent less than the original population after five cycles of selection. Hallauer and Sears (15) also reported that ear height increased with cycles of mass selection for yield. Patil et al. (35) found that yield was positively and significantly related to ear height when the number of internodes remained constant. However, yield was negatively correlated with the number of internodes when ear height remained constant. Moll and Robinson (34) found little change in ear height after the first cycle of selection for yield.

Many researchers have studied the types of gene action associated with ear height. Ahmad (2) concluded that most of the variance in ear height was due primarily to additive and dominance effects with epistasis being of little importance. Vožda (43), Daniel (5), and Gardner (9) found dominance effects to be present but small. On the other hand, Robinson et al. (36) found no dominance of genes affecting ear height but obtained a high estimate of heritability of ear height. Silva (41) observed heterosis for ear height. Giesbrecht (10) found that two inbred lines of corn differed by six genetic factors for ear height. Two of these factors also controlled internode length. Partial dominance was exhibited for ear height with a heritability of 82.4 percent. He pointed out that a study of ear height on the basis of its two component characters, number of internodes and internode length, provided a more accurate analysis of its inheritance than was obtained from a study of ear height as a unit character.

A few studies of plant height in corn also have been reported. Daniel (5) studied plant height in a diallel set of eleven inbreds and found that dominance effects were the most pronounced, while additive effects and dominance × dominance interactions were equal. Additive × additive and additive × dominance interaction effects on plant height were negligible for plant height. Krulikovski (26) found no additive gene effects for plant height. Green (12) demonstrated in two locations, Indonesia and Florida, that plant height and yield were positively correlated.

The inheritance of leaf number has been studied to some extent. Mehrota (32) found considerable variation in leaf number in each of seven lines of corn evaluated. Early maturing lines tended to produce a smaller number of leaves than later maturing lines. Total leaf number was negatively correlated with number of leaves produced above the ear and showed a high positive correlation with the number of leaves below the ear.

F_1 progenies had values intermediate between the parental values, with no differences shown between reciprocal crosses. Metwally (33) studied the F_2 generation from the crosses of five inbred lines to estimate the number of genes controlling leaf number in corn. He indicated that leaf number is controlled by a minimum of two major genes with a cumulative effect.

Many researchers were as interested in the statistical procedures used to analyze their data as they were in their findings on the morphological characters of the plants studied. Several of these investigators used diallel crosses.

Yates (45), in describing the statistical analysis of a diallel cross, fitted additive main effects for parents and interactions in the individual crosses. These main effects were referred to as "general combining ability" (gca) and the interactions as "specific combining ability" (sca).

The modern concepts of general and specific combining ability were developed by various workers (6, 11, 13, 14, 16, 23, 30, 31, 40). Sprague and Tatum (40), working with single crosses of corn, defined gca as the average performance of a line in several hybrid combinations and sca as those cases in which certain hybrid combinations performed better or worse than would be expected on the basis of average performance.

Henderson (19) defined general combining ability for some character as the average of the progeny of an individual or line when mated with a random sample from a specified population. Specific combining ability was defined as the deviation from the expected value on the basis of the general combining ability of the two parents.

Griffing (13) extended the concept of gca and sca to diallel systems in the application of various diallel methods to plant and animal experiments. He suggested that both additive and additive × additive variance is involved in gca and that sca includes dominance and the other forms of epistasis.

Matzinger (29) stated that the subdivision of the variance of diallel crosses into general and specific combining ability variances required no genetic assumptions since the subdivisions are purely statistical.

Rojas and Sprague (38) evaluated yields of single crosses of corn inbreds previously selected on the basis of sca and found that the estimated variance of sca was consistently greater than that of gca. They suggested that sca variances may include not only dominance and epistasis but a considerable amount of genotype-environment interaction. Federer and Sprague (7) found that sca was roughly equivalent to line × tester interaction.

Robinson et al. (37) and Gardner (9) evaluated gca and sca variances of corn hybrids derived from inbred lines of southern prolifics. Their data indicated that genetic linkages as well as epistasis may be considered as possible sources of bias in the interpretation of combining ability variances.

Another method used to test gene effects and epistasis is generation mean analysis. These tests were introduced by Mather (28) and later extended by Anderson and Kempthorne (3) and Hayman (18).

Anderson and Kempthorne developed a model for the study of quantitative inheritance. They partitioned the genotypic value of an individual into additive, dominance, and epistatic gene effects. By using this model they were able to estimate six parameters by employing generation means derived from crossing two homozygous lines.

Hayman's (18) procedure utilizes generation means also for estimating additive (d), dominance (h), and digenic epistatic effects: additive × additive (i), additive × dominance (j) and dominance × dominance (l). In this model six generations are required to estimate $\hat{m}$, $\hat{d}$, $\hat{h}$, $\hat{i}$, $\hat{j}$, and $\hat{l}$. However, according to Gamble (8), additive and dominance variances can not be uniquely measured when significant epistasis is present and the relative contributions of the types of gene action are not positively known. Estimates of the parameters do provide an indication of the relative importance of the various types of gene effects affecting the total genetic variation in a plant attribute. Gamble used population means of six inbred lines of corn and all possible F_1, F_2, B_1, and B_2 generation crosses to obtain estimates of the various gene effects on yield. The estimates of gene effects indicated that dominance was important. Estimates of additive gene effects were low and many were nonsignificant. Epistatic gene effects were considered to be more important than additive gene effects. The additive × additive and additive × dominance gene effects were relatively more important than dominance × dominance effects.

Various statistical methods have been used to estimate heritabilities of various morphological characters of corn. Three main categories of techniques for estimating the degree of heritability in crop plants have been reported. They are based on:

1. parent-offspring regression,
2. variance components from an analysis of variance, and
3. approximation of nonheritable variance from genetically uniform populations to estimate total genetic variance.

Warner (44) felt that these three techniques did not provide him with a reliable estimate of heritability. He presented an alternate method which offered the following advantages:

1. the estimate is made entirely on the basis of the F_2 and the backcrosses to each inbred parent, and
2. the estimation of nonheritable variance is necessary.

His formula for estimating heritability is:

$$\text{Heritability} = \frac{(1/2)D}{V_{F_2}} \quad \text{where}$$

$(1/2)D$ = the additive genetic component of variance of F_2 and V_{F_2} represents the phenotypic variance of the F_2.

This method is based on the normal assumptions of additivity of genic effects, no epistasis, independence of genotype and environmental variance plus an additional assumption that the environmental components of variance of the F_2 and two backcrosses are of comparable magnitude.

Some workers included heterosis in their studies of corn. Hayman (17) defined heterosis as the expression of a joint action of favorable combinations of genes at different loci. It is that interaction between nonallelic genes brought together from the parents which surpasses the simple summation of the effects of these genes in the parents. Hayman (18) indicated that heterosis is a composite phenomenon in a diallel cross of corn. Possible causes were epistasis, over-dominance, and the accumulation of favorable dominant genes in the heterozygotes. He observed that when epistasis is significant, one can classify individual crosses as duplicate or complimentary. Jinks and Jones (21) defined heterosis as the difference between the mean of an F_1 and that of its better parent. The expectations can be expressed in terms of the genetic parameters, additive, dominance, and nonallelic interaction components.

Promising results from the preliminary study by Josephson and Kincer (22) prompted further study of lower ear placement. The objectives of this study were: (1) to determine the effectiveness of the selection program for lower ear placement, and (2) to obtain information on the inheritance of ear height and associated characters in (a) a diallel set of crosses of the synthetics, (b) crosses of the generations of synthetics to both high- and low-ear single crosses, and (c) generation mean analysis of a white and a yellow single cross involving high- and low-ear inbreds of early and late maturity.

CHAPTER II

MATERIALS AND METHODS

I. POPULATIONS

Diallel Set of Synthetics

The early synthetics utilized in this study were developed from the following twelve low-ear inbreds and selections:

PP32-S5	Va3a	Va9-532
(A13.W18)-S6	Va17b	T458
(A413.T204)sel.	Va22	T113(M14.051)
(C103.Ky36-11)-S6	Va25	(T220.W22R)-S2

and the late synthetics from the following eight low-ear inbreds and selections:

Ab16	(Je26)-S4
Ab36	(Ky215.T101)-S4
Mp484	(Je1•PP)-S2
(Ky36-24.T13)-S4	(Je52•Robyn)-S3

The inbreds in each group were crossed in pairs and the resulting single crosses were crossed in all combinations. Equal quantities of seed of the double crosses were then composited to formulate the first generation for selection. The two maturity ranges were maintained by selecting plants which flowered in 60-62 days in the early synthetics and 68-70 days for the late synthetics. Approximately 250 plants were grown in each generation of selection. The plants were divided into two groups with bulk pollen collected from phenotypically low-ear plants of one group used to pollinate phenotypically low-ear plants of the other group. Reciprocal pollinations were made in a like manner. A minimum plant height was imposed on the selections as shown in Table 1. The number of plants selected in each generation ranged from 15-25 percent of the total plants.

Generations 1, 3, 5, 7, 8, 9, and 10 were crossed in all possible combinations at the Plant Science Field Laboratory at Knoxville, Tennessee, in 1974 to produce a diallel set of crosses to be tested at Knoxville and Crossville, Tennessee, in 1975. Synthetics for each generation used in the diallel set also were included in the tests. In addition, generations 11 and 12 were added to the test of the synthetics in 1975.

A randomized complete block design with six replications was used in each of the four experiments. The generations of synthetics were randomized within the diallel sets.

The test at Knoxville was in a field previously in corn in 1973 and 1974. The field was fertilized with 1000 pounds per acre of 6-12-12 with heptachlor added. The fertilizer was broadcast and disced in on April 29, 1975. The test was planted April 29, 1975 and the plots were sidedressed with 200 pounds of ammonium nitrate per acre on May 27, 1975. Following planting, 2.0 pounds of atrazine and 2.4 pounds of alachlor per acre were applied for weed control.

The test at Crossville was in a field previously in corn in 1974. The field was fertilized with 250 pounds of 0-26-26 and 112 pounds of nitrogen per acre broadcast and disced in. One hundred pounds of 7-28-28

TABLE 1

SELECTION CRITERIA FOR EARLY AND LATE MATURING SYNTHETIC POPULATIONS DURING EACH GENERATION

		Early Synthetics		Late Synthetics	
Year	Syn.	Ear Height, Ft.	Plant Height, Ft.	Ear Height, Ft.	Plant Height, Ft.
1962	1	Lowest ear placement		Lowest ear placement	
1963	2	≤ 2.5	≥ 7.0	≤ 2.4	≥ 7.0
1964	3	≤ 2.0	≥ 6.5	≤ 2.0	≥ 6.5
1965	4	≤ 2.0	≥ 6.5	≤ 2.3	≥ 7.0
1966	5	≤ 2.0 or ≤ 1.5	≥ 6.5 or ≥ 5.5	≤ 2.0 or 1:4 ratio	≥ 6.5
1967	6	≤ 2.0	≥ 6.0	≤ 1.5 + ≤ 1.8	≥ 6.5 + ≥ 7.0
1968	7	≤ 2.0	≥ 6.0 + ≥ 8.0	≤ 1.5 + ≤ 1.8	≥ 6.5 + ≥ 7.0
1969	8	≤ 2.0 + ≤ 1.5	≥ 6.5 + ≥ 5.5	≤ 1.5 + ≤ 1.8	≥ 6.5 + ≥ 7.0
1970	9	≤ 1.5	≥ 6.0	≤ 1.5	≥ 6.0
1971	10	≤ 1.5	≥ 6.0	≤ 1.5 + ≤ 1.8	≥ 6.0 + ≥ 8.0
1972	11	≤ 1.5	≥ 6.0	≤ 1.5	≥ 6.0
1973	12	≤ 1.5	≥ 6.0	≤ 1.5	≥ 6.0

per acre was applied in the row at the time of planting on May 5 and 6, 1975.

At both locations, each plot consisted of 20 plants spaced 12" apart in single rows 40" apart. Plots were initially planted at 6" intervals and subsequently thinned.

Generations of Synthetics Crossed to High- and Low-Ear Testers

In a separate experiment, generations 1 through 8 of the synthetics were crossed to high- and low-ear testers. The testers were:

1. T224 × T232 (high-ear) and Mo12Y × T458R (low-ear) for the early low-ear synthetics.
2. T232 × SC155Y (high-ear) and Mo12Y × T458R (low-ear) for the late low-ear synthetics.

The crosses, which had been made in 1970, and the eight generations of selection per se were tested at the Knoxville Plant Science Field Laboratory in 1974. These crosses were grown in a split-plot arrangement with three replications. Main plots were the crosses on each tester and the set of synthetics per se. Generations of synthetics crossed on each tester were the subplots. In the analyses, each main plot was analyzed as a separate experiment.

The test site for the synthetics and the crosses was in a field previously planted to corn in 1973. The field was fertilized with 1000 pounds of 6-12-12 with dieldrin per acre broadcast and disced in prior to planting on April 29, 1974. Following planting, atrazine and alachlor were each applied at a rate of 1.5 pounds per acre. The plot size and spacing were identical to those for the diallel set of crosses.

Tests of Generation Means

A white, early, low-ear inbred (E199) was crossed to a white, late, high-ear inbred (Mo18W). Also, a yellow, early, low-ear inbred (T458R) was crossed to a yellow, late, high-ear inbred (T232). These crosses were utilized in studying the inheritance of ear height and associated characters.

The parents, the F_1 and F_2 hybrids between them, and their first backcross populations were included in the experiment. E199, of the white inbreds, and T232, of the yellow inbreds, were considered as parent 1 in the experiments.

Seed for the segragating and nonsegragating generations were previously produced in 1970. The tests were conducted in 1974 at the Plateau Experiment Station, Crossville, Tennessee.

One plot of each parent and F_1 progeny and four plots of the two backcrosses and the F_2 populations were included in each replicate of the tests. An additional plot of the F_1 progeny was included in each replicate of the test of the cross T232 × T458R. The tests were replicated three times in a randomized complete block design. Additionally, 100 F_3 families from each cross also were grown in separate, nonreplicated experiments. Plot size and plant spacings were identical to those used for the diallel sets of crosses.

The tests were planted on May 13, 1974. Prior to planting, the test site was fertilized with 350 pounds of 7-28-28 and 400 pounds of ammonium nitrate per acre, broadcast and disced into the soil. One hundred and fifty pounds per acre of 7-28-28 fertilizer with aldrin was applied in the rows at the time of planting. Atrazine and alachor were applied following planting as a weed control.

II. AGRONOMIC DATA

Data were obtained on ear height, plant height, number of leaves below and above the ear, flowering date and yield from ten random guarded plants in each plot.

Ear height (in inches) was recorded as the distance from the base of the plant to the top ear-node attachment. Plant height (in inches) was measured as the distance from the base of the plant to the tip of the central tassel spike.

The number of leaves below the ear included the leaf at the top ear-node and all leaves that remained on the plant at the end of the flowering period. The number of leaves above the ear included all leaves above the top ear-bearing node.

Flowering data were obtained only at Knoxville and were recorded as the number of days from planting to the day when 50 percent of the plants shed pollen on the center spike of the tassel and when silks appeared.

Yield was measured on a plot basis and included all ears on the ten plants from which the other measurements were obtained. Ear corn weights were adjusted to 15.5 percent moisture and recorded to the nearest one-tenth of a pound.

III. STATISTICAL METHODS

Combining Ability Analysis

The analysis of variance of yield was conducted on a weight-per-plot basis. All other agronomic characters were analyzed on an individual plant basis. Appropriate F tests were made to determine the significance of differences among diallel entries. The data were then analyzed according to Griffing's (13) combining ability analysis Method 4, Model I.

Generation Mean Analysis

Hayman's procedure (18) and Gamble's notation (8) were used to calculate the estimates of additive ($\hat{a}$), dominance ($\hat{d}$), and three types of digenic epsitatic effects ($\hat{aa}$, $\hat{ad}$, $\hat{dd}$). Estimates of heritability were determined.

Heritability

Estimates of heritability of the various characters were calculated using the following formula:

$$H = \left(\frac{V_{F_2} - (V_{P_1} \times V_{P_2})1/2}{V_{F_2}} \right) \times 100,$$

where V's are observed phenotypic variances.

Heritability estimates also were derived from the components of variance in the analysis of variance table. The formula used was:

$$H = (\hat{\sigma}^2{}_G / \hat{\sigma}^2{}_G + \hat{\sigma}e^2) \times 100$$

where $\hat{\sigma}^2{}_G$ = genotypic variance and $\hat{\sigma}e^2$ = error variance.

Other Statistical Procedures

The distribution of data from the F_3 families from the crosses E199 × Mo18W and T232 × T458R were tested for skewness and kurtosis based on the procedures of Snedecor and Cochran (39). The procedures for estimating correlation and regression statistics, *t* tests, and analysis of variance also were based on standard procedures described by Snedecor and Cochran (39). Calculations were done using the IBM 360/65 computer at the University of Tennessee Computing Center.

CHAPTER III

EXPERIMENTAL RESULTS

I. ANALYSIS OF THE SYNTHETICS

Agronomic Performance

Early low-ear synthetics. Means of the generations of selection showed a significant reduction in ear height from 34.9 inches in generation 1 to 19.5 inches in generation 12 when grown at Knoxville, while the reduction was from 34.0 inches in generation 1 to 20.2 inches in generation 12 when grown at Crossville (Table 2). The greatest reduction in ear height occurred from generations 1 to 3.

The greatest reduction in plant height occurred from generations 1 to 3. Total reductions amounted to 7.7 inches at Knoxville and 11.2 inches at Crossville. However, after generation 3, the mean plant height remained almost constant throughout the later generations.

Gradual increases of plant/ear height ratios were observed at both Knoxville and Crossville. A wider range of plant/ear height ratios was noted at Knoxville than at Crossville, 2.93 to 4.90 and 3.12 to 4.78, respectively (Table 2).

The decrease in the number of leaves below the ear from generation 1 to 12 was 6.5 leaves to 5.0 leaves at Knoxville and from 6.4 leaves to 5.2 leaves at Crossville.

As the number of leaves below the ear decreased, there was a corresponding increase in the number of leaves above the ear. An increase

TABLE 2

MEANS OF VARIOUS AGRONOMIC CHARACTERS OF NINE GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT IN EARLY AND LATE LOW-EAR SYNTHETICS

	Early		Late	
Gen.	Knoxville	Crossville	Knoxville	Crossville
	Ear height, inches			
1	34.9	34.0	35.5	36.9
3	28.0	29.8	29.4	36.2
5	27.2	26.7	27.0	31.3
7	24.4	22.9	25.9	29.0
8	23.4	22.8	26.0	29.1
9	22.4	21.4	23.9	27.7
10	20.6	21.0	21.4	25.4
11	20.8	20.5	22.0	24.6
12	19.5	20.2	19.7	23.9
	Plant height, inches			
1	100.2	103.7	99.4	111.4
3	94.1	98.2	93.2	110.0
5	92.7	96.9	93.7	106.9
7	93.1	93.5	92.5	104.6
8	93.8	94.2	91.9	104.9
9	92.1	91.3	92.2	101.9
10	93.0	92.1	90.0	102.6
11	96.2	93.0	91.8	101.7
12	92.5	92.5	89.7	101.5
	Plant/ear height ratio			
1	2.93	3.12	2.84	3.08
3	3.42	3.39	3.22	3.13
5	3.49	3.72	3.56	3.51
7	3.95	4.18	3.66	3.66
8	4.11	4.29	3.63	3.64
9	4.24	4.33	3.94	3.77
10	4.70	4.46	4.31	4.16
11	4.75	4.73	4.28	4.24
12	4.90	4.78	4.66	4.47

TABLE 2 (continued)

Gen.	Early Knoxville	Early Crossville	Late Knoxville	Late Crossville
	---------------Number of leaves below the ear---------------			
1	6.5	6.4	6.1	6.2
3	6.2	6.1	5.8	6.0
5	6.0	5.8	5.4	5.9
7	6.1	5.3	5.6	5.9
8	5.9	5.4	5.6	5.9
9	5.8	5.4	5.4	5.8
10	5.2	5.1	5.3	5.7
11	5.3	5.2	5.3	5.7
12	5.0	5.2	4.9	5.1
	---------------Number of leaves above the ear---------------			
1	6.0	5.7	6.5	6.4
3	6.1	5.8	6.7	6.4
5	6.4	6.1	6.9	6.7
7	6.6	6.2	7.0	6.9
8	6.6	6.3	7.1	6.9
9	6.8	6.3	7.3	7.0
10	6.8	6.5	7.4	7.2
11	7.1	6.7	7.4	7.2
12	7.2	6.9	7.4	7.2
	------------Days to 50 percent pollen shed, no.------------			
1	60.7		65.5	
3	59.7		65.5	
5	60.4		65.8	
7	59.5		66.1	
8	60.2		67.3	
9	59.8		66.7	
10	59.3		66.0	
11	60.2		66.4	
12	60.2		65.3	

TABLE 2 (continued)

Gen.	Early Knoxville	Early Crossville	Late Knoxville	Late Crossville
	Days to silking, no.			
1	61.1		68.5	
3	60.1		68.8	
5	61.1		69.0	
7	59.9		69.5	
8	60.2		71.3	
9	60.2		70.7	
10	60.1		70.0	
11	60.8		70.3	
12	61.2		69.6	
	Yield, lbs. per plot			
1	3.8		4.1	
3	4.0		3.7	
5	3.1		3.5	
7	3.7		3.5	
8	3.2		3.7	
9	2.8		3.6	
10	3.2		3.6	
11	3.5		3.4	
12	3.0		3.0	

of 1.2 leaves was noted from generation 1 to 12 for both locations. The material grown at Knoxville averaged 0.3 more leaves above the ear than that grown at Crossville.

There were no significant differences in the number of days from planting to pollen shed or silking. Differences in yields were observed among the generations of synthetics, but they were not consistent.

Late low-ear synthetics. Means of the generations of selection in the late synthetics showed a significant reduction in ear height. The mean ear height decreased from 35.5 inches in generation 1 to 19.7 inches in generation 12 at Knoxville and from 36.9 inches in generation 1 to 23.9 inches in generation 12 at Crossville (Table 2). The greatest reduction in ear height occurred from generations 1 to 3 at Knoxville but a steady reduction was observed from generation 1 to 12 at Crossville.

The largest decrease in plant height occurred from generations 1 to 3 at Knoxville, while the largest decrease occurred from generations 3 to 5 at Crossville.

As with the early synthetics, a larger increase in plant/ear height ratios was noted in the synthetics grown at Knoxville. The increases, however, were gradual at both locations.

There was a reduction from 6.1 to 4.9 leaves below the ear in the generations at Knoxville and a reduction from 6.2 to 5.1 leaves below the ear in the generations at Crossville. The greatest reduction occurred in generations 11 and 12.

As the number of leaves below the ear decreased, there was an increase in the number of leaves above the ear. The total increase was not as great as with the early synthetics. As with the early synthetics, there were practically no differences in number of days from planting to pollen shed or silking.

The mean yield of generation 12 was significantly lower than the yield of generation 1. There were, however, only minor differences in yield in all other generations.

Analysis of Variance

The analyses of variance for the different agronomic characters were conducted on an individual plant basis except for yields at Knoxville which were conducted on a 10-plant plot mean basis. The mean squares are presented in Table 3 for the early synthetics and in Table 4 for the late synthetics. All mean squares were significant at the .01 probability level, except for yield in the late synthetics at Knoxville. Approximately the same magnitude of genotype/error F test ratios was obtained at the two locations and in the early and late synthetics.

Correlations between Various Agronomic Characters of the Synthetics

Correlation coefficients were calculated by combining the Knoxville and Crossville data for both the early and late synthetics.

Early low-ear synthetics.

There were significant positive correlations of ear height with the characters, plant height, number of leaves below the ear, days to pollen shed and silking, and yield (Table 5).

TABLE 3

ANALYSES OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS OF NINE GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975.

		Mean Squares							
Source	df	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear	Days to Pollen Shed	Days to Silking	Yield#
Knoxville									
Reps	5	39.56	329.21	1.28	1.50	0.53	7.77	15.48	0.12
Generations	8	1399.90**	395.05**	27.24**	12.98**	9.59**	12.42**	16.84**	0.56**
Residual	526	20.25	52.34	0.50	0.84	0.60	3.13	3.90	0.10
Crossville									
Reps	5	141.05	296.70	1.92	6.22	0.87	-	-	-
Generations	8	1297.48**	937.93**	20.06**	13.17**	8.59**	-	-	-
Residual	526	19.25	49.56	0.53	0.92	0.58	-	-	-

#Residual df for yield was 40.

**Indicates significance at the .01 probability level.

TABLE 4

ANALYSES OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS OF NINE GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975.

		Mean Squares							
Source	df	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear	Days to Pollen Shed	Days to Silking	Yield#
Knoxville									
Reps	5	48.55	825.94	0.38	2.48	0.61	10.73	11.35	0.67
Generations	8	1373.69**	458.94**	19.65**	7.18**	6.68**	24.71**	50.45**	0.35
Residual	526	18.04	50.83	0.36	0.64	0.77	4.95	6.83	0.21
Crossville									
Reps	5	34.31	144.15	1.17	1.87	1.29	-	-	-
Generations	8	1331.08**	790.14**	13.80**	5.52**	6.22**	-	-	-
Residual	526	25.14	39.34	0.40	0.91	0.63	-	-	-

#Residual df for yield was 40.

**Indicates significance at the .01 probability level.

TABLE 5

COEFFICIENTS OF SIMPLE CORRELATION BETWEEN VARIOUS AGRONOMIC CHARACTERS OF THE NINE GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975.

Character	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear	Days to Pollen Shed	Days to Silking	Yield[1]
Ear height	.556**	-.892**	.555**	-.261**	.256**	.148**	.400**
Plant height		-.238**	.215**	.056	.066	-.003	.110
Plant/ear height ratio			-.550**	.414**	-.251**	-.148**	-.352**
Leaves below the ear				-.209**	.190**	.030	.303**
Leaves above the ear					.110*	.105*	-.351**
Days to 50% pollen shed						.786**	.030
Days to 50% silking							-.010

*, **Indicate significance at the .05 and .01 probability levels, respectively.

[1]Correlation of yield with other characters was calculated on a plot mean basis.

There were significant negative correlations of ear height with plant/ear height ratio, and with the number of leaves above the ear. The plant/ear height ratio was negatively correlated with all other characters except for number of leaves above the ear. There was a significant negative correlation between number of leaves below and that above the ear, as would be expected.

Late low-ear synthetics. Most correlations observed were of approximately the same magnitude and sign as shown in the early synthetics (Table 6). Ear height, however, was not significantly correlated with number of days to silking as was shown in the early synthetics.

Regression Analysis

Early low-ear synthetics. A decrease of 1.26 inches per generation was observed in the selection for lower ear height at both locations (Figure 1). With the decrease in ear height, there was a resulting increase in the plant/ear height ratio. A significant increase of 0.18 per generation in the ratio was calculated from the Knoxville data, and a significant increase of 0.15 per generation was calculated from the Crossville data (Figure 2).

Number of leaves below the ear decreased by 0.11 leaves per generation at Knoxville. At Crossville the decrease per generation was 0.12 leaves (Figure 3). The decrease in the number of leaves below the ear resulted in a corresponding increase in the number of leaves above

TABLE 6

COEFFICIENTS OF SIMPLE CORRELATION BETWEEN VARIOUS AGRONOMIC CHARACTERS OF THE NINE GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975.

Character	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear	Days to Pollen Shed	Days to Silking	Yield[1]
Ear height	.585**	-.852**	.472**	.327**	.221**	-.012	.314*
Plant height		-.333**	.240**	-.012	.197**	.000	.202
Plant/ear height ratio			-.681**	.218**	-.182**	-.259**	-.469**
Leaves below the ear				-.189**	.258**	.030	.115
Leaves above the ear					.234**	.311**	-.080
Days to 50% pollen shed						.716**	-.048
Days to 50% silking							-.199

[1]Correlation of yield with other characters was calculated on a plot mean basis.

*, **Indicate significance at the .05 and .01 probability levels, respectively.

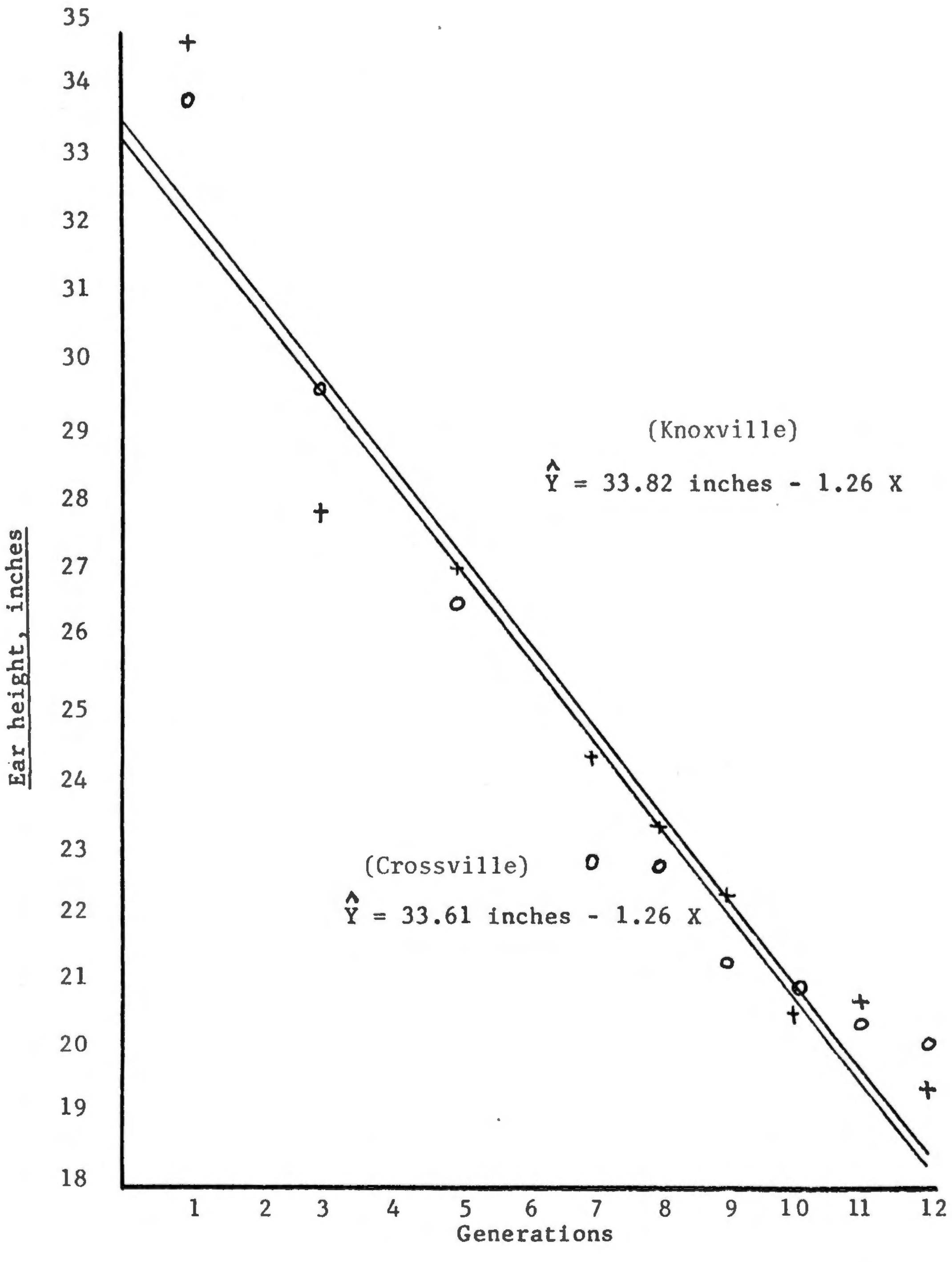

Figure 1. Observed and predicted ear heights in 9 generations of selection for lower ear height (early synthetics).

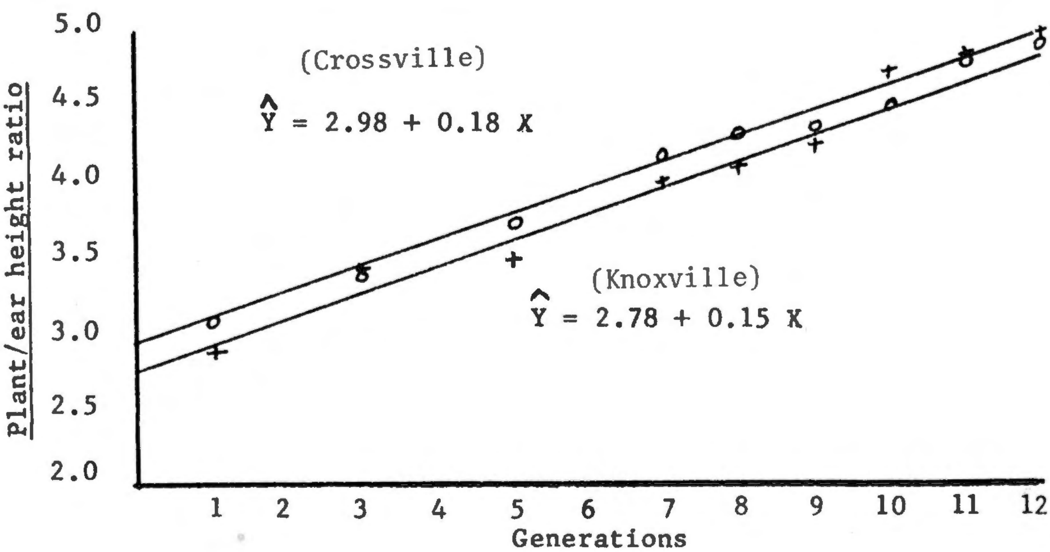

Figure 2. Observed and predicted plant/ear height ratios in 9 generations of selection for lower ear height (early low-ear synthetics).

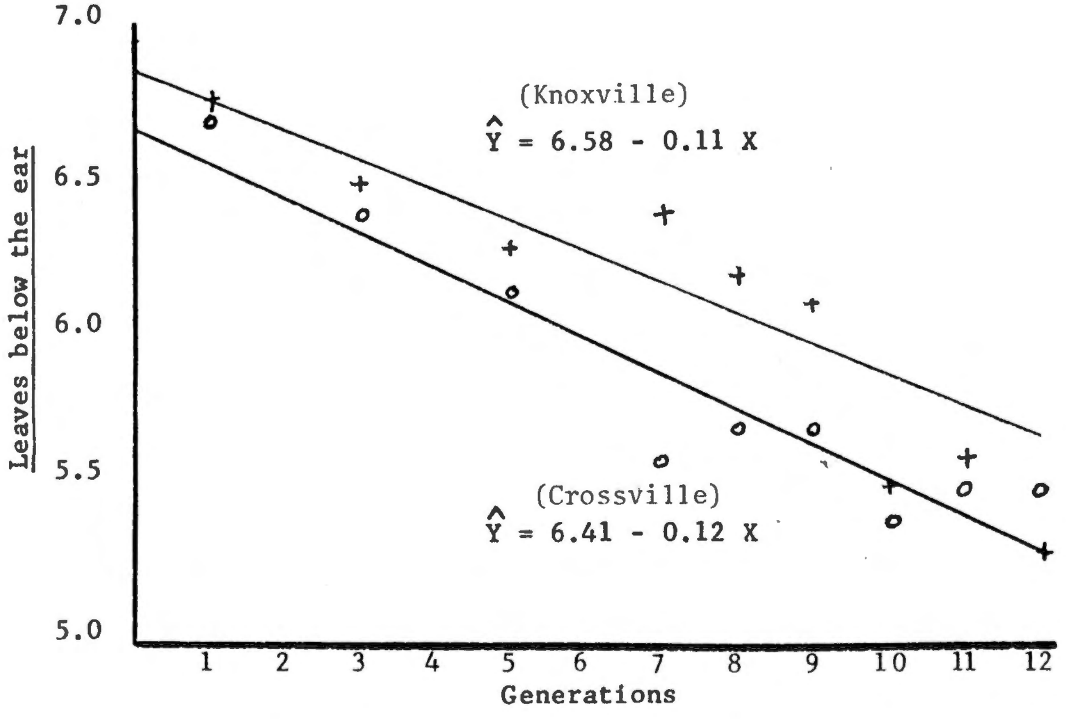

Figure 3. Observed and predicted number of leaves below the ear in 9 generations of selection for lower ear placement (early low-ear synthetics).

the ear. An increase per generation of 0.11 leaves above the ear was calculated from the data obtained at Knoxville and 0.10 leaves from the data obtained at Crossville (Figure 4).

A per-generation decrease in plant height of 0.38 inches and 0.97 inches was observed in the Knoxville and Crossville data, respectively.

Late low-ear synthetics. Results similar to those for the early synthetics were obtained for the late synthetics. Ear height decreased by 1.25 inches per generation at both locations (Figure 5).

Plant/ear height ratios increased 0.15 and 0.13 per generation at Knoxville and Crossville, respectively (Figure 6).

The number of leaves below the ear decreased by 0.09 leaves per generation at Knoxville and by 0.07 leaves per generation at Crossville (Figure 7). The number of leaves above the ear was predicted to increase by 0.09 leaves per generation at both locations (Figure 8). Plant height was also predicted to decrease by 0.66 inches per generation at Knoxville and by 0.96 inches per generation at Crossville.

II. ANALYSIS OF THE DIALLEL CROSS

Agronomic Performance

Early low-ear synthetics. Array means of the crosses showed a gradual reduction in ear height (Table 7). The reduction was 4.5 inches from generations 1 to 10 at Knoxville and 5.4 inches at Crossville. This reduction of cross means is much less than the reduction of generation means.

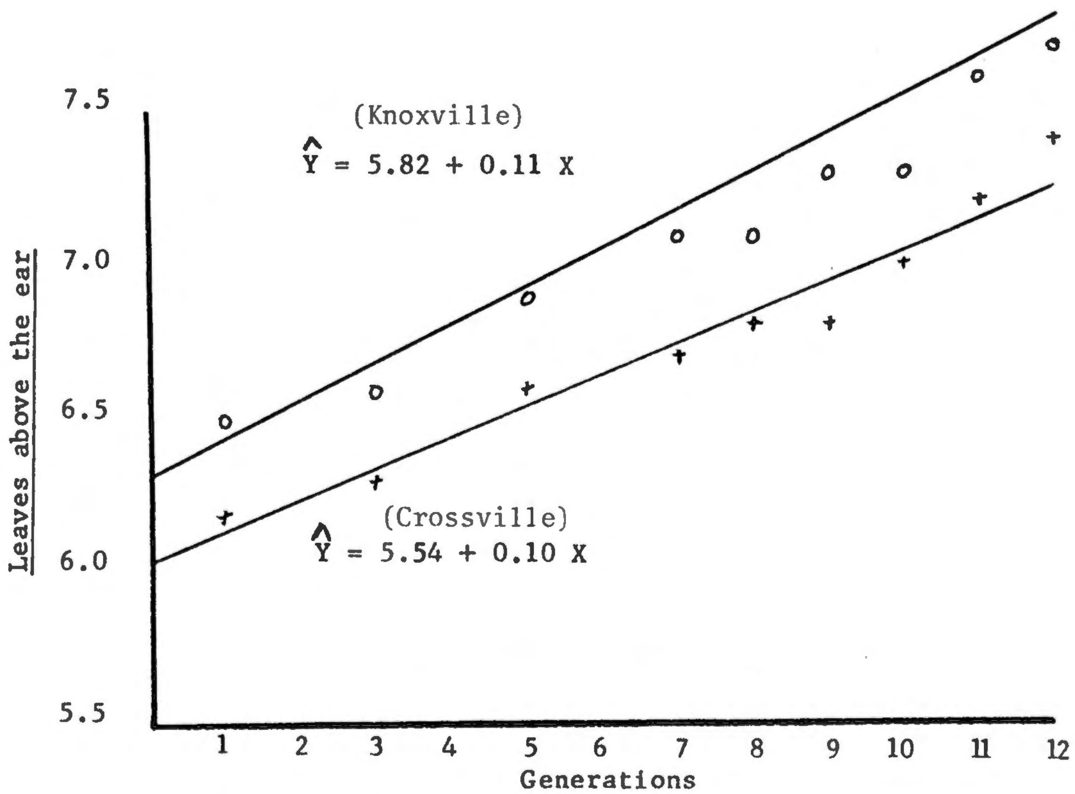

Figure 4. Observed and predicted number of leaves above the ear in 9 generations of selection for lower ear placement (early low-ear synthetics).

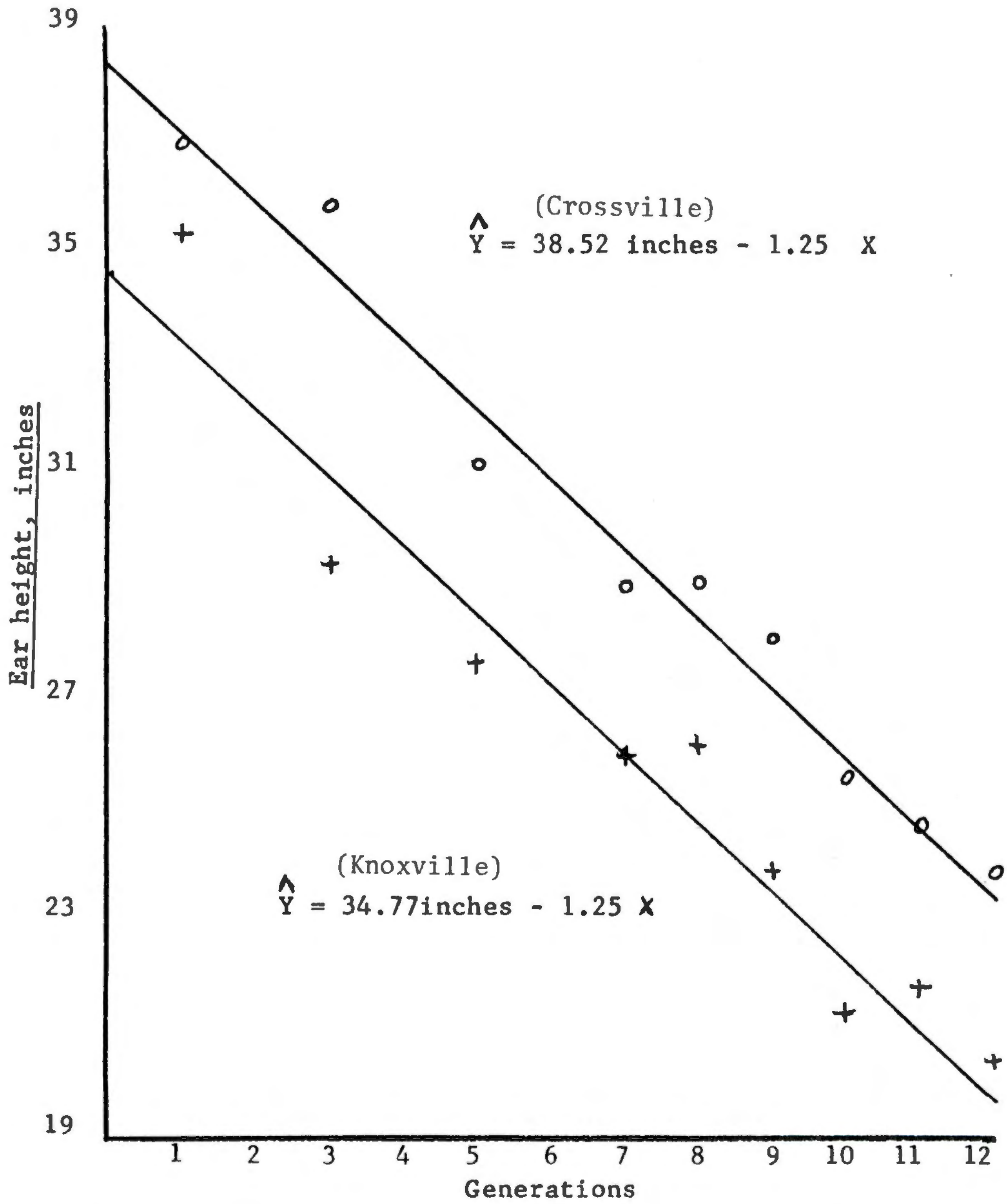

Figure 5. Observed and expected ear heights in 9 generations of selection for lower ear height (late synthetics).

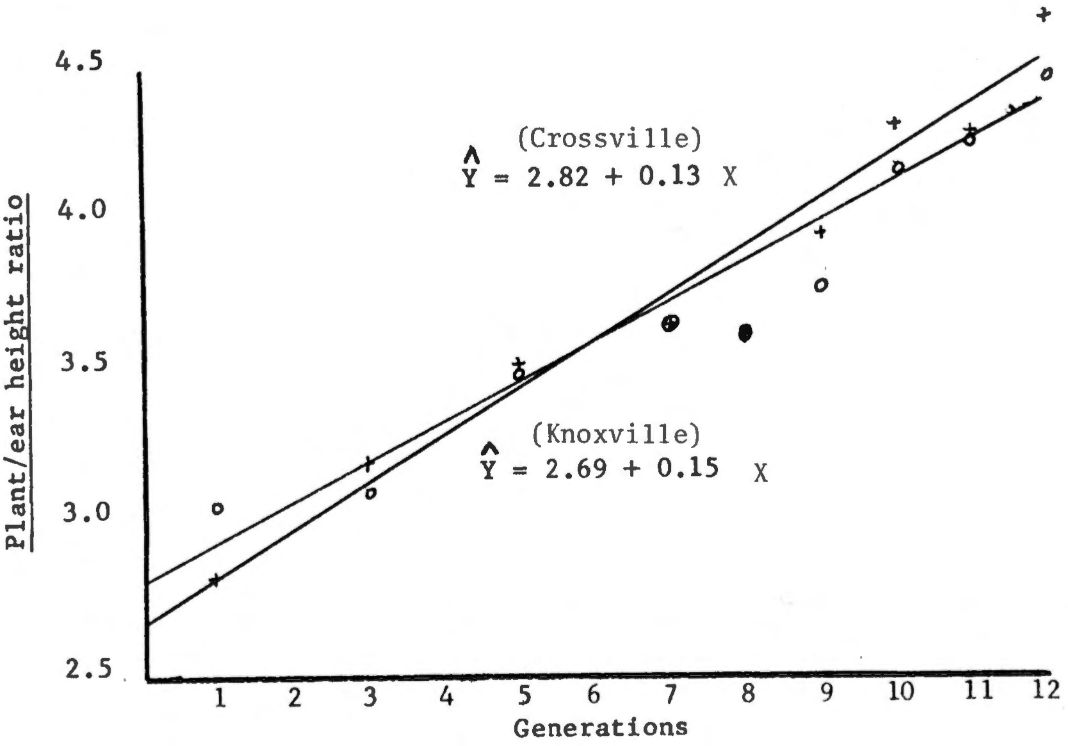

Figure 6. Observed and predicted plant/ear height ratios in 9 generations of selection for lower ear placement (late low-ear synthetics).

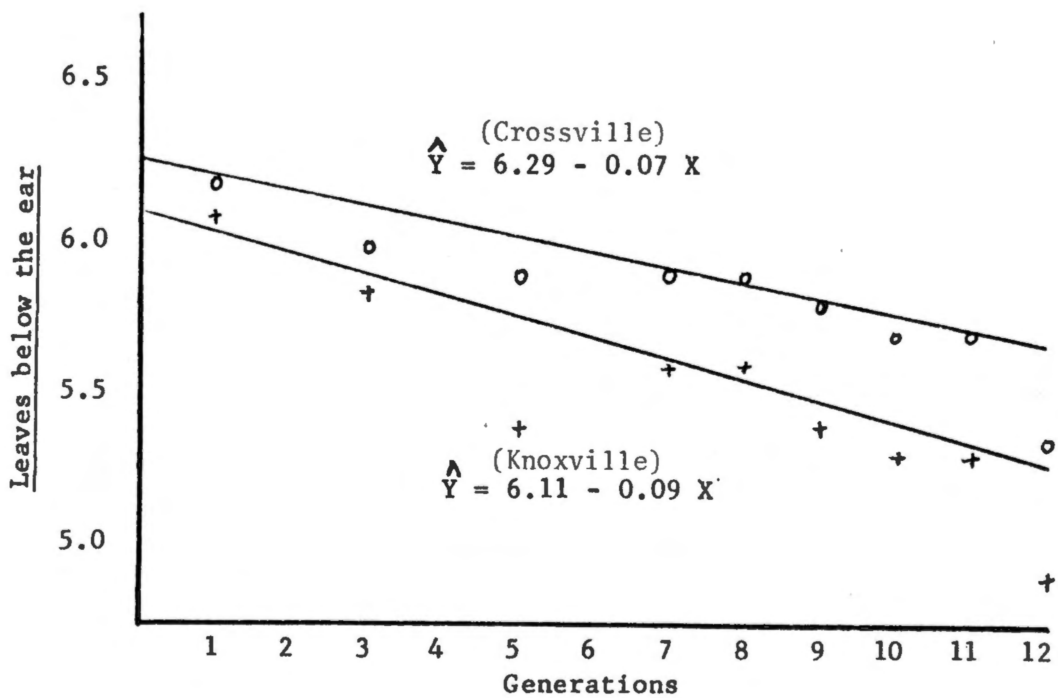

Figure 7. Observed and predicted number of leaves below the ear in 9 generations of selection for lower ear placement (late low-ear synthetics).

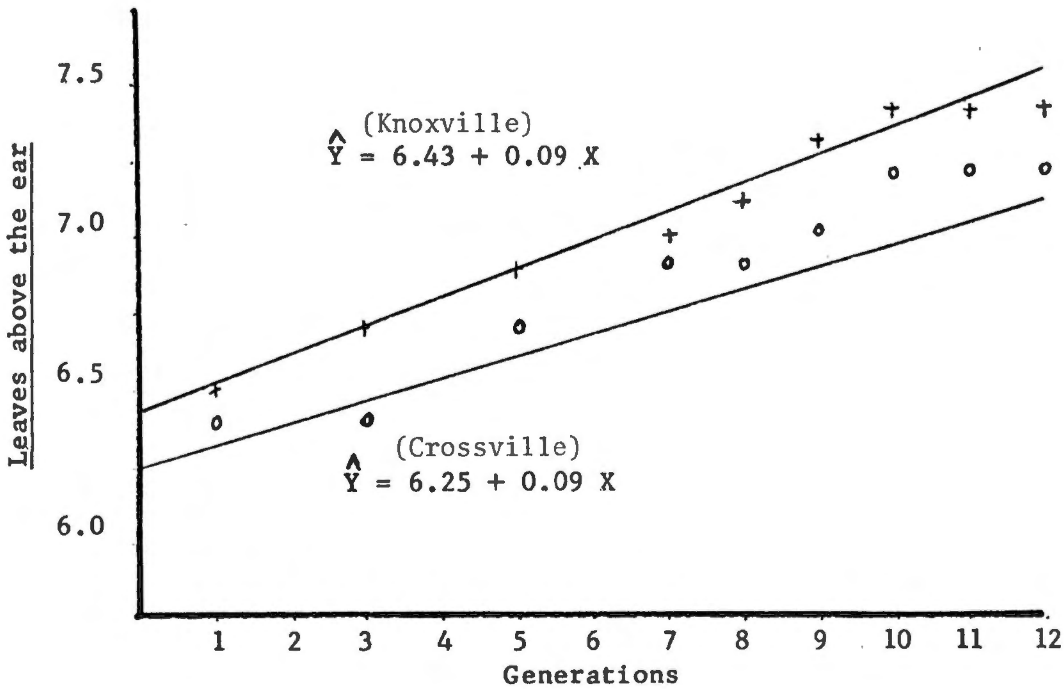

Figure 8. Observed and predicted number of leaves above the ear in 9 generations of selection for lower ear placement (late low-ear synthetics).

TABLE 7

MEAN EAR HEIGHT (INCHES) IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		32.7	32.5	30.3	30.0	30.0	29.4	34.9	30.8
3	33.0		30.8	28.1	28.9	27.0	28.0	28.0	29.2
5	31.3	29.1		27.6	27.4	25.9	26.4	27.2	28.4
7	30.8	27.8	26.4		26.2	26.2	24.9	24.4	27.2
8	30.3	27.8	25.9	24.1		25.0	24.5	23.4	27.0
9	30.1	27.8	25.9	23.8	22.7		24.4	22.4	26.4
10	30.0	27.8	25.8	23.8	22.6	22.8		20.6	26.3
Gen. Means	34.0	29.8	26.7	22.9	22.8	21.4	21.0		
Array of Cross Means	30.9	28.9	27.4	26.1	25.6	25.5	25.5		

A slight reduction in plant height occurred from generations 1 to 3 in both the generations of selection of the synthetics and in the array of means of the crosses at Knoxville (Table 8). Little change occurred from generations 3 to 10. At Crossville, there was a gradual reduction in the generation height means but no change in the array of cross means after generation 3. Increases from 3.15 to 3.64 and 3.33 to 3.97 occurred in the plant/ear height ratios at Knoxville and Crossville, respectively (Table 9). Generation mean ratios were greater at Knoxville than at Crossville, whereas cross means were slightly higher at Crossville.

A gradual reduction in number of leaves below the ear from generations 1 to 10 occurred at both locations (Table 10). There was a greater range in number of leaves below the ear in the synthetics than with the array means which was expected. With the decrease in the number of leaves below the ear, there was a corresponding increase in number of leaves above the ear (Table 11). Again, there was a narrower range in the array of cross means than in the generation means.

Differences between generations in the number of days from planting to pollen shed and silking were small for both generation means and in the array of means at both locations (Table 12).

Late low-ear synthetics. The array of means of the crosses for generations 1 to 10 showed a gradual reduction in ear height (Table 13). This amounted to 5.7 inches at Knoxville and 4.8 inches at Crossville, which was much less than the 14.1 inches and 11.5 inches reduction which occurred in the generation means at the locations, respectively.

TABLE 8

MEAN PLANT HEIGHT (INCHES) IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		95.8	95.3	93.7	94.9	96.1	94.9	100.2	95.1
3	101.7		94.4	91.8	93.0	92.6	93.5	94.1	93.5
5	99.2	97.0		93.2	89.9	90.8	93.3	92.7	92.8
7	100.0	96.7	96.3		94.0	90.4	91.1	93.1	92.4
8	100.1	98.2	94.9	95.2		91.1	93.5	93.8	92.7
9	101.4	98.4	96.6	94.3	94.5		93.2	92.1	92.4
10	103.4	100.4	96.8	94.4	96.3	96.6		93.0	93.3
Gen. Means	103.7	98.2	96.9	93.5	94.2	91.3	92.1		
Array of Cross Means	101.0	98.8	96.8	96.2	96.5	97.0	98.0		

TABLE 9

MEAN PLANT/EAR HEIGHT RATIOS IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		3.00	3.00	3.15	3.21	3.28	3.28	2.93	3.15
3	3.13		3.12	3.31	3.44	3.48	3.40	3.42	3.29
5	3.24	3.37		3.41	3.34	3.56	3.61	3.49	3.34
7	3.30	3.53	3.73		3.63	3.50	3.71	3.95	3.45
8	3.37	3.61	3.79	4.02		3.73	3.88	4.11	3.54
9	3.40	3.62	3.78	4.09	4.29		3.93	4.24	3.58
10	3.52	3.68	3.89	4.06	4.32	4.36		4.70	3.64
Gen. Means	3.12	3.39	3.72	4.18	4.29	4.33	4.46		
Array of Cross Means	3.33	3.49	3.63	3.79	3.90	3.92	3.97		

TABLE 10

MEAN NUMBER OF LEAVES BELOW THE EAR IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		6.4	6.3	6.5	6.4	6.4	6.4	6.5	6.4
3	6.4		6.3	6.0	6.1	5.9	6.0	6.2	6.1
5	6.1	6.2		6.0	5.9	5.9	5.9	6.0	6.1
7	6.2	6.1	5.9		5.9	5.8	5.8	6.1	6.0
8	6.3	6.1	5.6	5.6		5.8	5.7	5.9	6.0
9	6.3	6.2	5.6	5.6	5.7		5.7	5.8	5.9
10	6.1	6.1	5.6	5.7	5.4	5.4		5.2	5.9
Gen. Means	6.4	6.1	5.8	5.3	5.4	5.4	5.1		
Array of Cross Means	6.2	6.2	5.8	5.9	5.8	5.8	5.7		

TABLE 11

MEAN NUMBER OF LEAVES ABOVE THE EAR IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		6.3	6.2	6.3	6.3	6.6	6.5	6.0	6.4
3	6.0		6.3	6.6	6.6	6.6	6.6	6.1	6.5
5	6.1	6.2		6.6	6.7	6.7	6.7	6.4	6.5
7	6.3	6.4	6.4		6.7	6.7	6.7	6.6	6.6
8	6.4	6.4	6.4	6.4		6.7	6.9	6.6	6.7
9	6.4	6.5	6.4	6.5	6.5	6.5		6.8	6.7
10	6.4	6.6	6.5	6.5	6.5	6.5		6.8	6.7
Gen. Means	5.7	5.8	6.1	6.2	6.3	6.3	6.5		
Array of Cross Means	6.3	6.4	6.3	6.4	6.4	6.5	6.5		

TABLE 12

MEAN NUMBER OF DAYS FROM PLANTING TO 50 PERCENT POLLEN SHED AND SILKING IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE, TENNESSEE IN 1975. DAYS TO 50 PERCENT POLLEN SHED ABOVE DIAGONAL AND DAYS TO 50 PERCENT SILKING BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		60.6	60.6	60.1	60.8	60.1	60.9	60.7	60.5
3	61.3		60.8	59.6	59.5	60.5	60.3	59.7	60.2
5	60.8	60.9		60.0	60.1	60.0	59.9	60.4	60.2
7	60.1	60.2	60.9		60.0	59.6	60.0	59.5	60.0
8	61.2	59.8	60.7	60.1		59.6	60.0	60.2	60.0
9	60.2	61.1	60.4	59.4	59.9		59.7	59.8	59.9
10	61.3	60.8	60.0	60.8	60.5	60.8		59.3	60.2
Gen. Means	61.1	60.1	61.1	59.9	60.2	60.2	60.1		
Array of Cross Means	60.8	60.7	60.6	60.3	60.4	60.3	60.7		

TABLE 13

MEAN EAR HEIGHT (INCHES) IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		36.7	34.0	32.2	32.0	32.4	31.3	35.5	33.1
3	35.7		30.9	29.1	29.9	28.8	28.6	29.4	30.7
5	35.6	33.3		28.2	27.9	27.9	28.2	27.0	29.5
7	34.4	31.1	31.3		27.1	26.0	25.3	25.9	28.0
8	34.6	30.9	30.9	30.2		25.8	25.6	26.0	28.1
9	34.2	30.8	29.8	30.4	29.7		25.2	23.9	27.7
10	32.8	30.3	30.2	29.3	29.2	27.0		21.4	27.4
Gen. Means	36.9	36.2	31.3	29.0	29.1	27.7	25.4		
Array of Cross Means	34.6	32.0	31.9	31.1	30.9	30.3	29.8		

A slight reduction in plant height occurred from generations 1 to 10 in both the generation and array of cross means at Knoxville (Table 14). Little change occurred from generations 3 to 10. There was a gradual reduction in the array of cross plant height means from generations 1 to 8 at Crossville. Little change occurred after generation 8. The generation means of the synthetics at Crossville showed a gradual decline from generations 1 to 9, while generation 10 increased slightly.

Gradual increases in plant/ear height ratios occurred at Knoxville with the increases becoming less in the later generations (Table 15). Similar trends were observed for the array of cross means at Crossville. A wider range in plant/ear height ratios was observed in both the generation means of the synthetics and in the array of cross means at Knoxville.

There was a reduction of 0.4 leaves below the ear from generations 1 to 10 in the array of cross means at Knoxville and a drop of 0.3 leaves at Crossville (Table 16). The generation means exhibited a larger reduction at both locations.

As with the early synthetics, there was an increase in the number of leaves above the ear in both the generation means of the synthetics and in the array of means of their crosses (Table 17). The array of cross means increased 0.5 leaves above the ear from generations 1 to 10 at Knoxville and 0.3 leaves at Crossville. The increase in number of leaves above the ear in the generation means from generations 1 to 10 was 0.9 and 0.8 leaves at Knoxville and Crossville, respectively.

TABLE 14

MEAN PLANT HEIGHT (INCHES) IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		103.2	99.2	96.4	99.0	101.3	100.9	99.4	100.0
3	109.5		95.9	94.3	94.1	98.3	96.1	93.2	97.0
5	109.3	108.7		95.1	95.6	95.7	96.0	93.7	96.3
7	108.9	106.0	106.4		96.8	94.5	91.9	92.5	94.8
8	108.9	106.2	104.0	103.5		94.6	98.1	91.9	96.4
9	108.6	105.9	102.6	103.9	103.6		95.7	92.2	96.7
10	109.0	106.6	105.2	103.2	103.3	102.3		90.0	96.5
Gen. Means	111.4	110.0	106.9	104.6	104.9	101.9	102.6		
Array of Cross Means	109.0	107.2	106.0	105.3	104.5	104.5	104.9		

TABLE 15

MEAN PLANT/EAR HEIGHT RATIOS IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		2.86	2.97	3.05	3.16	3.16	3.29	2.84	3.08
3	3.12		3.17	3.29	3.18	3.52	3.53	3.22	3.24
5	3.13	3.32		3.46	3.47	3.50	3.49	3.56	3.34
7	3.23	3.46	3.48		3.62	3.70	3.74	3.66	3.48
8	3.20	3.50	3.43	3.56		3.72	3.93	3.63	3.51
9	3.27	3.46	3.52	3.49	3.58		3.91	3.94	3.59
10	3.41	3.60	3.60	3.60	3.66	3.91		4.31	3.63
Gen. Means	3.08	3.13	3.51	3.66	3.64	3.77	4.16		
Array of Cross Means	3.22	3.41	3.41	3.47	3.49	3.53	3.63		

TABLE 16

MEAN NUMBER OF LEAVES BELOW THE EAR IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		6.0	6.0	5.9	6.0	5.6	5.6	6.1	5.9
3	6.2		5.8	6.0	5.7	5.7	5.9	5.8	5.9
5	6.2	6.0		5.7	5.5	5.4	5.4	5.4	5.6
7	6.1	6.0	5.9		5.6	5.5	5.5	5.6	5.7
8	6.1	6.0	5.8	5.9		5.5	5.5	5.6	5.6
9	6.1	6.0	5.8	5.8	5.8		5.4	5.4	5.5
10	5.9	5.9	5.7	5.7	5.7	5.6		5.3	5.5
Gen. Means	6.2	6.0	5.9	5.9	5.9	5.8	5.7		
Array of Cross Means	6.1	6.0	5.9	5.9	5.9	5.9	5.8		

TABLE 17

MEAN NUMBER OF LEAVES ABOVE THE EAR IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		6.5	6.6	6.6	6.7	6.9	6.9	6.5	6.7
3	6.7		6.6	6.9	7.1	7.0	6.9	6.7	6.8
5	6.9	6.9		6.9	6.9	7.0	7.2	6.9	6.9
7	6.9	7.0	7.0		7.2	7.2	7.2	7.0	7.0
8	6.9	7.1	7.2	7.1		7.3	7.3	7.1	7.1
9	7.0	7.1	7.2	7.2	7.2		7.4	7.3	7.1
10	6.9	7.2	7.2	7.2	7.2	7.2		7.4	7.2
Gen. Means	6.4	6.4	6.7	6.9	6.9	7.0	7.2		
Array of Cross Means	6.9	7.0	7.1	7.1	7.1	7.2	7.2		

Small differences were observed in number of days from planting to pollen shed and silking in both the generation means of the synthetics and in the array of means of their crosses at both locations (Table 18).

A slight reduction in yield was noted in both the generation means and in the array of means of crosses of the early synthetics (Table 19). Even smaller reductions were noted in the late synthetics.

Analysis of Combining Ability

Analysis of variance of combining ability. Analysis of variance for combining ability was conducted following the procedure outlined in Griffing's (13) Method 4 Model I.

The general (gca) and specific (sca) combining ability variances of the different agronomic characters are shown in Tables 20 through 23. The gca and sca variance components also are presented for comparison. The mean squares, derived for differences in gca and sca, were significant at the .01 probability level with respect to all characters at both locations and in both the early and late maturing synthetics.

Except for yield of the late synthetics grown at Knoxville, general combining ability variances greatly exceeded those of specific combining ability (Tables 20 to 23). Magnitudes of mean squares were similar in the early and late synthetics grown at both locations.

These results suggest primarily additive gene action controlling the inheritance of these characters as shown by the high gca/sca variance ratios; however, nonadditive variation also was important.

TABLE 18

MEAN NUMBER OF DAYS FROM PLANTING TO 50 PERCENT POLLEN SHED AND SILKING IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE, TENNESSEE IN 1975. DAYS TO 50 PERCENT POLLEN SHED ABOVE DIAGONAL AND DAYS TO 50 PERCENT SILKING BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		65.4	65.9	65.5	65.5	65.8	65.5	65.5	65.6
3	69.1		65.9	65.9	65.6	66.5	67.1	65.5	66.1
5	69.8	69.8		66.7	66.8	65.8	66.8	65.8	66.3
7	69.3	69.8	70.6		66.9	66.5	65.6	66.1	66.2
8	69.1	68.9	71.2	71.3		66.7	67.5	67.3	66.5
9	69.9	70.6	69.5	70.7	70.5		66.4	66.7	66.3
10	69.2	68.9	70.3	69.3	71.2	69.7		66.0	66.5
Gen. Means	68.5	68.8	68.9	69.5	71.3	70.7	70.0		
Array of Cross Means	69.4	69.5	70.2	70.2	70.4	70.2	69.8		

TABLE 19

MEAN YIELDS IN POUNDS PER PLOT IN THE DIALLEL SET OF CROSSES IN SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT. GROWN AT KNOXVILLE, TENNESSEE, IN 1975. EARLY LOW-EAR SYNTHETICS ABOVE DIAGONAL AND LATE LOW-EAR SYNTHETICS BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	Gen. Means	Array of Cross Means
1		3.7	4.3	3.8	3.7	3.5	3.7	3.8	3.8
3	4.0		3.7	3.9	4.1	3.7	3.8	4.0	3.8
5	4.4	3.6		4.1	3.6	3.6	3.6	3.1	3.8
7	3.9	3.7	3.7		3.8	3.7	3.8	3.7	3.8
8	4.1	4.0	3.5	4.1		3.7	3.4	3.2	3.7
9	4.3	3.9	3.8	3.8	3.7		3.4	2.8	3.6
10	4.1	3.9	4.2	3.7	3.9	3.5		3.2	3.6
Gen. Means	4.1	3.7	3.5	3.5	3.7	3.6	3.6		
Array of Cross Means	4.1	3.9	3.9	3.8	3.8	3.8	4.0		

TABLE 20

ANALYSIS OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS IN THE DIALLEL SET OF CROSSES GROWN AT KNOXVILLE, TENNESSEE, IN 1975 (EARLY LOW-EAR SYNTHETICS)

		Mean Squares							
Source	df	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear	Days to Pollen Shed	Days to Silking	Yield
Replication	5	39.73	1016.70	0.96	1.26	0.85	47.12	68.70	1.17
Synthetic	20	570.35**	444.88**	5.36**	4.35**	2.03**	11.61**	17.63**	0.38**
Rep*Syn.	100	40.25**	122.44**	0.52**	1.18**	0.82**	6.60**	8.46**	0.11
Residual	1134	19.74	46.31	0.23	0.67	0.54	2.95	3.78	
General Combining Ability	6	1861.78**	1050.55**	17.02**	13.24**	5.78**	21.12**	18.31**	0.09**
Specific Combining Ability	14	16.98**	185.31**	0.36**	0.54**	0.41**	7.51**	15.43**	0.05**
Error	1134	0.329	0.772	0.004	0.011	0.009	0.049	0.063	0.010
Components									
$1/6\ \widehat{\Sigma q_i^2}$		6.21	3.50	0.06	0.02	0.02	0.07	0.08	0.02
$1/14\ \widehat{\Sigma\ \Sigma S_{ij}^2}$		0.28	3.09	0.01	0.01	0.01	0.13	0.60	0.05

**Indicates significance at the .01 probability level.

TABLE 21

ANALYSIS OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS IN THE DIALLEL SET OF CROSSES GROWN AT CROSSVILLE, TENNESSEE, IN 1975 (EARLY LOW-EAR SYNTHETICS)

Source	df	Mean Squares: Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear
Replication	5	112.27	327.48	0.86	2.30	1.23
Synthetic	20	581.31**	424.42**	8.06**	5.90**	1.13**
Rep*syn.	100	30.51**	86.50**	0.42**	1.70**	0.82**
General Combining Ability	6	1896.53**	1237.36**	25.77**	17.75**	2.86**
Specific Combining Ability	14	17.64**	76.01**	0.47**	0.86**	0.39**
Error	1134	0.319	0.784	0.005	0.012	0.008
Components						
$1/6\ \widehat{\Sigma q_i^2}$		6.32	4.12	0.09	0.06	0.01
$1/14\ \widehat{\Sigma\Sigma S_{ij}^2}$		0.31	1.27	0.01	0.02	0.01

**Indicates significance at the .01 probability level.

TABLE 22

ANALYSIS OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS IN THE DIALLEL SET OF CROSSES GROWN AT KNOXVILLE, TENNESSEE, IN 1975 (LATE LOW-EAR SYNTHETICS)

		Mean Squares							
Source	df	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear	Days to Pollen Shed	Days to Silking	Yield
Replication	5	27.77	1178.03	1.31	2.96	1.23	12.90	67.27	0.20
Synthetic	20	372.44**	192.26**	4.14**	2.94**	4.19**	24.12**	37.48**	0.27
Rep*syn.	100	37.48**	125.87**	0.38**	0.91**	0.93**	7.77**	18.95**	0.19
Residual	1134	20.04	45.31	0.24	0.68	0.62	4.22	9.48	
General Combining Ability	6	1198.58**	397.31**	12.97**	8.19**	12.97**	41.00**	59.51**	0.05**
Specific Combining Ability	14	18.38**	104.37**	0.34**	0.69**	0.40**	16.89**	28.04**	0.47**
Error	1134	0.334	0.755	0.004	0.011	0.012	0.070	0.158	0.019
Components									
$1/6\ \widehat{\Sigma q_i^2}$		4.00	1.32	0.04	0.03	0.26	0.13	0.19	0.02
$1/14\ \widehat{\Sigma\Sigma S_{ij}^2}$		0.31	1.98	0.01	0.01	0.01	0.49	0.47	0.03

*Indicates significance at the .01 probability level.

TABLE 23

ANALYSIS OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS IN THE DIALLEL SET OF CROSSES GROWN AT CROSSVILLE, TENNESSEE, IN 1975

Source	df	Mean Squares				
		Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear
Replication	5	84.02	209.18	1.75	2.29	1.77
Synthetic	20	326.26**	375.85**	2.22**	1.70**	1.36**
Rep*Syn.	100	35.51**	69.81**	0.45**	1.88**	1.14**
Residual	1134	24.52	37.86	0.27	0.67	0.61
General Combining Ability	6	1045.05**	1127.19**	6.85**	5.42**	3.95**
Specific Combining Ability	14	18.21**	53.84**	0.23**	0.11**	0.25**
Error	1134	0.408	0.633	0.004	0.011	0.010
Components						
$1/6\ \widehat{\Sigma q_i^2}$		3.48	3.75	0.02	0.02	0.01
$1/14\ \widehat{\Sigma \Sigma S_{ij}^2}$		0.29	0.91	0.00	0.00	0.00

**Indicates significance at the .01 probability level.

Combining Ability Effects

The general combining ability effects (g_i) for the different generations of synthetics and the specific combining ability effects (s_{ij}) in their crosses were estimated according to Griffing (13). These effects, along with their appropriate standard errors, are shown in Table 24 through 29 for the early synthetics and in Tables 30 through 36 for the late synthetics.

Early low-ear synthetics. Values for gca effects on ear height were highly significant at both Knoxville and Crossville except for generation 5 (Table 24). There was an indication that progress in selecting for lower ear placement in the later generations was reduced since the effects were lower in these generations.

Only the cross of generations 1 × 3 grown at Knoxville had a significant positive sca effect on ear height. This indicates that this particular cross had a significantly higher ear placement than the other crosses which is substantiated by the data in Table 13, page 44. There was a trend toward lower sca values in the crosses of the later generations which indicates less variation in those crosses.

Generation 1 had a larger gca value for plant height at both locations and was the only significant one at Knoxville (Table 25). There was no consistent reductions in values after the third generation, although values were significant (.01 level) at Crossville, except for generation 10, indicating that, after the initial reduction in plant height, the height remained almost consistent with each succeeding generation of selection. This was expected since a minimum plant height

TABLE 24

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON EAR HEIGHT ASSOCIATED WITH EACH OF THE SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		1.10**	-0.26	-0.25	-0.51	0.30	-0.38	4.68**
3	-0.78		-0.47	-0.44	0.31	-0.32	-0.17	1.77**
5	-0.67	-0.51		0.09	-0.30	0.17	0.83	0.39
7	0.30	-0.20	0.12		0.75	0.09	-0.24	-1.46**
8	0.48	0.43	0.32	0.07		-0.20	-0.04	-1.35**
9	0.34	0.51	0.38	-0.17	-0.62		-0.03	-1.82**
10	0.33	0.55	0.37	-0.13	-0.68	-0.68		-2.20**
G.C.A.	4.55**	2.12**	0.32	-1.22**	-1.85**	-1.93**	-1.99**	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.47	0.36
S.E. $(S_{ij} - S_{ik})$[2]	0.73	0.71

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 25

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON PLANT HEIGHT ASSOCIATED WITH EACH OF THE SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		2.31**	-0.80	-1.93*	-1.08	0.80	0.71	3.82**
3	-1.13		-0.42	-0.39	-2.42**	1.41	-0.49	0.22
5	-1.34	-0.81		1.30	-0.03	-0.33	-0.27	-0.67
7	0.23	-0.30	1.63*		2.86**	0.31	-2.15*	-0.23
8	-0.02	0.69	-0.27	0.81		-1.59	2.27**	-0.53
9	0.73	0.34	0.93	-0.60	-0.88		-0.63	-0.19
10	1.54*	1.21	-0.14	-1.76	-0.32	-0.52		-0.39
G.C.A.	3.90**	1.21**	-1.21**	-1.92**	-1.47**	-0.94**	0.35	

	Knoxville	Crossville
S.E. $(S_{ij})^1$	0.72	0.56
S.E. $(S_{ij} - S_{ik})^2$	1.11	1.12

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 26

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON PLANT/EAR HEIGHT RATIOS ASSOCIATED WITH EACH OF THE SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		0.05	0.04	-0.05	0.02	-0.07	0.01	-0.40**
3	0.16**		0.04	0.00	-0.15**	0.10	-0.04	-0.20**
5	0.10	0.03		0.05	0.02	-0.04	-0.11*	-0.08**
7	-0.03	0.00	0.03		0.01	0.00	-0.02	0.08**
8	-0.10	-0.05	-0.04	0.00		-0.02	0.13**	0.13**
9	-0.09	-0.07	-0.08	0.04	0.11		0.03	0.21**
10	-0.03	-0.07	-0.03	-0.04	-0.04	0.08	0.09	0.27**
G.C.A.	-0.48**	-0.27**	-0.10**	0.08**	0.22**	0.24**	0.30**	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.06	0.05
S.E. $(S_{ij} - S_{ik})$[2]	0.09	0.09

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 27

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON NUMBER OF LEAVES BELOW THE EAR ASSOCIATED WITH EACH OF THE SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		-0.17	-0.10	0.08	0.06	0.08	0.06	0.44**
3	-0.16		0.23*	-0.04	0.01	-0.02	0.00	0.08
5	-0.11	0.03		-0.06	-0.07	-0.01	0.29*	-0.04
7	-0.04	-0.09	0.18		0.02	0.00	0.01	-0.08
8	0.16	0.01	-0.05	-0.05		0.01	-0.03	-0.11*
9	0.12	0.18	-0.05	-0.05	0.05		-0.05	-0.12**
10	0.04	-0.18*	0.01	0.06	-0.11	-0.14		-0.18**
G.C.A.	0.38**	0.31**	-0.08	-0.08	-0.15**	-0.14**	-0.24**	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.08	0.07
S.E. $(S_{ij} - S_{ik})$[2]	0.13	0.14

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 28

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON NUMBER OF LEAVES ABOVE THE EAR ASSOCIATED WITH EACH OF THE SEVEN GENERATIONS OF SELECTIONS FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		0.05	-0.05	-0.06	-0.08	0.15	-0.19	-0.23**
3	-0.17		-0.13	0.05	0.04	-0.02	-0.04	-0.11**
5	-0.26	-0.09		0.07	0.08	0.02	0.01	-0.06
7	0.06	0.02	0.05		0.02	-0.03	-0.07	0.05
8	0.09	0.03	0.01	-0.04		-0.13	0.06	0.07
9	0.03	0.10	0.03	-0.04	-0.07		-0.04	0.14**
10	-0.01	0.10	0.02	-0.06	-0.02	0.03		0.14**
G.C.A.	-0.16**	-0.06	-0.07	0.03	0.05	0.08*	0.13**	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.08	0.08
S.E. $(S_{ij} - S_{ik})$[2]	0.38	0.11

[1]Standard error of estimate of sca between ith and jth line.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 29

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON NUMBER OF DAYS TO POLLEN SHED AND SILKING ASSOCIATED WITH EACH OF SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE, TENNESSEE, IN 1975. DAYS TO POLLEN SHED ABOVE DIAGONAL AND DAYS TO SILKING BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		-0.07	-0.11	-0.24	0.40*	-0.22	0.24	0.46**
3	0.27		0.47*	-0.40*	-0.55**	0.56**	0.00	0.10
5	-0.17	0.09		0.02	0.00	-0.00	-0.38	0.13
7	-0.44*	-0.15	0.57**		0.27	-0.02	0.37	-0.27**
8	0.53*	-0.75**	0.29	0.10		-0.10	-0.01	-0.17
9	-0.48*	0.66**	0.08	-0.46*	-0.16		-0.22	-0.28**
10	0.28	-0.12	-0.87**	0.36	-0.02	0.36		0.04
G.C.A.	0.31**	0.20	0.12	-0.34**	-0.21	-0.30**	0.22*	

	Pollen shed	Silking
S.E. (S_{ij})[1]	0.18	0.21
S.E. $(S_{ij} - S_{ik})$[2]	0.28	0.32

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 30

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON EAR HEIGHT ASSOCIATED WITH EACH OF THE SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975.

Generation	1	3	5	7	8	9	10	G.C.A.
1		-0.30	0.46	-0.25	-0.31	0.44	-0.05	3.47**
3	-0.04		0.65	-0.61	0.45	-0.71	0.50	1.60**
5	0.02	0.74		-0.11	-0.03	-0.84	-0.13	0.63*
7	-0.27	-0.51	-0.16		0.25	0.94	-0.21	-0.84**
8	0.16	-0.53	-0.32	-0.11		-0.00	-0.37	-1.16**
9	0.43	0.12	-0.66	0.76	0.34		0.23	-1.78**
10	-0.32	0.22	0.37	0.28	0.44	-1.00		-1.97**
G.C.A.	3.65**	0.62*	0.40	-0.46	-0.72**	-1.43**	-2.06**	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.47	0.52
S.E. $(S_{ij} - S_{ik})$[2]	0.73	0.81

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 31

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON PLANT HEIGHT ASSOCIATED WITH EACH OF THE SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		-0.09	0.23	-0.85	-0.12	1.57*	0.68	2.34**
3	-1.53*		1.22	-0.84	-0.04	-0.04	-0.19	0.43
5	-0.39	1.25		1.43	-2.35**	-0.96	1.72*	-0.41
7	0.10	-0.58	1.12		2.35**	-0.96	-1.22	-0.98*
8	0.50	0.06	-0.74	-0.43		-0.62	0.80	-0.51
9	0.77	0.03	-1.66*	0.52	0.74		1.15	-0.95
10	0.56	0.52	0.42	-0.73	0.13	0.84		0.09
G.C.A.	3.67**	1.40**	0.08	-0.81*	-1.28**	-1.79**	-1.25**	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.71	0.65
S.E. $(S_{ij} - S_{ik})$[2]	1.10	1.00

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 32

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON PLANT/EAR HEIGHT RATIOS ASSOCIATED WITH EACH OF SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		0.06	0.01	0.02	-0.02	0.00	-0.07	-0.33**
3	-0.01		-0.04	0.02	0.04	0.03	-0.14**	-0.16**
5	0.00	-0.04		0.05	-0.12*	0.06	0.04	-0.10**
7	0.03	0.04	0.06		0.04	-0.14**	0.00	0.03
8	-0.02	0.06	-0.03	0.04		0.00	0.06	0.13**
9	-0.02	0.04	0.02	-0.08	-0.02		-0.16**	0.18**
10	0.02	-0.08	-0.02	-0.09	-0.05	0.14**		0.25**
G.C.A.	-0.27**	-0.05	-0.05	0.02	0.04	0.10**	0.21**	

	Knoxville	Crossville
S.E. $(S_{ij})^1$	0.06	0.06
S.E. $(S_{ij} - S_{ik})^2$	0.08	0.08

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 33

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON NUMBER OF LEAVES BELOW THE EAR ASSOCIATED WITH EACH OF SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		-0.10	0.14	-0.03	0.15	-0.06	-0.10	0.23**
3	-0.05		-0.07	0.12	-0.13	0.01	0.17	0.22**
5	0.06	0.02		0.06	-0.06	-0.01	-0.07	-0.05
7	-0.04	-0.02	-0.02		-0.03	-0.03	-0.09	0.01
8	0.01	0.03	-0.02	-0.01		0.04	0.04	-0.06
9	0.06	0.03	-0.04	0.00	-0.01		0.06	-0.18**
10	-0.04	0.00	0.00	0.08	0.01	0.10		-0.16**
G.C.A.	0.23**	0.12**	-0.03	-0.01	-0.05	-0.09	-0.17**	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.08	0.08
S.E. $(S_{ij} - S_{ik})$[2]	0.13	0.13

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 34

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON NUMBER OF LEAVES ABOVE THE EAR ASSOCIATED WITH EACH OF SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE AND CROSSVILLE, TENNESSEE, IN 1975. KNOXVILLE DATA ABOVE DIAGONAL AND CROSSVILLE DATA BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		0.00	0.02	-0.09	-0.02	0.04	-0.06	-0.33**
3	-0.10		-0.07	0.06	0.14	0.02	-0.15	-0.16**
5	0.06	-0.06		0.02	-0.08	-0.03	0.14	-0.10*
7	0.03	0.03	-0.11		0.05	-0.04	0.01	0.03
8	-0.01	0.05	0.06	-0.02		0.01	-0.09	0.13**
9	0.03	-0.01	0.02	0.03	0.05		0.06	0.20**
10	-0.01	0.09	0.03	0.04	-0.13	-0.02		0.23**
G.C.A.	-0.21**	-0.09*	-0.02	0.03	0.08	0.10*	0.11*	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.08	0.06
S.E. $(S_{ij} - S_{ik})$[2]	0.13	0.13

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 35

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON NUMBER OF DAYS TO POLLEN SHED AND SILKING ASSOCIATED WITH EACH OF SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE, TENNESSEE, IN 1975. DAYS TO POLLEN SHED ABOVE DIAGONAL AND DAYS TO SILKING BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		0.03	0.27	0.06	-0.35	0.26	-0.28	-0.73**
3	0.32		-0.28	-0.02	-0.84**	0.40	0.71**	-0.17
5	0.21	0.07		0.38	0.14	-0.64**	0.14	0.12
7	-0.23	0.10	0.06		0.37	0.18	-0.96**	-0.02
8	-0.71*	-1.14**	0.46	0.58		-0.71**	1.67**	0.36**
9	0.31	0.97**	-1.04**	0.22	-0.18		0.23	0.10
10	0.10	-0.32	0.24	-0.73*	1.00**	-0.28		0.34**
G.C.A.	-0.64**	-0.49**	0.30	0.26	0.53**	0.24	-0.20	

	Pollen shed	Silking
S.E. (S_{ij})[1]	0.22	0.25
S.E. $(S_{ij} - S_{ik})$[2]	0.34	0.50

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

TABLE 36

ESTIMATES OF GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITY EFFECTS ON YIELD ASSOCIATED WITH EACH OF SEVEN GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT (EARLY AND LATE LOW-EAR SYNTHETICS). GROWN AT KNOXVILLE, TENNESSEE, IN 1975. EARLY SYNTHETICS ABOVE DIAGONAL AND LATE SYNTHETICS BELOW DIAGONAL.

Generation	1	3	5	7	8	9	10	G.C.A.
1		-0.13	0.28	-0.18	-0.09	0.20	-0.09	0.30**
3	-0.21		-0.18	-0.03	0.17	0.08	0.08	-0.03
5	0.37	-0.19		-0.10	-0.32	-0.02	0.33	-0.05
7	-0.22	-0.01	0.11		0.30	0.10	-0.10	-0.09
8	-0.03	0.31	-0.19	-0.03		-0.10	0.03	-0.05
9	-0.08	0.01	-0.06	0.01	0.13		-0.27	-0.07
10	0.07	0.09	-0.04	0.07	-0.19	0.00		-0.02
G.C.A.	0.06	0.09	0.10	0.12	-0.03	-0.18*	-0.15*	

	Knoxville	Crossville
S.E. (S_{ij})[1]	0.09	0.13
S.E. $(S_{ij} - S_{ik})$[2]	0.13	0.18

[1]Standard error of estimate of sca between ith and jth lines.

[2]Standard error to compare the estimate of sca of crosses within the same parental array.

criteria was imposed throughout the cycles of selection. Six of the 21 sca values were significant in the Knoxville data while only two were significant in the Crossville data.

Values of gca for the plant/ear height ratios ranged from -0.40 to 0.27 at Knoxville and -0.48 to 0.30 at Crossville and all were significant at the .01 probability level (Table 26, page 60). Values of generations 7 to 10 were all positive and show that selecting for lower ear height caused less change per generation in the plant/ear height ratios. Only three sca values for plant/ear height ratio were significant at Knoxville and only one at Crossville.

There were significant gca effects on number of leaves below the ear (Table 27, page 61). Less change occurred in the later generations of selection, as would be expected. Generations 5 and 7 had values indicating that a small reduction in number of leaves below the ear was obtained. The crosses of generations 3 × 5 and 5 × 10 showed significant positive sca effects on number of leaves below the ear. On the other hand, generations 3 × 10 showed a significant negative sca effect on number of leaves below the ear at Crossville.

The gca effects on number of leaves above the ear ranged from highly significant negative values for the earlier generations to highly significant positive values for the later generations (Table 28, page 62). This is an indication that the increase per generation in number of leaves was less in the later generations. None of the sca effects were significant.

The gca effects on number of days to 50 percent pollen shed and silking varied among the different generations but were similar for the two characters (Table 29, page 63). Generation 1 had higher positive gca effects whereas generations 7 and 9 had high negative gca effects. This variation would be expected since selection was made within a specific flowering range. The sca effects on number of days to 50 percent pollen shed and silking were variable, as both significant positive and negative effects were noted. Effects were generally greater in crosses between the early and the later generations of selection.

Late low-ear synthetics. Values for ear height ranged from highly significant positive gca effects in the earlier generations of selection to highly significant negative effects in the later generations at both locations, indicating that selection for low ear placement was effective (Table 30, page 64). Trends in the late synthetics were similar to those in the early maturing synthetics. There were no significant sca effects on ear height.

A high positive gca effect for plant height was observed in the first generation of selection (Table 31, page 65). All generations, except generation 5, showed significant gca effects at Crossville. The sca effects on plant height were variable among individual crosses at both locations. Significant positive sca effects in the crosses of generations 1 × 9, 5 × 10, and 7 × 8 at Knoxville and 1 × 3 and 5 × 9 at Crossville were observed.

A trend from significant negative gca values for plant/ear height ratios to significant positive gca values was observed at both locations, indicating the same effectiveness of selection for this trait as selection for ear height (Table 32, page 66). Plant/ear height ratio tended to remain stable in the later generations. The sca effects on plant/ear height ratios were small and variable.

Gca effects on number of leaves below the ear ranged from high positive effects in generation 1 to high negative effects for generation 10 (Table 33, page 67). As was shown in the early synthetics, smaller differences were noted in the later generations. There were no significant sca effects on number of leaves below the ear.

Gca effects on number of leaves above the ear had a greater range at Knoxville than at Crossville. The ranges were -0.33 to 0.23 for the Knoxville data and -0.21 to 0.11 for the Crossville data (Table 34, page 68). Again, less progress was made in the later generations than in the earlier generations of selection.

Gca effects on days from planting to 50 percent pollen shed and silking varied among the different generations (Table 35, page 69). In the Knoxville data, there was a trend toward more positive numbers in the later generations of selection. The sca effects were quite variable and both positive and negative values were obtained but none were significant.

The gca effects on yield in the first generation of the early synthetics were significant and positive (Table 36, page 70). After the initial decline, yields remained almost constant. Significant negative gca effects were observed in generations 9 and 10 in the late synthetics. This indicates that there were lower yields in the later generations of selection, possibly an indication of inbreeding depression. There were no significant sca effects on yield.

III. LOW-EAR SYNTHETICS CROSSED TO HIGH AND LOW-EAR TESTERS

This study was conducted to determine the amount of progress made in selecting for low-ear placement in eight early and eight late low-ear synthetic populations developed by phenotypic recurrent selection. Each synthetic was crossed to a high-ear and to a low-ear single cross.

The data from generations 5 and 6 were purposely deleted from the analyses because measurements from these generations were inconsistent with the remaining generations and from the previous experiment with the diallel set of crosses. This was possibly due to genotype-environment interaction.

Agronomic Performance

Early low-ear synthetics. The early synthetics themselves and their progenies from crosses to the high-ear tester showed a continuous reduction in ear height from generation 1 through generation 8 (Table 37). Reductions in ear height in the crosses to the low-ear tester were small and somewhat inconsistent. Reductions in plant height were continuous throughout the generations but were somewhat inconsistent in the crosses.

Plant/ear height ratios increased consistently with each generation of selection; however, in the crosses, the increases in ratio were small and somewhat variable. Other characters measured also were somewhat inconsistent.

Late low-ear synthetics. Results similar to those for the early synthetics were obtained with the late synthetics, but height data

TABLE 37

GENERATION MEANS OF VARIOUS CHARACTERS IN SIX GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT AND TESTCROSSES TO A HIGH- AND TO A LOW-EAR TESTER (EARLY LOW-EAR SYNTHETICS)

Generation	Ear Height (Inches)	Plant Height (Inches)	Plant/ear Height Ratio	Leaves Below the Ear (no.)	Leaves Above the Ear (no.)	Days to 50% Pollen Shed	Days to Silking	Yield (lbs/plot)
	Synthetics							
1	28.9	80.2	2.85	7.2	5.9	68.9	71.4	3.4
2	27.2	78.8	2.97	6.9	5.7	66.9	69.4	3.6
3	85.0	74.6	3.08	7.2	6.0	67.3	69.6	3.9
4	25.1	75.2	3.09	7.2	6.1	66.6	68.9	3.7
7	20.5	73.8	3.76	6.1	6.1	67.2	70.2	2.8
8	20.6	71.7	3.56	6.4	5.8	66.7	68.4	3.0
	High-ear tester (T224 × T232)							
1	39.0	94.8	2.47	8.3	6.3	70.7	72.1	5.5
2	38.3	93.2	2.47	8.3	6.5	68.3	70.1	4.8
3	37.4	89.2	2.41	7.9	6.2	68.7	71.0	5.3
4	36.7	88.5	2.43	8.3	6.3	68.9	71.2	4.7
7	35.9	89.3	2.52	8.3	6.5	67.3	69.9	5.2
8	34.9	88.8	2.58	8.0	6.5	68.6	70.7	4.4
	Low-ear tester (Mo12Y × T458R)							
1	32.2	82.2	2.61	8.1	6.1	68.8	72.3	3.8
2	33.8	87.5	2.64	7.8	6.2	67.9	71.3	4.2
3	32.8	82.5	2.54	7.8	5.8	66.7	69.9	4.2
4	31.3	81.8	2.65	7.8	6.1	68.6	71.6	4.4
7	31.4	81.6	2.65	7.7	6.3	67.2	70.6	4.7
8	31.3	82.5	2.68	7.8	5.9	66.3	70.4	4.2

appeared to be more inconsistent (Table 38). Number of leaves below the ear generally decreased following each generation, especially generations 7 and 8, while number of leaves above the ear increased slightly. Crosses to both testers had more leaves below the ear initially, but a reduction in number occurred with each succeeding generation of selection. Numbers of leaves above the ear in the synthetics and their crosses were similar.

Analysis of Variance

Early low-ear synthetics. Significant differences in the various characters were detected with respect to all characters except number of leaves above the ear and days to silking in the synthetics (Table 39). Mean squares of ear and plant height and days to 50 percent pollen shed and silking were significant (.01 level) in the testcross with the high-ear tester. However, only mean squares of plant height and days to 50 percent pollen shed were significant in the testcrosses with the low-ear tester.

Late low-ear synthetics. Mean squares of ear height, plant/ear height ratio, leaves below the ear, and days to 50 percent pollen shed and silking were significant in the late synthetics (Table 40). In the testcrosses with the high-ear tester, plant height and days to 50 percent pollen shed and silking mean squares were significant (.01 level). Except for mean squares of leaves below the ear and yield all of the characters' mean squares were significant (.01 level) in the testcrosses with the low-ear tester.

TABLE 38

GENERATION MEANS OF VARIOUS CHARACTERS IN SIX GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT AND IN TESTCROSSES TO A HIGH- AND TO A LOW-EAR TESTER (LATE LOW-EAR SYNTHETICS)

Generation	Ear Height (Inches)	Plant Height (Inches)	Plant/ear Height Ratio	Leaves Below the Ear (no.)	Leaves Above the Ear (no.)	Days to 50% Pollen Shed	Days to Silking	Yield (lbs/plot)
				Synthetics				
1	30.3	83.5	2.80	7.6	6.2	72.1	75.2	3.8
2	29.8	85.0	2.89	7.7	6.4	71.9	75.2	4.4
3	25.9	82.8	3.30	6.9	6.8	71.7	75.3	3.5
4	28.3	78.3	2.82	7.6	6.7	71.9	75.4	3.8
7	26.8	82.5	3.14	7.6	6.7	71.9	76.2	3.5
8	24.3	81.8	3.45	7.1	6.5	73.9	77.4	3.6
				High-ear tester (T232 × SC155Y)				
1	44.7	98.3	2.24	8.8	6.4	73.7	75.7	4.8
2	42.6	98.3	2.33	8.9	6.5	74.2	77.1	5.2
3	41.2	91.5	2.24	9.1	6.5	75.9	78.5	4.4
4	41.4	93.7	2.30	8.4	6.5	75.2	78.6	4.8
7	41.2	96.5	2.38	8.7	6.9	76.8	80.3	5.0
8	41.9	98.8	2.39	8.4	6.8	75.1	79.5	5.3
				Low-ear tester (Mo12Y × T458R)				
1	38.3	91.3	2.39	8.7	6.0	69.6	72.7	4.8
2	39.1	95.7	2.46	8.4	6.3	68.7	75.1	5.4
3	40.9	96.6	2.38	8.3	6.4	70.0	73.5	5.0
4	36.6	88.7	2.45	8.6	6.1	69.7	73.0	5.2
7	36.6	94.3	2.61	8.0	6.7	70.3	75.1	4.9
8	36.9	93.9	2.55	8.6	6.5	72.6	75.7	5.1

TABLE 39

ANALYSIS OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS IN SIX GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT AND TESTCROSSES TO A HIGH- AND TO A LOW-EAR TESTER (EARLY LOW-EAR SYNTHETICS)

		Mean Squares							
Source	df	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear	Days to 50% Pollen Shed	Days to Silking	Yield
				Synthetics					
Replication	2	425.16	481.35	4.00	4.24	2.47	85.68	76.23	0.11
Generation	5	355.66**	306.64**	3.87**	6.66**	0.73	12.88**	19.12	0.58*
Residual#	172	22.44	66.74	0.27	1.41	0.52	2.91	5.88	0.15
				High-ear tester (T224 × T232)					
Replication	2	738.62	1011.12	1.00	2.34	0.82	49.59	34.23	0.18
Generation	5	69.13**	212.54**	0.12	1.75	0.45	21.41**	11.65**	0.49
Residual#	172	21.28	65.04	0.08	0.78	0.50	3.72	4.52	0.24
				Low-ear tester (Mo12Y × T458R)					
Replication	2	619.00	909.57	1.43	0.29	2.07	28.58	21.29	0.98
Generation	5	29.90	150.20*	0.07	0.62	0.86	17.93**	13.97	0.23
Residual#	172	21.10	50.74	0.13	1.00	0.49	4.81	9.47	0.20

*, **Indicate significance at the .05 and .01 probability levels, respectively.

#df for days to pollen shed and silking is 100 and for yield is 10.

TABLE 40

ANALYSIS OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS IN SIX GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT AND TESTCROSSES TO A HIGH- AND TO A LOW-EAR TESTER (LATE LOW-EAR SYNTHETICS)

		Mean Squares							
Source	df	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear	Days to 50% Pollen Shed	Days to Silking	Yield
				Synthetics					
Replication	2	60.67	638.71	0.32	1.25	0.47	39.23	46.08	0.98
Generation	5	162.00**	146.51	2.20**	2.41*	1.33	15.50*	14.44	0.39
Residual#	172	22.77	81.59	0.24	1.04	0.64	5.43	8.30	0.30
				High-ear tester (T232 × SC155Y)					
Replication	2	889.36	1562.82	0.62	5.76	2.40	7.00	24.73	0.40
Generation	5	54.46	263.86**	0.13	2.01	1.22	22.37**	49.86**	0.34
Residual#	172	29.12	59.09	0.06	0.95	0.55	5.07	9.24	0.38
				Low-ear tester (Mo12Y × T458R)					
Replication	2	60.69	512.22	0.12	1.06	1.12	14.78	61.16	0.87
Generation	5	87.80**	258.61**	0.24**	1.98	2.09**	30.48**	33.95**	0.13
Residual#	172	22.17	73.44	0.06	1.06	0.46	5.59	7.69	0.14

*, **Indicate significance at the .05 and .01 probability levels, respectively.

#df for days to pollen shed and silking is 100 and for yield is 10.

Regression Analysis

Regression analysis was done to determine average changes which occurred in the various agronomic characters per generation of selection for lower ear height (Table 41).

Ear height decreased significantly in the early synthetics (-1.20 inches per generation) and in their crosses to the high-ear tester (-0.53 inches per generation). Ear height also decreased significantly in the late synthetics (-0.68 inches per generation) and in their crosses to the low-ear tester (-0.37 inches per generation). Plant height was reduced in only the early synthetics and in their crosses to the high-ear tester. The plant/ear height ratios increased significantly in all genotypes, except in the early synthetics crossed to the low-ear tester.

The number of leaves below the ear decreased significantly in the early synthetics and in their testcrosses to the high-ear tester (Table 41). The number of leaves below the ear decreased also in the crosses of the late synthetics to the high-ear tester. The number of leaves above the ear increased significantly in only the late synthetics crossed to the two testers.

The number of days to 50 percent pollen shed increased significantly in the early synthetic generations in testcrosses to the high-ear tester (Table 41). The number of days to pollen shed also increased in the late synthetics and in their crosses to the low-ear tester. A reduction in the number of days to pollen shed occurred in the early synthetics and in the cross of the late synthetics to the high-ear tester.

TABLE 41

REGRESSION ANALYSES OF VARIOUS AGRONOMIC CHARACTERS WITHIN SIX GENERATIONS OF SELECTION FOR LOWER EAR HEIGHT. DATA FROM SYNTHETICS AND TESTCROSSES TO A HIGH AND TO A LOW-EAR TESTERS

	Early Synthetics			Late Synthetics		
Character	Y Intercept	Slope	Prob.	Y Intercept	Slope	Prob.
	----------------Synthetics----------------					
Ear height (inches)	29.60	-1.20	**	30.40	-0.68	**
Plant height (inches)	80.05	-1.00	**	83.50	-0.28	ns
Plant/ear ht. ratio	2.71	+0.12	**	2.78	+0.07	**
Leaves below the ear (no.)	7.41	-0.14	**	7.56	-0.05	ns
Leaves above the ear (no.)	5.86	-0.01	ns	6.40	+0.02	ns
Days to 50% pollen shed	67.95	-0.17	*	71.26	+0.29	**
Days to silking	70.51	-0.20	ns	74.57	+0.29	*
Yield (lbs/plot)	3.87	-0.11	*	4.82	+0.03	ns
	-----------High-ear testers-----------					
	(T224 × T232)			(T232 × SC155Y)		
Ear height (inches)	39.24	-0.53	**	43.40	-0.30	ns
Plant height (inches)	93.55	-0.71	**	95.61	+0.14	ns
Plant/ear ht. ratio	2.41	+0.02	*	2.23	+0.02	**
Leaves below the ear (no.)	8.35	-0.06	*	9.01	-0.06	*
Leaves above the ear (no.)	6.26	+0.03	ns	6.34	+0.07	**
Days to 50% pollen shed	74.06	+0.26	**	69.76	-0.25	**
Days to silking	76.01	+0.54	**	71.47	-0.15	ns
Yield (lbs/plot)	5.30	-0.08	ns	4.62	+0.06	ns
	------Low-ear tester (Mo12Y × T458R)---------					
Ear height (inches)	33.16	-0.24	ns	39.61	-0.37	**
Plant height (inches)	84.37	-0.34	ns	93.19	+0.26	ns
Plant/ear ht. ratio	2.59	+0.01	ns	2.36	+0.03	**
Leaves below the ear (no.)	7.96	-0.03	ns	8.56	-0.03	ns
Leaves above the ear (no.)	6.06	0.00	ns	6.05	+0.07	**
Days to 50% pollen shed	68.62	-0.25	ns	68.57	+0.38	**
Days to silking	71.81	-0.19	ns	71.78	+0.47	**
Yield (lbs/plot)	3.98	+0.06	ns	5.08	0.00	ns

The number of days to silking increased significantly in the crosses of the early synthetics to the high-ear tester. The number of days to silking also increased in the late synthetics and in their crosses to the low-ear tester. A significant regression of yield on generations of synthetics was exhibited in the early synthetics.

IV. ANALYSIS OF SEGREGATING AND NONSEGREGATING GENERATIONS OF THE CROSSES E199 × Mo18W and T232 × T458R

The means, ranges, and standard deviations of various characters in the parents, F_1, F_2, and backcrosses to the parents of the crosses E199 × Mo18W and T232 × T458R are summarized in Tables 42 and 43, and the means are presented graphically in Figures 9 through 13.

Cross E199 × Mo18W

The mean ear height of E199 was approximately one-half that of Mo18W (Figure 9). The ear height of the F_1 was higher than any of the subsequent generations. Both backcrosses had ear heights approximately midway between the respective parents and the F_1.

Histograms of plant height illustrates the same general pattern as those of ear height (Figure 10). E199 was shorter than Mo18W, and the backcrosses were approximately midway between the respective parents and the F_1.

E199 had a much higher plant/ear height ratio than any of the other generations (Figure 11). The backcross of E199 also reflected the influence on plant/ear height ratio of E199. Ratios for Mo18W, the F_1, and F_2 and the backcross to Mo18W were similar in magnitude. E199 had

TABLE 42

INDIVIDUAL PLANT MEANS OF VARIOUS AGRONOMIC CHARACTERS FOR PARENTS, F_1, F_2, AND FIRST BACKCROSS POPULATIONS FROM THE CROSS E199 × Mo18W GROWN AT CROSSVILLE, TENNESSEE in 1974

Population	No. of Plants	Mean	Range	S.E.	C.V. (%)
	Ear height (inches)				
P_1	30	15.7	9.0 - 19.0	2.6	16.3
P_2	30	29.2	22.0 - 35.0	3.2	11.0
F_1	30	36.6	32.0 - 44.0	3.1	8.4
F_2	120	29.0	20.0 - 40.0	4.7	16.3
B_1	120	25.7	17.0 - 38.0	3.7	14.5
B_2	120	33.0	25.0 - 44.0	4.0	12.2
	Plant height (inches)				
P_1	30	55.0	45.0 - 63.0	4.2	7.6
P_2	30	70.3	53.0 - 79.0	5.5	7.8
F_1	30	85.4	78.0 - 96.0	4.0	4.7
F_2	120	70.1	43.0 - 88.0	8.3	11.8
B_1	120	70.4	52.0 - 88.0	7.3	10.3
B_2	120	75.9	61.0 - 95.0	6.6	8.8
	Plant/ear ratio				
P_1	30	3.61	2.37 - 5.78	0.8	20.8
P_2	30	2.42	2.07 - 2.98	0.2	9.3
F_1	30	2.35	1.89 - 2.73	0.2	8.0
F_2	120	2.46	1.51 - 3.55	0.4	15.4
B_1	120	2.77	1.80 - 4.00	0.4	12.8
B_2	120	2.32	1.90 - 3.20	0.2	9.9
	Number of leaves below the ear				
P_1	30	6.4	4.0 - 8.0	0.8	12.7
P_2	30	8.6	7.0 - 10.0	0.8	9.0
F_1	30	8.8	8.0 - 10.0	0.7	7.6
F_2	120	8.5	6.0 - 11.0	1.1	13.4
B_1	120	8.1	5.0 - 11.0	1.0	13.4
B_2	120	9.0	7.0 - 11.0	0.9	10.1

TABLE 42 (continued)

Population	No. of Plants	Mean	Range	S.E.	C.V. (%)
	Number of leaves above the ear				
P_1	30	5.4	5.0 - 6.0	0.5	9.2
P_2	30	5.6	5.0 - 7.0	0.6	11.0
F_1	30	6.2	6.0 - 7.0	0.4	6.1
F_2	120	6.0	4.0 - 8.0	0.7	12.1
B_1	120	5.6	4.0 - 7.0	0.7	13.0
B_2	120	6.0	5.0 - 8.0	0.7	11.5

TABLE 43

INDIVIDUAL PLANT MEANS OF VARIOUS AGRONOMIC CHARACTERS FOR PARENTS, F_1, F_2, AND FIRST BACKCROSS POPULATIONS FROM THE CROSS T232 × T458R GROWN AT CROSSVILLE, TENNESSEE IN 1974

Population	No. of Plants	Mean	Range	S.E.	C.V. (%)
	-----Ear height (inches)-----				
P_1	30	42.7	35.0 - 53.0	4.8	11.3
P_2	30	40.6	30.0 - 50.0	5.1	12.7
F_1	60	58.3	45.0 - 70.0	7.4	7.9
F_2	120	55.9	35.0 - 76.0	7.4	13.0
B_1	120	56.3	44.0 - 65.0	4.5	8.0
B_2	120	53.6	39.0 - 68.0	5.6	10.5
	-----Plant height (inches)-----				
P_1	30	96.8	73.0 - 108.0	6.6	6.8
P_2	30	101.0	89.0 - 113.0	5.7	5.6
F_1	60	119.9	103.0 - 133.0	6.0	5.0
F_2	120	113.8	92.0 - 133.0	8.2	7.2
B_1	120	111.6	94.0 - 130.0	6.1	5.5
B_2	120	116.3	92.0 - 140.0	7.7	6.6
	-----Plant/ear height ratio-----				
P_1	30	2.29	1.83 - 2.68	0.2	8.7
P_2	30	2.52	2.18 - 3.25	0.3	7.1
F_1	60	2.06	1.76 - 2.33	0.1	7.1
F_2	120	2.06	1.63 - 2.72	0.2	10.7
B_1	120	1.99	1.71 - 2.37	0.1	7.2
B_2	120	2.18	1.82 - 2.68	0.2	8.5
	-----Number of leaves below the ear-----				
P_1	30	8.1	7.0 - 9.0	0.7	8.6
P_2	30	8.9	7.0 - 11.0	1.1	8.5
F_1	60	8.9	7.0 - 11.0	0.8	8.5
F_2	120	9.2	7.0 - 12.0	1.1	12.0
B_1	120	9.0	7.0 - 11.0	0.8	9.1
B_2	120	9.1	7.0 - 12.0	1.0	11.1

TABLE 43 (continued)

Population	No. of Plants	Mean	Range	S.E.	C.V. (%)
	Number of leaves above the ear				
P_1	30	5.6	4.0 - 7.0	0.7	11.9
P_2	30	6.1	5.0 - 7.0	0.6	10.0
F_1	60	6.4	5.0 - 7.0	0.5	8.3
F_2	120	6.5	5.0 - 8.0	0.7	10.6
B_1	120	6.4	5.0 - 8.0	0.7	10.2
B_2	120	6.6	5.0 - 8.0	0.7	10.6

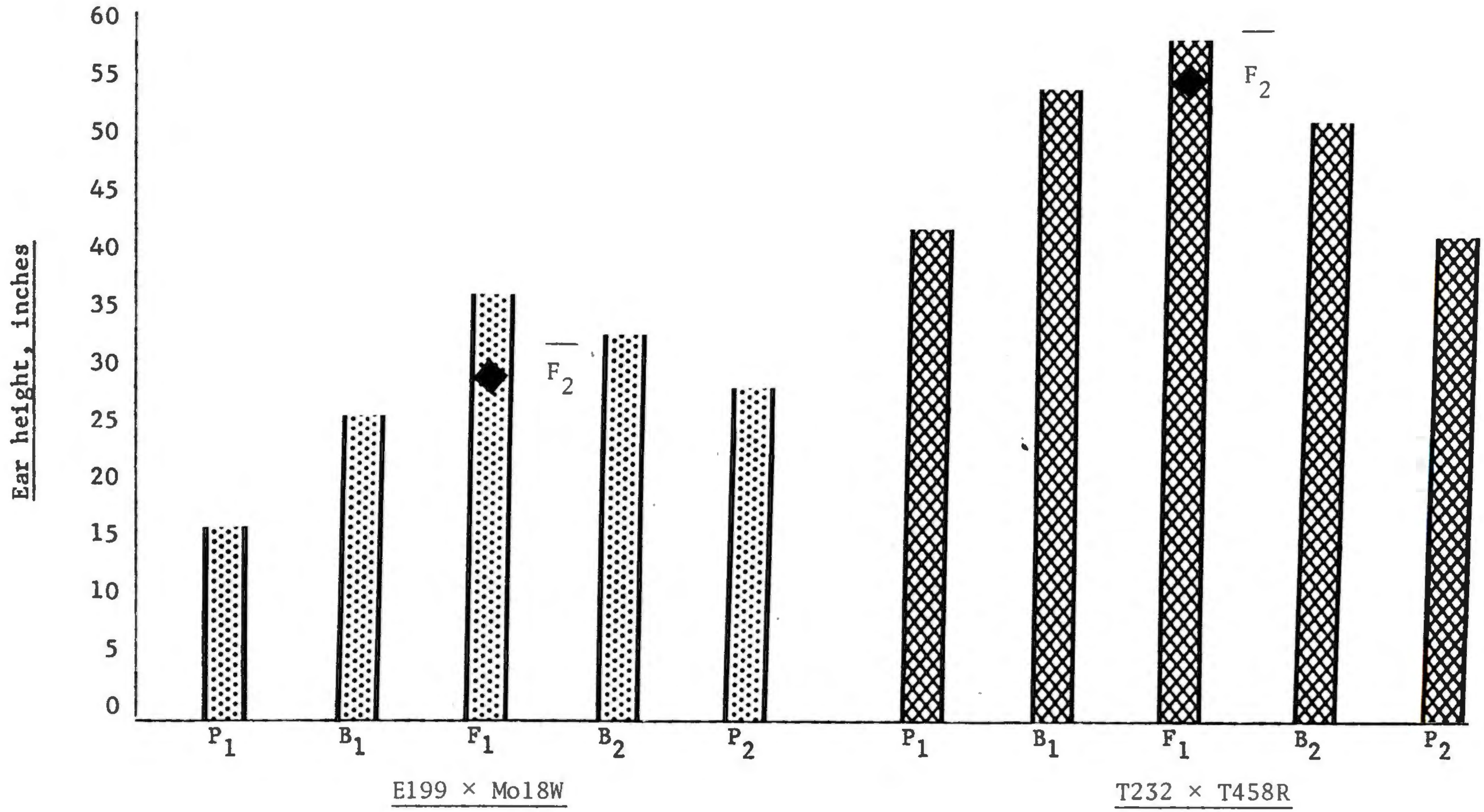

Figure 9. Histogram of ear height of parents, F_1, F_2, and first backcross populations from the crosses E199 × Mo18W and T232 × T458R.

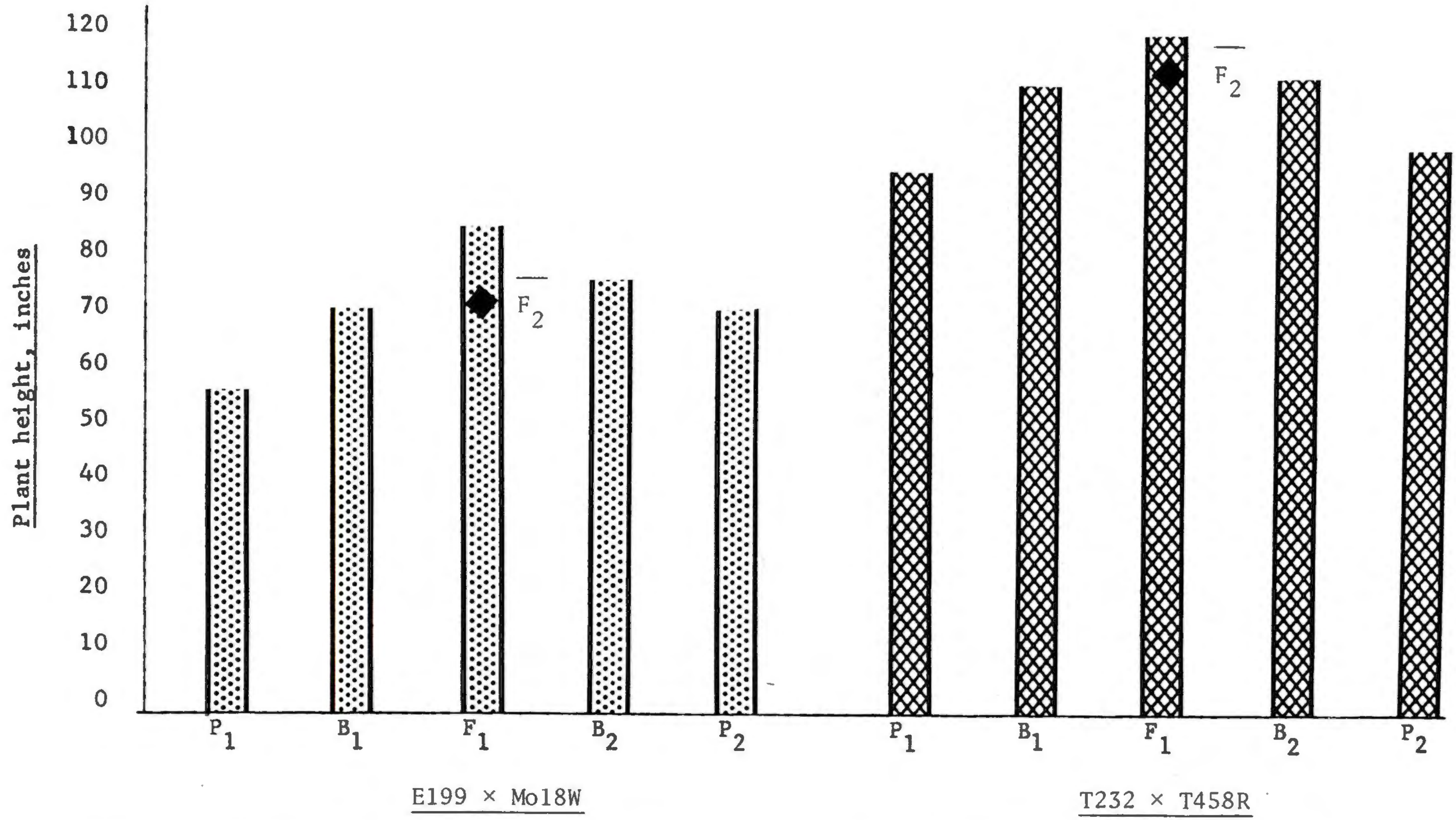

Figure 10. Histogram of plant height of parents, F_1, F_2, and first backcross populations from the crosses E199 × Mo18W and T232 × T458R.

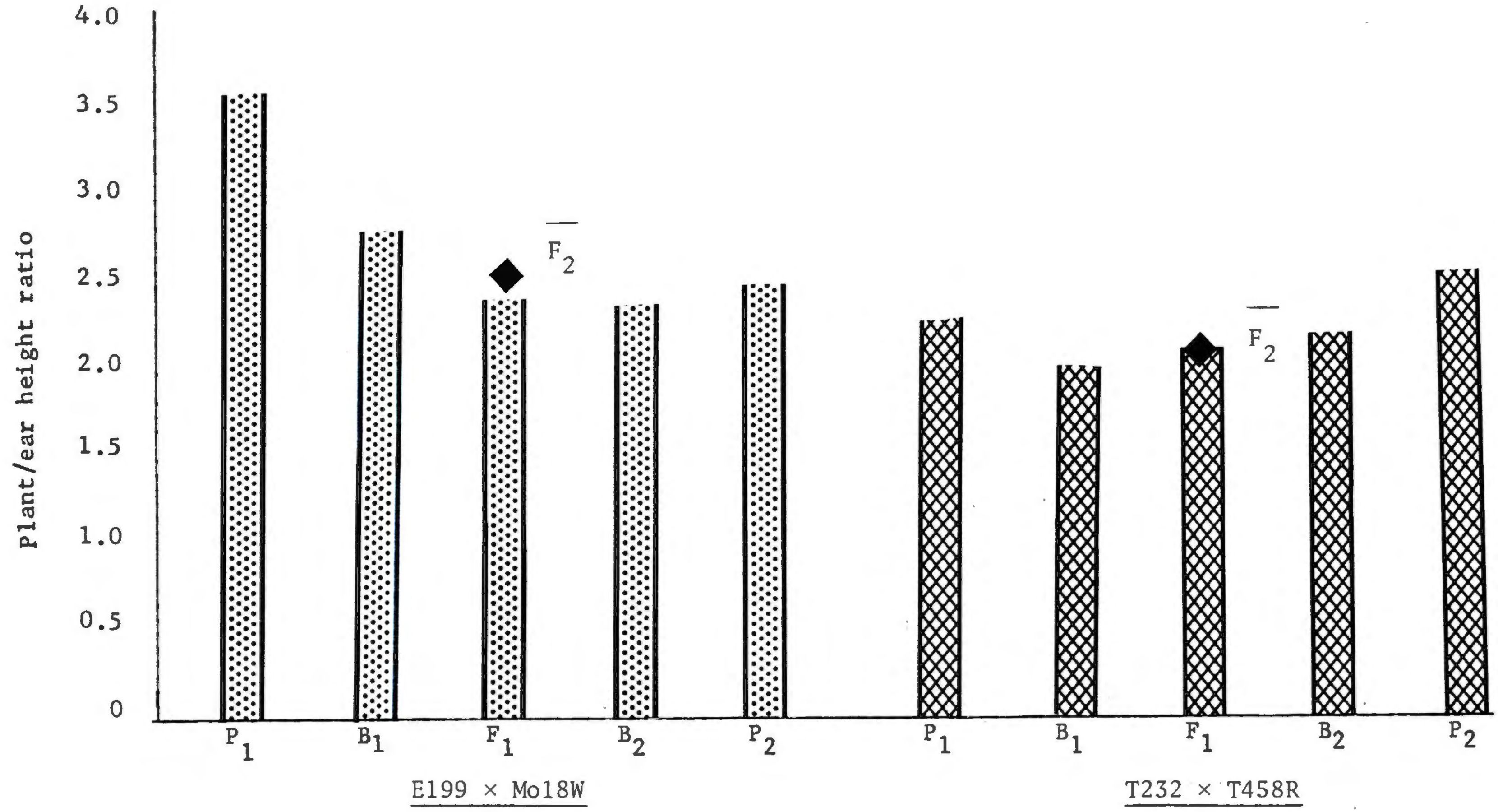

Figure 11. Histogram of plant/ear height ratios of parents, F_1, F_2, and first backcross populations from the crosses of Mo18W × E199 and T232 × T458R.

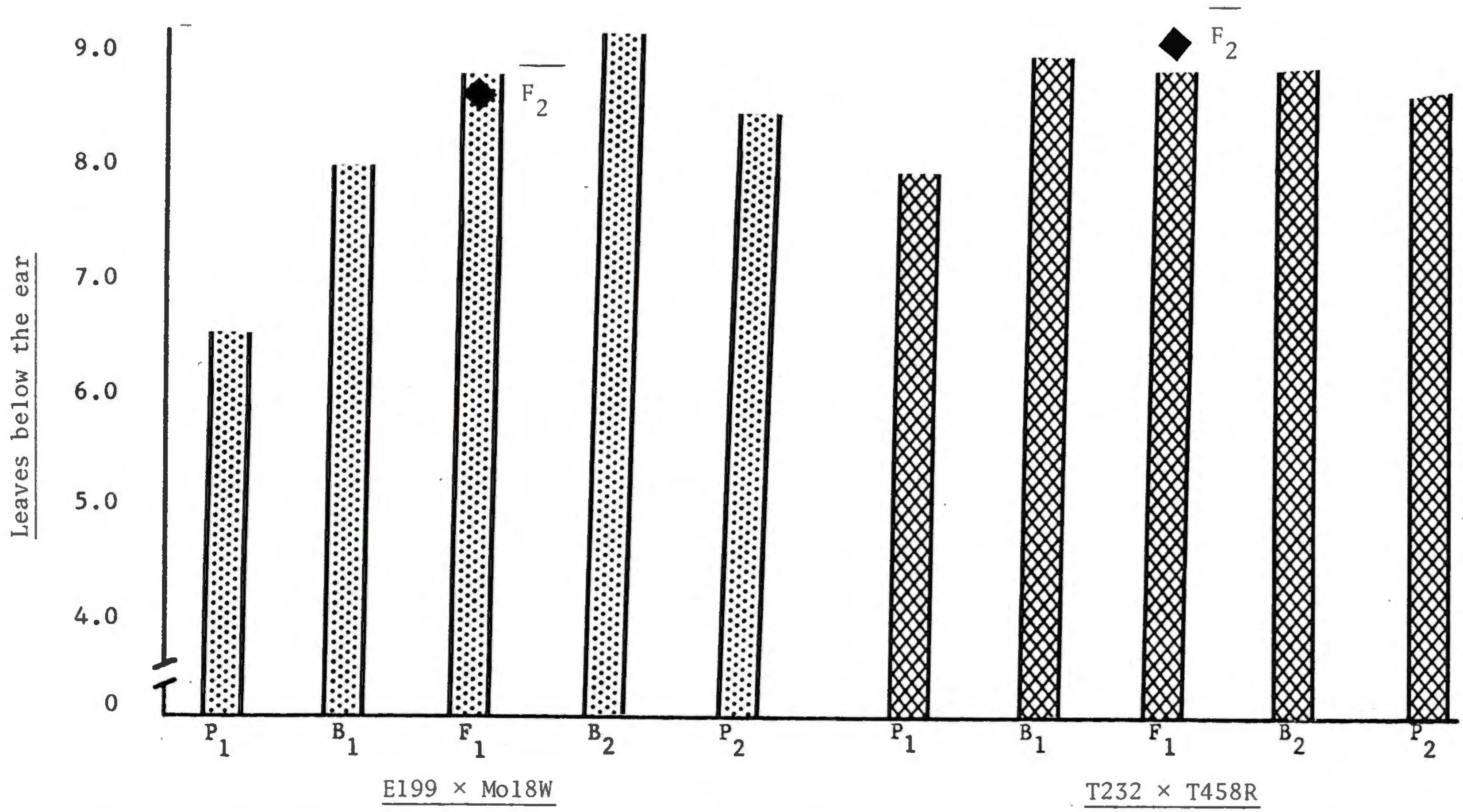

Figure 12. Histogram of number of leaves below the ear of parents, F_1, F_2, and first backcross populations from the crosses E199 × Mo18W and T232 × T458R.

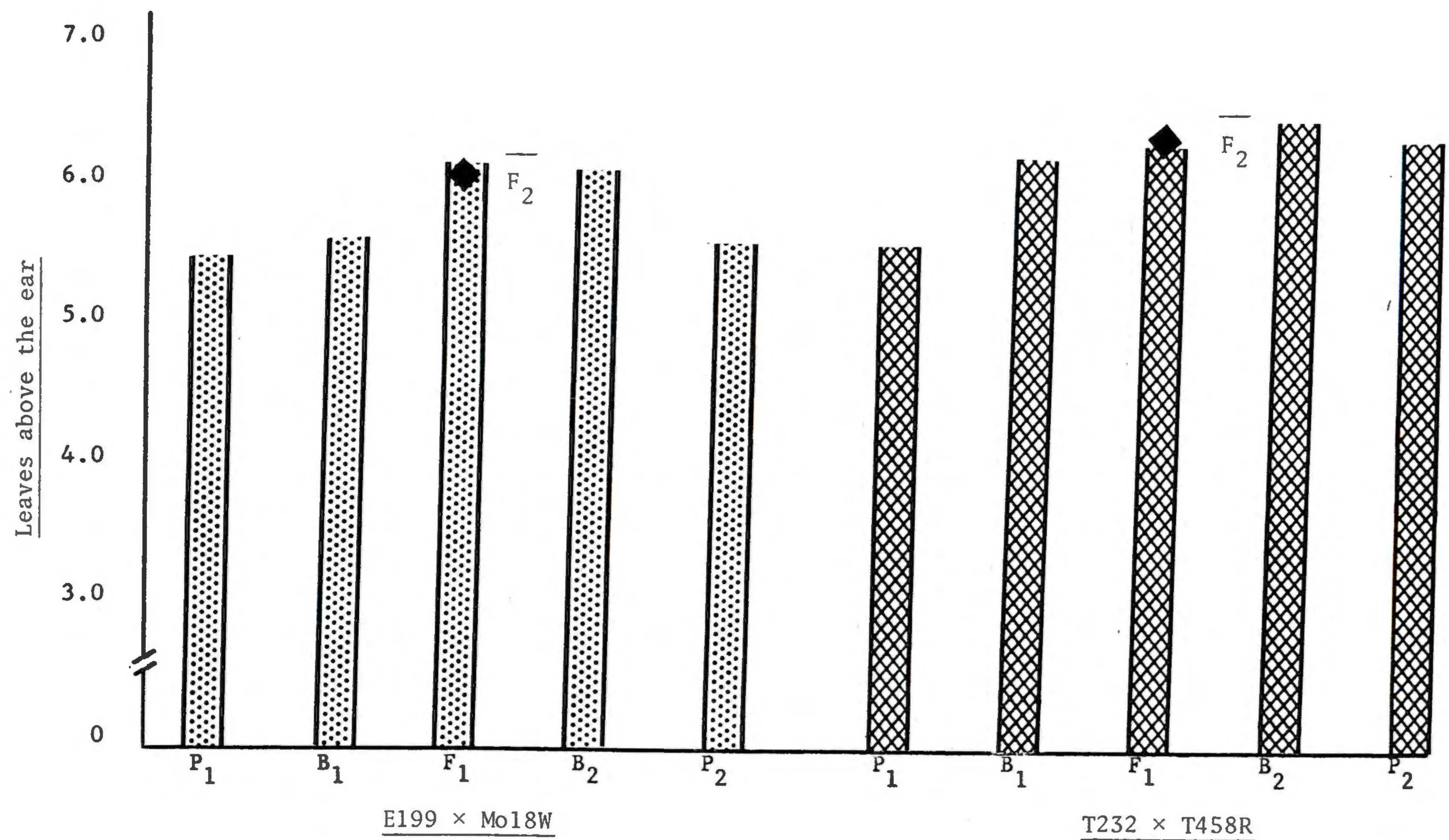

Figure 13. Histogram of number of leaves above the ear of parents, F_1, F_2, and first backcross populations from the crosses E199 × Mo18W and T232 × T458R.

fewer leaves below and above the ear than Mo18W and the hybrid generations (Figures 12, page 90 and Figure 13, page 91).

Cross T232 × T458R

The various generations of this cross behaved in a manner similar to those of the cross E199 × Mo18W. Inbreds T232 × T458R proved to be similar with respect to all characters.

The ear height means of both parents were approximately the same (Figure 9, page 87). Likewise, both backcrosses were nearly equal. Plant height means of both parents were similar as were those of both backcrosses (Figure 10, page 88). F_2 plants were shorter than F_1 plants, reflecting inbreeding depression. Both parents had higher plant/ear height ratios than did their crosses (Figure 11, page 89). The values for the F_1 and F_2 were identical.

There were more leaves below the ear on F_2 plants than in other generations (Figure 12). F_1 plants had fewer leaves below the ear than did plants of either backcross. T232 had fewer leaves below the ear than any other generation (Figure 13).

Mean Comparisons

Generation means were compared by means of a simple _t_ test. The means used were obtained by pooling replications. Variances were calculated on an individual plant basis. Results of these analyses are presented in Table 44. Plant and ear height, and plant/ear height ratio means were usually significantly different. Number of leaves below and above the ear showed smaller differences among generations than did other characters.

TABLE 44

COMPARISONS OF GENERATION MEANS OF VARIOUS CHARACTERS OF THE CROSSES E199 × Mo18W AND T232 × T458R

Mean Comparisons	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear
	E199 × Mo18W				
P1 vs P2	17.98**	12.06**	8.30**	10.75**	1.23
P1 vs F1	28.40**	28.67**	8.90**	12.71**	6.74**
P1 vs F2	14.40**	9.67**	11.95**	9.57**	3.95**
P1 vs B1	13.87**	10.94**	8.82**	8.84**	1.35
P1 vs B2	22.44**	16.44**	16.17**	16.04**	4.13**
P2 vs F1	9.08**	12.15**	1.31	1.23	4.81**
P2 vs F2	0.21	0.09	0.50	0.50	2.69**
P2 vs B1	4.70**	0.11	5.28**	2.28*	0.14
P2 vs B2	4.87**	4.31**	2.15*	2.11*	2.81**
F1 vs F2	8.32**	9.73**	1.54	1.59	1.62
F1 vs B1	14.73**	10.85**	6.38**	3.51**	4.22**
F1 vs B2	4.49**	7.44**	0.67	1.08	1.69
F2 vs B1	6.00**	0.31	6.74**	2.80**	3.04**
F2 vs B2	7.13**	6.00**	3.47**	2.93**	0.00
B1 vs B2	14.66**	6.12**	11.92**	5.30**	3.11**
	T232 × T458R				
P1 vs P2	1.61	2.64*	3.52**	3.51**	2.85**
P1 vs F1	15.05**	16.70**	5.84**	4.74**	6.15**
P1 vs F2	9.24**	10.49**	5.68**	5.30**	6.11**
P1 vs B1	14.57**	11.69**	11.31**	5.44**	5.88**
P1 vs B2	9.73**	4.90**	2.85**	5.18**	6.76**
P2 vs F1	16.66**	12.69**	9.30**	0.25	2.64*
P2 vs F2	10.62**	8.02**	11.38**	1.39	2.77**
P2 vs B1	16.53**	8.61**	14.04**	0.39	2.42
P2 vs B2	11.80**	10.26**	7.82**	0.93	3.47**
F1 vs F2	2.53*	5.11**	0.10	2.15*	0.49
F1 vs B1	3.10**	8.61**	3.06**	0.88	0.10
F1 vs B2	5.49**	3.20**	4.36**	1.56	1.47
F2 vs B1	0.53	2.39*	2.90**	1.84	0.81
F2 vs B2	2.68**	2.42*	4.56**	0.81	1.11
B1 vs B2	4.09**	5.15**	8.82**	1.01	1.84

*, **Indicate significance at the .05 and .01 probability levels, respectively based on _t_ tests.

Analysis of Variance of Generation Means

The analysis of variance of generations was conducted using plot means in all generations. The analysis of variance indicated that mean squares for all characters were highly significant as was previously indicated by the mean comparisons (Table 45). Mean squares for plant height, plant/ear height ratio and number of leaves below the ear were considerably greater in E199 × Mo18W than in T232 × T458R.

Analysis of F_3 Progenies

Frequency distributions in the F_3 progeny of the two crosses are presented in Figures 14 through 18. Tests for skewness and kurtosis indicated that these distributions were normally distributed.

Analysis of variance of means of the various characters showed the mean squares to be significantly different at the .01 probability level (Table 46). A comparison of F_2 families with F_3 progenies showed that F_2 plants were more vigorous with respect to ear and plant heights, but the plant/ear height ratios were approximately the same (Table 47). F_2 plants had a greater average number of leaves both below and above the ear. The standard deviations of F_2 plants were also slightly larger than those of the F_3 progeny.

Heritability Estimates

Heritability estimates, based on calculations from variances among F_3 families, presented in Table 45, were much higher than those based on the formula of Mahmud and Kramer (27) (Table 48). Ranges of estimates of heritability of ear height, plant height, number of leaves below the ear,

TABLE 45

ANALYSES OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS OF THE CROSSES E199 × Mo18W AND T232 × T458R GROWN AT CROSSVILLE, TENNESSEE, IN 1974

Source	df	Mean Squares				
		Ear Height	Plant Height	Plant/Ear Height Ratio	Number of Leaves Below the Ear	Number of Leaves Above the Ear
				E199 × Mo18W		
Replication	2	8.56	17.64	0.16	0.44	0.07
Population	5	154.20**	239.07**	0.69**	2.71**	0.26**
Residual	10	2.81	7.77	0.05	0.05	0.04
				T232 × T458R		
Replication	2	1.76	16.49	0.00	0.50	0.04
Population	5	175.62**	46.04**	0.11**	0.50**	0.40**
Residual	10	4.56	10.26	0.004	0.11	0.02

**Indicates significance at the .01 probability level.

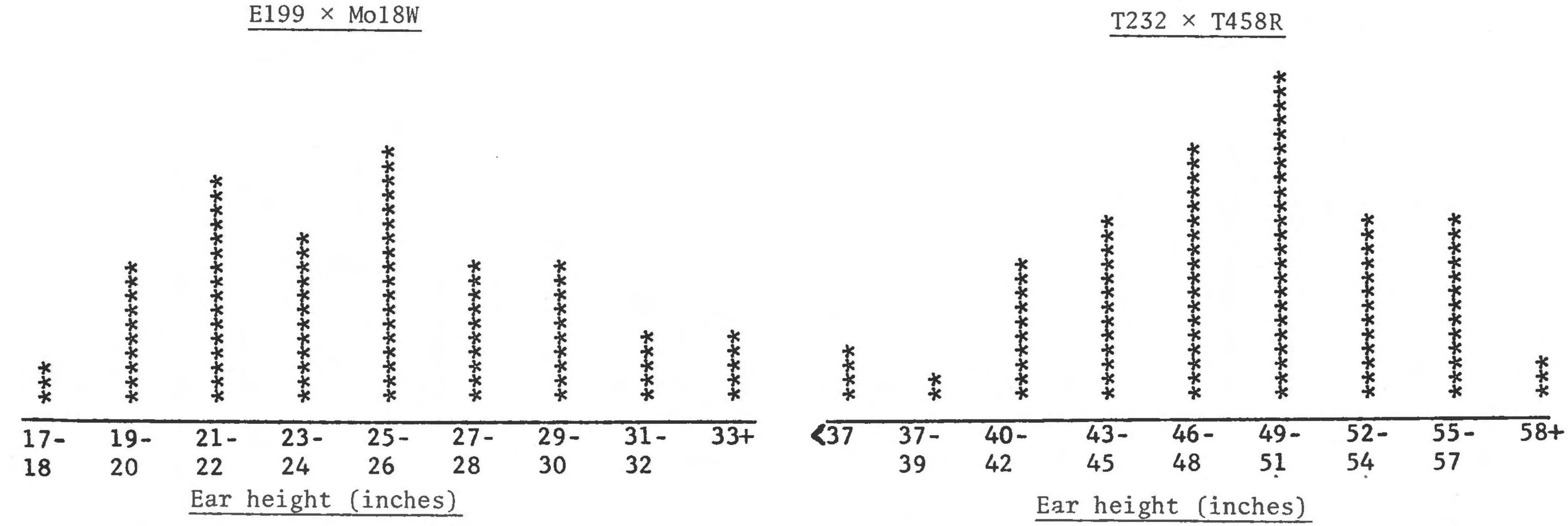

Figure 14. Distributions of ear height of F_3 progeny of the crosses E199 × Mo18W and T232 × T458R grown at Crossville, Tennessee, in 1974. (Each asterisk represents one F_2 family.)

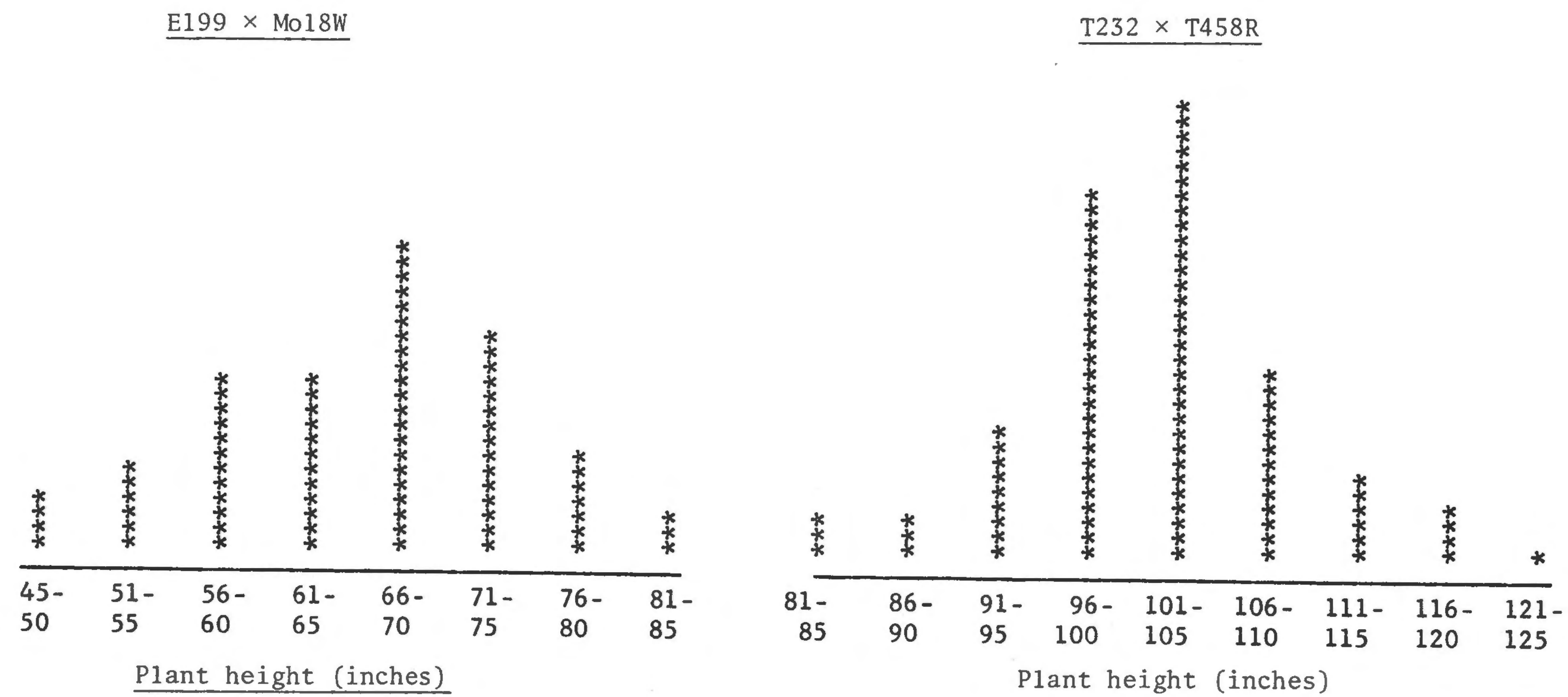

Figure 15. Distributions of plant height of F_3 progeny of the crosses E199 × Mo18W and T232 × T458R grown at Crossville, Tennessee, in 1974. (Each asterisk represents one F_2 family.)

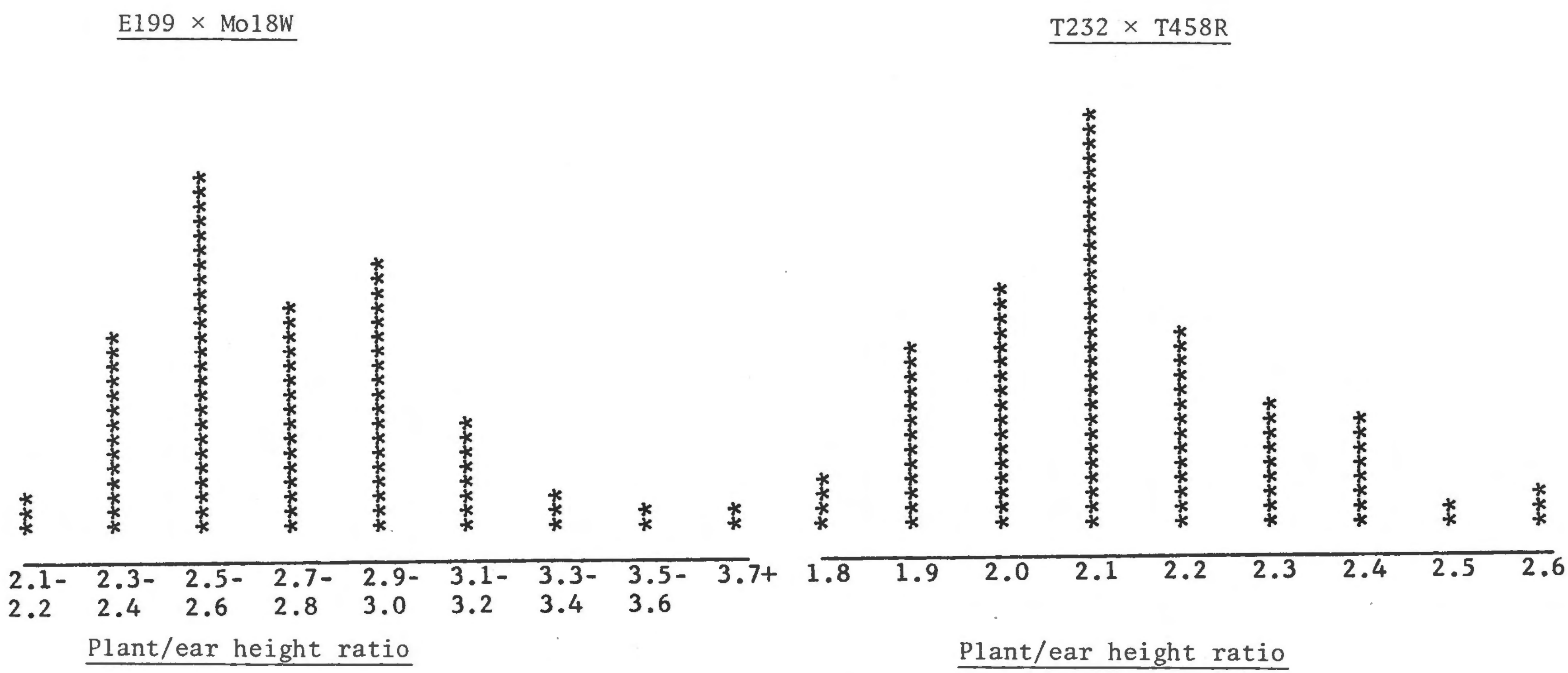

Figure 16. Distributions of plant/ear height ratio of F_3 progeny of the crosses E199 × Mo18W and T232 × T458R grown at Crossville, Tennessee, in 1974. (Each asterisk represents one F_2 family.)

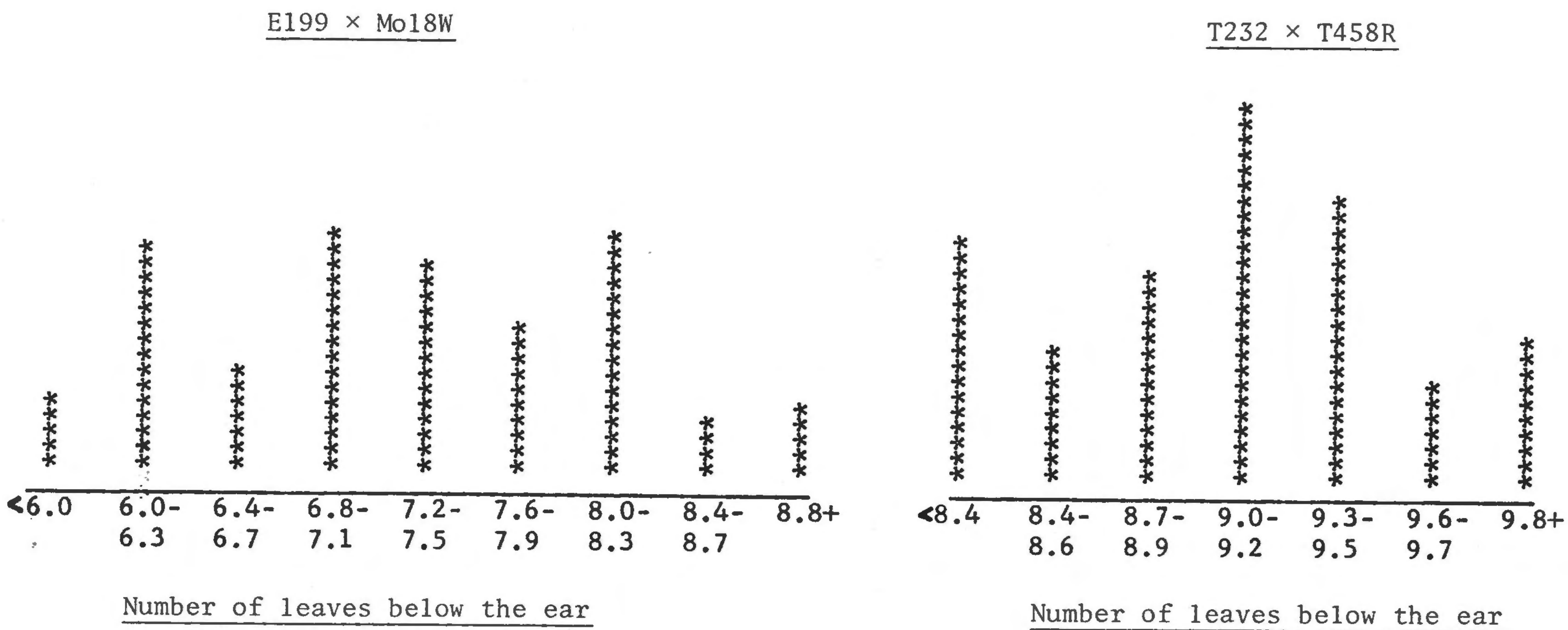

Figure 17. Distributions of leaves below the ear of F_3 progeny of the crosses E199 × Mo18W and T232 × T458R grown at Crossville, Tennessee, in 1974. (Each asterisk represents one F_2 family.)

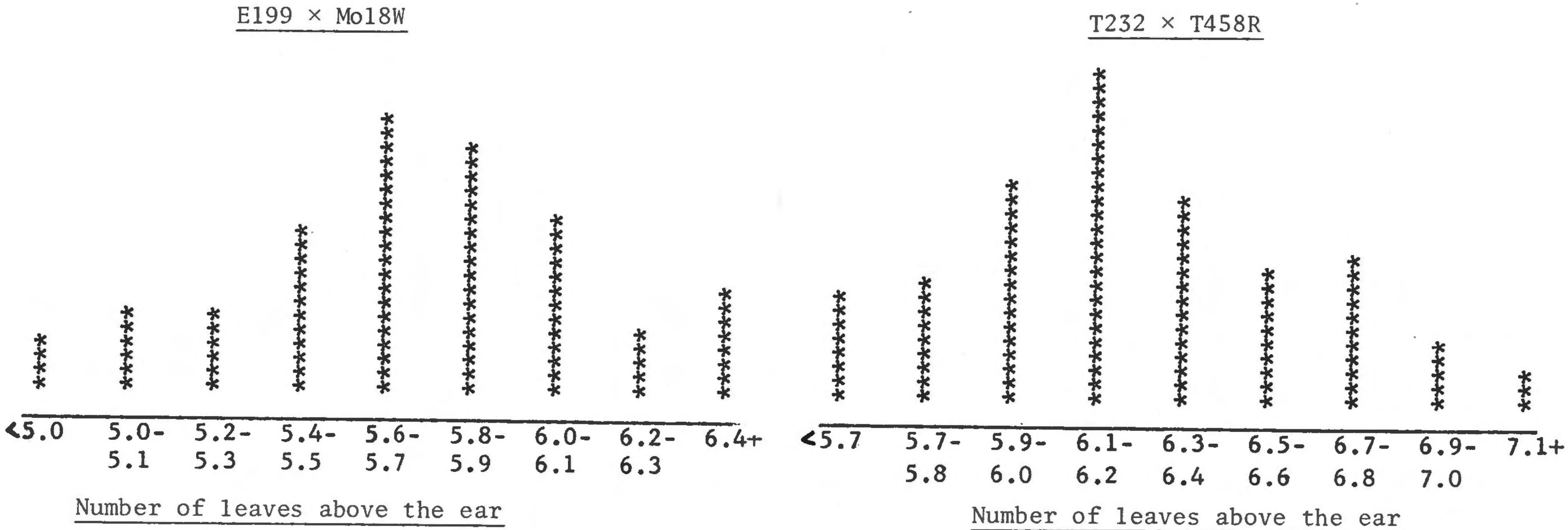

Figure 18. Distributions of leaves above the ear of F3 progeny of the crosses E199 × Mo18W and T232 × T458R grown at Crossville, Tennessee, in 1974. (Each asterisk represents one F_2 family.)

TABLE 46

ANALYSES OF VARIANCE OF VARIOUS AGRONOMIC CHARACTERS OF THE F_3 PROGENY FROM THE CROSSES E199 × Mo18W AND T232 × T458R GROWN AT CROSSVILLE, TENNESSEE, IN 1974

		Mean Squares				
Source	df	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear
				E199 × Mo18W		
Progeny	91	173.73**	716.94**	1.26**	9.06**	1.85**
Residual	828	18.62	42.17	0.23	0.84	0.42
				T232 × T458R		
Progeny	99	349.91**	526.16**	0.37**	3.66**	1.98**
Residual	900	26.09	35.83	0.04	0.73	0.42

**Indicates significance at the .01 probability level.

TABLE 47

COMPARISON OF F_2 AND F_3 MEANS OF VARIOUS CHARACTERS OF THE CROSSES E199 × Mo18W AND T232 × T458R GROWN AT CROSSVILLE, TENNESSEE, IN 1974

Character	F_2 Mean	F_3 Mean
	-----------E199 × Mo18W-----------	
Ear height, inches	29.0 ± 4.7	25.0 ± 4.3
Plant height, inches	70.1 ± 8.3	66.0 ± 6.2
Plant/ear height ratio	2.5 ± 0.4	2.7 ± 0.5
Number of leaves below the ear	8.5 ± 1.1	7.3 ± 0.9
Number of leaves above the ear	6.0 ± 0.7	5.7 ± 0.6
	-----------T232 × T458R-----------	
Ear height, inches	55.9 ± 7.4	48.4 ± 5.2
Plant height, inches	113.8 ± 8.2	101.6 ± 6.0
Plant/ear height ratio	2.0 ± 0.2	2.1 ± 0.2
Number of leaves below the ear	9.2 ± 1.1	9.0 ± 0.9
Number of leaves above the ear	6.5 ± 0.7	6.2 ± 0.6

TABLE 48

COMPARISONS OF ESTIMATES OF HERITABILITY (H) OF VARIOUS CHARACTERS CALCULATED VIA TWO DIFFERENT PROCEDURES

	$\hat{H}^1$ (%)	$\hat{H}^2$ (%)
	---------E199 × Mo18W------------	
Ear height	94.1	66.2
Plant height	89.3	63.1
Leaves below the ear	90.7	50.4
Leaves above the ear	77.3	45.7
	---------T232 × T458R------------	
Ear height	92.5	55.0
Plant height	91.3	44.8
Leaves below the ear	80.1	37.8
Leaves above the ear	78.8	13.6

$^1\hat{H} = [\hat{\sigma}^2_G/(\hat{\sigma}_G^2 + \hat{\sigma}_E^2)] \times 100.$

$$^2\hat{H} = \frac{V_{F_2} - (V_{P_1} \times V_{P_2})^{1/2}}{V_{F_2}} \times 100.$$

and number of leaves above the ear were 55.0 percent to 94.1 percent, 44.8 percent to 91.3 percent, 37.8 percent to 90.0 percent, and 13.6 percent to 78.8 percent, respectively.

Components of Generation Means

Significant additive effects on ear height, number of leaves below and above the ear, and plant/ear height ratio were observed in E199 × Mo18W (Table 49). In both crosses dominance effects on plant height were noted. Additive and dominance effects on plant/ear height ratio in the cross T232 × T458R were observed. There were no significant epistatic effects noted on any character in either cross.

TABLE 49

ESTIMATES OF GENETIC EFFECTS ON VARIOUS CHARACTERS OF CROSSES E199 × Mo18W AND T232 × T458R GROWN AT CROSSVILLE, TENNESSEE, IN 1974

Genetic Components	Ear Height	Plant Height	Plant/Ear Height Ratio	Leaves Below the Ear	Leaves Above the Ear
			E199 × Mo18W		
Mean (m)	29.0 ± 4.7	70.1 ± 8.3	2.5 ± 0.4	8.5 ± 1.1	6.0 ± 0.7
additive (a)	-7.3** ± 1.5	-5.1 ± 2.9	0.5* ± 0.2	-0.8* ± 0.4	-0.4* ± 0.2
dominance (d)	31.3 ± 22.1	90.0* ± 38.9	3.3 ± 1.8	8.0 ± 5.3	5.4 ± 3.5
aa	1.5 ± 21.8	12.3 ± 38.5	0.3 ± 1.7	0.3 ± 5.3	-0.7 ± 3.5
ad	-0.6 ± 5.8	2.1 ± 10.4	-0.1 ± 0.6	0.3 ± 1.5	-0.3 ± 1.1
dd	-0.9 ± 23.1	-9.0 ± 40.8	0.2 ± 1.9	-1.9 ± 5.7	0.9 ± 4.1
			T232 × T458R		
Mean (m)	55.9 ± 7.4	113.8 ± 8.2	2.1 ± 0.2	9.2 ± 1.1	6.5 ± 0.7
additive (a)	2.7 ± 3.4	-4.6 ± 2.4	0.2* ± 0.1	-0.1 ± 0.6	-0.2 ± 0.2
dominance (d)	55.9 ± 33.6	118.5* ± 36.6	2.0* ± 1.0	7.7 ± 5.1	6.3 ± 3.3
aa	-3.7 ± 33.1	00.7 ± 36.0	0.1 ± 1.0	-0.7 ± 5.0	0.1 ± 3.2
ad	1.7 ± 8.0	-2.5 ± 10.8	-0.1 ± 0.3	0.3 ± 1.4	0.1 ± 1.1
dd	-15.7 ± 31.2	-18.9 ± 42.2	0.5 ± 1.1	-0.7 ± 5.6	-1.5 ± 4.1

*, **Indicates significance at the .05 and .01 probability levels, respectively.

CHAPTER IV

DISCUSSION

I. ANALYSIS OF THE SYNTHETICS PER SE

Progress was obtained for lower ear placement by phenotypic recurrent selection. In 12 generations, the plant/ear height ratios were increased from less than 3.0 to over 4.0. This indicates that ear placement can be lowered while holding plant height constant.

Selection for low-ear placement was equally effective in both the early and late synthetics with ear-height reductions being the same in both.

These results agree with those of Vera and Crane (42) who obtained a decrease in ear height of 4.5 percent per selection cycle and with Acosta and Crane (1) who obtained a decrease of 6.0 percent per selection cycle. Plant height also had been reduced slightly in their tests.

The potential of selecting for lower ear placement allows one to select plants which have a larger number of leaves above the ear. With an increase in number of leaves above the ear, there should be an increase in the photosynthetic leaf area. If these leaves are more efficient in producing carbohydrates to be stored in the ear, then there should be an increase in yield.

Lower ear placement should reduce lodging as there would be less leverage on the stalk. It should aid in mechanical harvesting as low-eared plants tend to be more uniform in ear height than high-ear plants.

The two low-ear synthetic populations offer the possibility of selecting low-ear inbreds for use in production of single or double crosses which would have low ear placement. These inbreds could be crossed to high-ear, but otherwise satisfactory inbreds to reduce ear height. The low-ear synthetics themselves can also be crossed with other varieties, populations, exotics, etc. to obtain more useable material.

The significant negative correlations between yield and plant/ear height ratio and yield and number of leaves above the ear indicate that in selecting for low-ear placement, the selection was also for lower yield. This is not necessarily so since inbreeding depression is the probable cause of the lower yields.

II. ANALYSIS OF THE DIALLEL CROSS

Ear height decreased in both the early and late synthetics when tested in two locations. In all cases, the generations of synthetics themselves had a wider range of ear heights than did the arrays of parents of the diallel crosses. This is an indication that selection for lower ear placement was effective since smaller differences would be expected relative to the parental arrays.

Plant height varied throughout the generations of selection. The difference in range of plant height between the synthetics themselves and of the arrays of their crosses was not as great as with ear heights. In the later generation arrays, parental means were generally higher than the later generations of synthetics themselves indicating that, perhaps, inbreeding depression became more pronounced in the later generations of the synthetics than in the crosses of the various generations.

Plant/ear height ratios increased in each succeeding generation of selection for lower ear height. Again, the synthetics themselves had a wider range of ratios than did arrays of parental means. Selection for lower ear height in the later generations was still quite effective as shown by the large increases in the plant/ear height ratios in those later generations of selection. This indicates that further selection for lower ear placement is feasible.

With each succeeding generation of selection number of leaves below and above the ear changed from more leaves below the ear to more leaves above the ear. Again smaller differences were noted in the arrays of parental means than in the synthetics. Internode length remained approximately the same from generation 1 to 10, while the ear was lowered on the plant. Since the total number of leaves did not change the data clearly indicates that ear placement was transferred one node lower on the stalk.

The later generations of synthetics flowered approximately one day earlier than the early generations. Small differences were expected between the early and late generations as the plants were selected for a specific maturity range.

The yields of the crosses varied slightly but showed no trend throughout the cycles of selection for lower ear height even though some yield reduction might be expected to result from inbreeding depression in succeeding generations.

The general and specific combining ability variances indicated mostly additive gene action controlling the inheritance of the various characters, but there were indications of some nonadditive variation. One would expect mainly additive effects in this study since in a selection program that is carried through several cycles one is able to combine only additive effects.

The largest gca effects on ear height was positive effects occurring in the first cycle of selection, with decreasing values for each succeeding generation until high negative gca effects were present in the later generations. The largest decrease in gca effects was between generations 1 and 3 indicating that, in the selection program, the greatest reduction in ear height was at this point. Progress continued to be shown in the later generations and further selection for lower ear height would still be feasible. There were no significant sca effects on ear height, indicating that there was a lack of dominance in any particular generation. However, the various crosses in the later generations had greater sca values which would indicate that the lowest ear placement would be obtained in crosses of the later generations.

After the initial decrease in plant height from generation 1 to 3, any further decrease was probably due to inbreeding depression. The sca effects on plant height varied from highly significant positive effects to nonsignificant negative effects. One would desire nonsignificant gca effects to keep the plant height nearly constant over the generations.

The best estimate of the effectiveness of selection for lower ear height is with the ratio of plant/ear height. The linear increase of the plant/ear height ratios indicates that with further selection it is possible to obtain even lower ear placement.

With lower ear placement, there was an increase in number of leaves above the ear and a decrease in number of leaves below the ear. In the later generations the change in number of leaves below to leaves above became less with each succeeding cycle of selection. The sca effects on number of leaves above and below the ear indicated some genotype-environment interaction.

The gca effects on days to pollen shed and silking varied throughout the generations. Since the selected plants were chosen within a specific maturity group, no significant gca effects would be expected.

The gca effects on yield indicate that the first generations had a higher yield in the early synthetics and the later generations had a lower yield in the late synthetics. Possibly, this decrease was due to inbreeding depression. There were no significant sca effects on yield with either the early or late synthetics indicating that no particular cross differed from the average.

III. LOW-EAR SYNTHETICS CROSSED TO HIGH- AND LOW-EAR TESTERS

The differences among the generations with respect to the various agronomic characters were not as clearcut as they were in the diallel set of crosses. This was expected since the testers would have an influence in offsetting differences among the synthetics.

Reductions in ear height of the synthetics were smaller and inconsistent when crossed to the two testers than in the synthetics themselves. Plant/ear height ratios show more consistency, even though the crosses to the two testers showed smaller differences. The late synthetics had a greater trend toward more leaves above the ear than did the early synthetics. Mean squares of the various characters were not as large as those obtained in the analyses of the diallel crosses. The synthetics themselves showed significant differences for all characters except number of leaves above the ear and yield. Greater differences were noted in the crosses of the late synthetics to the testers than in the early synthetics.

Significant reductions in ear height occurred in three of the six tests. These reductions were expected since the selection was for lower ear placement. Only two of the six tests showed reductions in plant height. These two may be explained on the basis of inbreeding depression since attempts were made to maintain a constant plant height. Five of the six tests showed an increase in plant/ear height ratios. Again, there should have been an increase in the plant/ear height ratios if selection for lower ear height had been effective. Number of leaves below the ear decreased in two of the tests and increased in only one of the tests. The change from leaves below the ear to leaves above the ear was expected unless the lowered ears were due only to shortened internodes below the ear.

There was little difference in number of days from planting to pollen shed or silking which would be expected. Only one test showed a reduction in yield.

IV. ANALYSIS OF SEGREGATING AND NONSEGREGATING GENERATIONS

The cross T232 × T458R was more vigorous than the cross E199 × Mo18W. The F_1 hybrids of both crosses were taller than the parents indicating heterosis. The shorter F_2 plants indicated inbreeding depression but the plant/ear height ratios of F_2 plants remained approximately the same as those of the F_1 plants.

A comparison of all combinations of generations, using t tests, showed several highly significant differences among the generations for various characters. In both crosses the F_1 plant values were significantly greater than those from either parent. Ear height, plant height, and plant/ear height ratios were usually different when comparing generation means. Smaller differences were noted among generations with respect to numbers of leaves below and above the ear.

Analyses of variance yielded significant mean squares for all characters. This was expected since both inbreds and hybrids were being compared.

The various characters of the F_3 progeny were normally distributed as determined by tests for skewness and kurtosis. Estimates of heritability of ear height ranged from 55.0 percent to 92.0 percent and agree reasonably with the 82.4 percent that Giesbrecht (10) found. The 13.6 percent estimate of heritability of number of leaves above the ear compared with the 22.8 percent to 30.0 percent reported by Metwally (33).

The additive gene effects on ear height found in the cross E199 × Mo18W agrees with the results of Ahmud (2) and Robinson et al. (36).

Giesbrecht (10) also found some dominance effects on number of leaves above and below the ear. The cross T232 × T458R showed both significant additive and dominance gene effects on plant/ear height ratio. The failure to obtain significant epistatic gene effects agrees with other researchers (8, 18) who also found little evidence of epistatic gene effects. Both white and yellow endosperm and early and late maturing inbreds were involved. Additive gene effects were noted on all characters, except plant height in the inbreds. Dominance effects also were found on numbers of leaves below and above the ear in the inbreds. The additive gene effects indicate that a recurrent selection program would be effective in utilizing additive effects. The dominance effects could be utilized in single or double crosses to improve a specific character.

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He is married to the former Pham Thi Lien of Vietnam and they have two children, Donna and David.