# RELATIONSHIPS AMONG CERTAIN MORPHOLOGICAL AND FLOWERING CHARACTERS IN *GOSSYPIUM HIRSUTUM* L.

by

LONNIE GENE DALTON

Bachelor of Science

Oklahoma Agricultural and Mechanical College

Stillwater, Oklahoma

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Thesis Approved:

John M. Green
Thesis Advisor

Charles L. Leinweber

Robert MacVicar
Dean of the Graduate School

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## INTRODUCTION

Relationships between lint and boll properties of American upland cotton (*Gossypium hirsutum* L.) have been extensively studied, but only limited work has been done on the relationships between morphological and flowering characters. Several of these characters have been thought to be correlated, but definite information is not readily available to verify this assumption.

The objective of this study was to determine the relationships among certain morphological and flowering characters in order to supply some information that would be helpful to the breeder. A relationship between an easily measured morphological character and earliness, 10 and 20 day total bloom counts in this study, would be of value. Such a character which is significantly correlated with 10 and 20 day bloom count totals could be used as a "yardstick" for selecting for earliness early in the season.

Four varieties, representing a relatively wide range of variation in the characters measured, and the $F_2$ generation of single crosses and the double cross involving those varieties were used to estimate environmental and genetic correlations of certain morphological and flowering characters.

## LITERATURE REVIEW

### Morphological Characters

The characters that are considered in this experiment are largely morphological. Some clarification should be given regarding these characters in upland cotton (Gossypium hirsutum L.).

Eaton (4) in reviewing work with cotton, has clearly stated some characteristic features of the plant:

(a) Branches produced by the cotton plant may be either vegetative or fruiting.

(b) One or more vegetative branches are developed from the basal sixth to ninth main stalk (main axis) nodes.

(c) Flowering is progressive and becomes more rapid as the plant grows.

(d) The flowering and fruiting behavior of American upland cotton is day length neutral.

(e) The fruiting branch developes from a main stalk or from a vegetative branch node.

(f) The usual position of the first fruiting branch is at the seventh main stalk node, but they have been observed as low as the third or fourth node.

(g) Variations in growth behavior have led to the classification of varieties as determinate or indeterminate with respect to growth rates.

1. Determinate: Plants fruit heavily early in the season and then the terminal bud becomes dormant and fruiting declines.
2. Indeterminate: Plants flower throughout the season, usually later maturing, bolls are set but floral production does not stop.

A number of workers have reported studies of morphological characters some of which were included in the present study. In experiments on Uppam cotton (Gossypium herbaceum L.), Venkataramanan (16) compared two types of branching which give rise to primary and secondary sympodia. He showed that bolls on the primary sympodial branches had a longer maturation period but were better in seed weight, lint weight and lint length than bolls on secondary branches. He noted that the flowering curve of the primary sympodia was earlier than the secondary one.

McClelland (cited by McClelland and Neely (11)) worked with plants of Cleveland Big Boll cotton and found that plants tended to be regular in blooming habit when grown under constant soil moisture content. He noted that the vertical intervals were approximately three days between blooms and the horizontal intervals were approximately six days between blooms. McClelland and Neely (11) theorized that ".... if the vertical interval is 3 and the horizontal interval 6, and nothing disturbs regularity, blooms should occur on any one plant only at 3-day intervals, and there would be no true daily curve for individual plants." If a large number of plants tend to bloom at the same time, regularity is pronounced and the blooming curve has high peaks, but if the plants are staggered in their date of first bloom a smoothing of the flowering curve is observed.

McNamara, et al. (12) worked with six upland types: Acala, Lone Star, Rowden, Delfos, Half and Half, and Kekchi. These commercial strains differed widely in several characters: e. g., plant type, plant growth, and productiveness. These workers noted that the first true leaf appeared at the first node above the two opposite nodes of the cotyledon, and after seven or eight true leaves had been developed they considered the seedling to be in the fruiting stage. The mean number of nodes to the node which bore the first productive fruiting branch was observed, and the mean values for varieties studied were as follows: Lone Star, 7.97; Kekchi, 7.92; Delfos, 8.33; Half and Half, 8.55; Acala, 8.67; and Rowden, 8.70 nodes. These data show some variation among varieties in the mean number of nodes to the first fruiting branch, and there appeared to be a relationship between the mean number of the nodes to the first fruiting branch and the blooming rate.

Martin, et al. (10) state that "different types and varieties of cotton differ in the length and the number of internodes of the fruiting branch."

In McClelland's work (cited in (11)) it was pointed out that the time required to produce blooms on a plant was shorter in the vertical interval than the horizontal interval and the suggestion was made that the length of the internode of the fruiting branch may also be a factor influencing earliness.

Buie (2) studied methods of determining earliness, and posed the following question:

Is it determined by time of initial flowers, rapidity of blooming early in the season, retention of a large percentage of bolls, production of potentially high lint bolls, short boll development and maturation period, or a combination of these characters?

He found that the boll maturation period as well as the other characters mentioned had a direct relationship to maturity and concluded that "earliness, in its final analysis, is not a simple heritable character, but one dependant upon many factors both hereditary and environmental."

Hintz and Green (7) studied components of earliness in three varieties of upland cotton. These components were rate of squaring, rate of blooming, length of the square period, boll growth rates, and length of the boll period. They concluded that the inheritance of boll period was controlled by genes having an additive effect. Selection would be expected to be effective in hybrid populations segregating for boll period.

Correlations

Snedecor (14) gives the following definition of correlation:

Correlation is seen to be the quotient of two averages of variation: one, the covariance of the two measurements, $X_1$ and $X_2$; the other an average of two sample variances (i. e., mean squares). It is an abstract number measuring covariation: if of two related characters each occurs in various sizes, this correlation is a measure of the extent to which their variations are concomitant.

The sample correlation coefficient (r) is used as a measure of correlation, and is derived from the formula: $r = x_1 x_2 / \sqrt{(X_1)^2 (X_2)^2}$.

Patterson (13) states that "it has been demonstrated that for n=100, a value of r of $\pm 0.30$ may be obtained purely by chance from two characters known to be entirely independent." He notes that the standard error, in a correlation based on n pairs of variates, normally attributed to r is either: $\frac{1-r^2}{\sqrt{n}}$ or $\frac{1-r^2}{\sqrt{n-1}}$.

Correlated Characters in Cotton

Many correlations have been determined in cotton, but emphasis has been placed upon lint, boll, and fiber properties with little attention given to the morphological characters.

Dunlavy (3) observed correlations among the following characters in upland cotton: Lint per cent, weight of seed, lint index, boll size, number of seed per lock, and per cent of five-lock bolls. He observed the following eight pairs to be correlated:

(a) lint index and weight of seed-positive

(b) boll size and weight of seed-positive

(c) per cent of five-lock bolls and boll size-positive

(d) weight of seed and lint per cent-negative

(e) boll size and lint index-positive

(f) lint per cent and staple-negative

(g) weight of seed and staple-positive

(h) boll size and lint per cent-negative

He determined correlation coefficients for these characters in all possible combinations and observed that boll size and weight of seed were significantly correlated with four of the six characters.

Brannon (1) found that certain characters were closely associated with yield of seed cotton (e. g., length of lint, lint per cent and size of boll). He found that lint per cent and time to maturity were significantly correlated with length of lint. He also noted that the characters locks per boll, per cent flowers shed at 18 days, lint per cent, weight of 100 seeds, and area of the leaf were significantly correlated with size of boll.

Kearney (9) worked on Egyptian types of cotton and determined correlations on fifteen seed, fiber and boll characteristics. He found significance in twenty-six pairs of characters, but the relationships weren't of the nature to afford genetic correlation. He also worked with an Egyptian-upland hybrid. Only one significant correlation in this hybrid, negative correlation between fiber length and fiber color, appeared to be neither physical nor physiological.

Green (5) determined simple correlations on all possible combinations of the lint characters, upper half mean, Pressley index, fineness, seed index, and lint index. The correlation coefficients were based on the phenotype and included environmental and genetic affects. The correlation coefficients are applicable only if selection is based upon the phenotype. He states that "most published studies of correlations in cotton have not yielded information on the relative importance of genetic and environmental effects."

Stroman (15) studied multiple correlations of eight characters in seven varieties: weight of lint per boll, lint per cent, number of five-lock bolls, number of four-lock bolls, number of vegetative branches, number of fruiting branches, height, and yield. His results indicated that (1) seven characters were significantly correlated with yield, five-lock bolls and weight per boll, (2) a high negative correlation exists between number of four and five-lock bolls, (3) the number of four-lock bolls was correlated significantly to height of plant, and (4) correlations of five-lock bolls and four-lock bolls with number of fruiting branches were variable.

Hodson (8) determined correlations on characters which make up the "type" of the plant. He studied a number of varieties over a period of seven years, and reported the following correlations:

(a) Number of base limbs with number of fruiting branches, $r = -0.1907 \pm 0.0454$ to $0.2987 \pm 0.1123$

(b) Number of base limbs with the number of bolls per plant, $r = -0.0182 \pm 0.0674$ to $0.4348 \pm 0.0938$

(c) Number of base limbs and height, $r = -0.0845 \pm 0.0468$ to $0.1982 \pm 0.0648$

(d) Number of fruiting branches with number of nodes on the axis, number of internodes on the main axis, height of plant, and length of the internode on the main axis. $r = 0.2124 \pm 0.0699$ to $0.5796 \pm 0.0768$

Hodson concluded that "the average length of the internode depends upon two factors: The type of variety and the environment." He noted that an environment favorable for production of limbs also was favorable to production of bolls.

Hodson's work was more closely related to the type of work involved in this study.

## MATERIALS AND METHODS

One double cross (Lankart 611 X Lockett No. 1) X (Deltapine 15 X Stoneville 62), its component single crosses, and the parent varieties were used in this study.

The single crosses were made in the summer of 1954. The double cross was made in the summer of 1955, and $F_2$ seed of all crosses were produced at Iguala, Mexico, in the winter of 1955-56. Breeder's or registered seed of each variety was used.

A randomized complete block design with 10 replications was used in this experiment. The entire experiment consisted of 13 entries, but for the purpose of determining the correlations only seven entries were used.

The experiment was planted in a silt loam soil at Chickasha, Oklahoma on May 11, 1956 in single row plots 40 feet long with a 40 inch spacing between rows. A "w-type" seedbed made by commercial 4-row planting equipment was used. The plots were thinned by hand to a 2 foot spacing between plants in each plot, which gave approximately 20 plants per plot. No special cultivation practices were used. The plants were cultured according to commercial methods in this experiment.

Since the environment influenced the development of the characters studied, the amount of rainfall received by months, between April 1 and September 30, is reported as follows: April 2.23 inches, May 4.23 inches, June 2.42 inches, July 2.04 inches, August 0.55 inches, and September 0.02 inches.

The plants in this study were tagged using 2 X $3\frac{1}{2}$ inch tags. These tages, numbered from 1 to 20, were attached to the mainstem of selected plants[1/] in every plot. The numbered tags were placed on the plants in numerical order with the number 1 plant always on the same end of each plot.

The initial blooming day was indicated by the appearance of the first bloom on any individual plant in the experiment. The data were taken on 752 plants or an average of 107.4 plants per entry and 17.9 plants per plot. Each plant in the study was inspected daily for the appearance of new blooms and counts were recorded each day for all plants involved. Accumulated bloom counts were calculated for each plant of each entry at 10, 20, 30, and 50 days.

The following morphological measurements were taken on the plants which had been tagged:

(1) Height at the beginning of the flowering season. This was done by measuring the height of each plant with a cm. rule on July 4, 1956. The height of the plant was considered to be the distance between the cotyledonary node and the apex of the plant.

(2) Height of the plant at maturity. This measurement was made with a cm. rule at the time of first harvest. The height was considered to be the distance between the cotyledonary node and the apex of the plant.

(3) Total number of nodes at the beginning of the flowering season. The number of nodes between the cotyledonary node and the apex

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1/ On some plants, the terminal bud had aborted and these plants were not tagged; but to maintain equal distance between plants of each plot, these plants were not removed.

of the plant was made and recorded July 4, 1956.

(4) Total nodes at maturity. The total number of nodes between the cotyledonary node and the apex of the plant was taken and recorded at the time of first harvest.

(5) Length of first internode of the first productive fruiting fruiting branch from the main axis node to the flower stalk (Figure 1a). When each individual plant bloomed for the first time, this measurement was taken. The time of measurement was variable for the plants in this study.

(6) Length of the internode of the main axis directly below the node that bore the first productive fruiting branch (Figure 1b). This was taken at the same time as (5) above.

(7) Number of nodes from the cotyledonary node to the node which bore the first fruiting branch. The number of nodes between the cotyledonary node and the node which bore the first fruiting branch was recorded at the same time as characters (5) and (6) above.

Bloom count totals were coded as follows: 10 days, (8); 20 days, (9); 30 days, (10); and 50 days, (11). Code numbers 1 through 11 were used to identify the variables in appendix tables I and II.

The first bloom appeared on July 4, 1956. Bloom count data were compiled for 50 days, until September 11, 1956.

Simple correlation coefficients were computed for all possible combinations of 11 different characters on the I. B. M. 650, an electronic computer.

Two sets of correlation coefficients were calculated: (1) r values with replication effects removed, which were computed by taking the corrected sums of squares and cross products pooled over 6 replications (d.f.= n-12), and (2) r values ignoring replication effects, were computed by taking the total number of observations (d.f.= n-2) in the experiment.

Observed r values calculated within varieties can be considered to be environmental. Observed r's in the segregating populations can be considered to be environmental and genetic, the difference between varietal r's and those in the $F_2$'s of single crosses and the double cross being an indication of the magnitude of the genetic relationship.

For convenience the entries will be abreviated in the tables for the varieties, single crosses and the double cross involved in this study as follows:

Deltapine 15 - Delt. 15

Stoneville 62 - Sto. 62

Lankart 611 - Lank. 611

Lockett No. 1 - Lock. No. 1

Deltapine 15 X Stoneville 62 - (Delt. 15 X Sto. 62)

Lankart 611 X Lockett No. 1 - (Lank. 611 X Lock No. 1)

(Deltapine 15 X Stoneville 62) X (Lankart 611 X Lockett No. 1) - (Delt. 15 X Sto. 62) X (Lank. 611 X Lock. No. 1) or D. C.

Also the coefficient of variation will be referred to as C. V. in the body of the thesis.

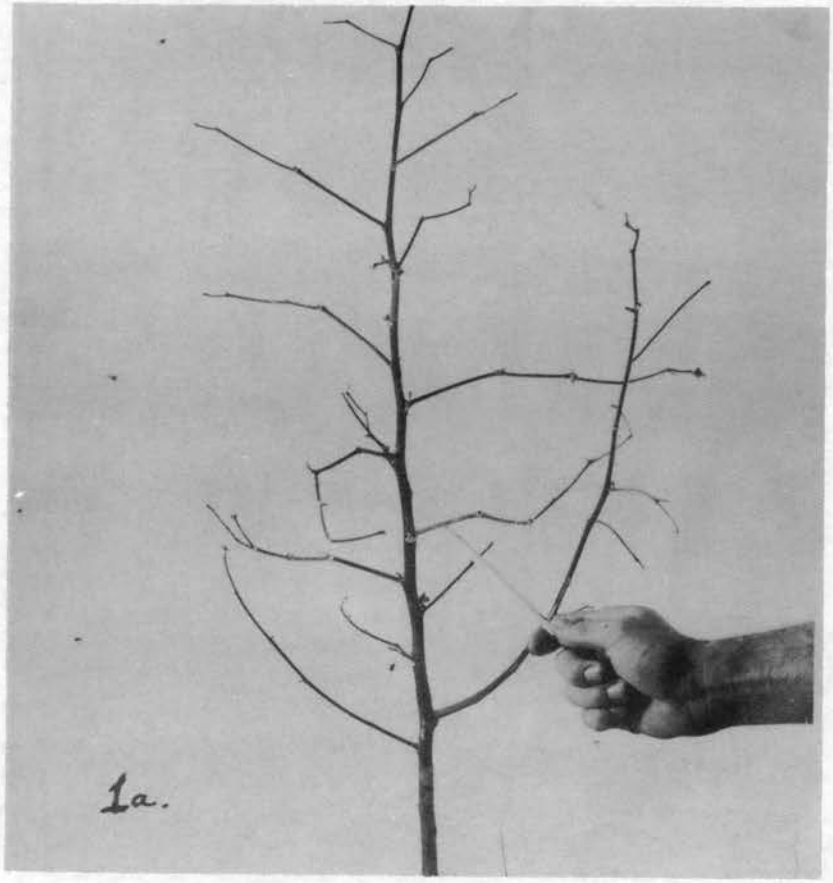


Figure 1a. The internode of the first fruiting branch, which was measured when the first bloom appeared on the plant, is indicated by the pointer.

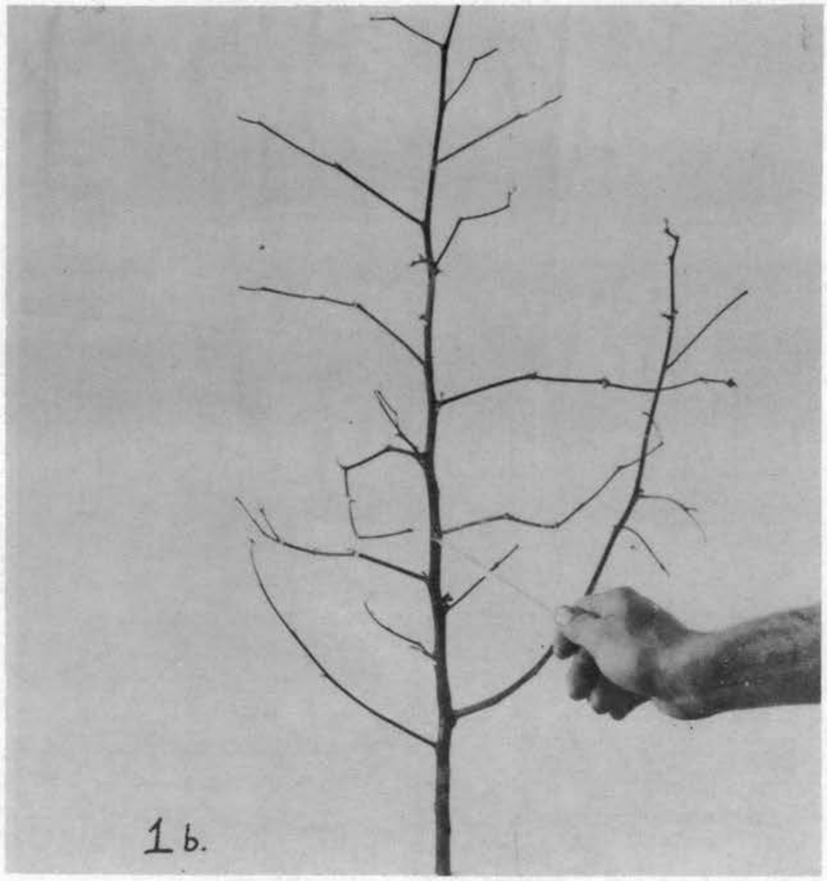


Figure 1b. The node which bore the first productive fruiting branch is indicated by the pointer. The number of nodes from this to the cotyledonary node, and the length of the internode directly below the pointer were recorded when the first bloom appeared on the plant.

## EXPERIMENTAL RESULTS

Since the parent varieties used had not been previously classified for the characters studied, it is of interest to note differences and similarities among them. Mean values for each character, the standard error of the mean, and the coefficient of variation appear in table II of the appendix.

Deltapine 15 and Stoneville 62 were similar in the following characters:

(1) plant height at the beginning of the fruiting season

(2) plant height at maturity

(3) total number of nodes at the beginning of the fruiting season

(4) total number of nodes at maturity

(5) length of the internode on the main axis directly below the node which bore the first fruiting branch.

The $F_2$ means of (Deltapine 15 X Stoneville 62) fell below the means of either parent, and this could be attributed to environmental effects.

The means, standard error of the mean, and the C. V. are presented in table I for those characters that differ in Deltapine 15, Stoneville 62 and the $F_2$ of their single cross. Deltapine 15 had a higher mean ($71.64 \pm 1.91$) for length of the first internode on the first productive fruiting branch than Stoneville 62 ($61.89 \pm 1.98$) and number of nodes to the first fruiting branch ($8.69 \pm 0.19$), but Stoneville 62 had a higher mean in the 10, 20, 30, and 50 day bloom count totals than Deltapine 15.

TABLE I

MEANS, STANDARD ERRORS OF THE MEANS, AND COEFFICIENTS OF VARIATION OF 7 CHARACTERS IN WHICH STONEVILLE 62 AND DELTAPINE 15 DIFFERED

| | | Delt. 15 | Sto. 62 | (Delt. 15 X Sto. 62) |
|---|---|---|---|---|
| (a) length of the first internode of the first productive fruiting branch | $\bar{x}$ | 71.64±1.91 | 61.89±1.98 | 51.25±2.52 |
| | C.V. | 27.57% | 32.88% | 48.27% |
| (b) number of nodes to the node that bore the first productive fruiting branch | $\bar{x}$ | 8.69±0.19 | 7.61±0.14 | 7.32±0.17 |
| | C.V. | 22.67% | 19.05% | 22.81% |
| (c) length of the internode directly below the node which bore the first fruiting branch | $\bar{x}$ | 28.04±0.86 | 29.58±0.73 | 27.55±0.82 |
| | C.V. | 31.56% | 25.29% | 29.22% |
| (d) 10 day bloom count totals | $\bar{x}$ | 0.87±0.10 | 1.52±0.14 | 1.29±0.17 |
| | C.V. | 124.14% | 96.05% | 125.58% |
| (e) 20 day bloom count totals | $\bar{x}$ | 2.77±0.24 | 5.74±0.33 | 4.54±0.40 |
| | C.V. | 89.89% | 58.89% | 85.46% |
| (f) 30 day bloom count totals | $\bar{x}$ | 6.10±0.45 | 11.69±0.50 | 9.42±0.64 |
| | C.V. | 76.39% | 44.31% | 66.03% |
| (g) 50 day bloom count totals | $\bar{x}$ | 14.92±0.61 | 20.67±0.65 | 15.68±0.75 |
| | C.V. | 42.29% | 32.51% | 46.68% |

The coefficient of variation indicated more variation in the $F_2$ of (Deltapine 15 X Stoneville 62) than in either parent in all the above characters except 20 and 30 day bloom count totals.

The C.V. of Stoneville 62 (32.88%) indicated more variation than Deltapine 15 (27.57%) in the length of the first internode on the first productive fruiting branch; the C.V. of Deltapine 15 (31.56%) was higher than Stoneville 62 (25.29%) in the length of the internode directly below the node which bore the first productive fruiting branch, but the means were approximately the same. More variation was observed in Deltapine 15 than in Stoneville 62 in 10, 20, 30 and 50 day bloom count totals as indicated by the C.V.

Lankart 611 and Lockett No. 1 did not differ significantly in the following characters as indicated in table II of the appendix.

(1) total nodes at the beginning of the fruiting season

(2) total nodes at maturity

(3) length of the internode on the main axis directly below the node which bore the first fruiting branch.

Lankart 611 and Lockett No. 1 differed in 8 characters. The means, C.V., and standard error of the mean for these characters of these varieties and their single cross are given in table II.

Lockett No. 1 had a higher mean than Lankart 611 in the four measurements of structure. Lankart 611 had a higher mean than Lockett No. 1 in 10, 20, and 30 day bloom count totals. The inherent lateness of Lockett No. 1 is shown by a lower mean for the earlier bloom count periods and by a large increase of blooms between 30 and 50 days. Lankart bloomed earlier but had fewer total blooms at 50 days. The means of the $F_2$ of (Lankart 611 X Lockett No. 1) fell between the means of the two parents as expected in most of the entries.

The C.V. of length of the first internode on the first productive fruiting branch in Lankart 611 (53.97%) indicated more variation than in Lockett No. 1 (46.83%). The C.V. for the number of nodes to the node which bore the first fruiting branch in Lockett No. 1 (28.19%)

indicated more variation than in Lankart 611 (17.34%). The C.V. of height at maturity in the $F_2$ of (Lankart 611 X Lockett No. 1) (12.85%) showed more variation than either parent, and in the single cross the C.V. (28.09%) also showed more variation in number of nodes to the node which bore the first productive fruiting branch. The C.V. of 10, 20, and 30 day bloom count totals of the single cross falls between the C.V.'s of the parents as expected.

TABLE II

MEANS, STANDARD ERRORS OF THE MEANS, AND COEFFICIENTS OF VARIATION FOR EIGHT CHARACTERS IN WHICH LANKART 611 AND LOCKETT NO. 1 DIFFERED

| | | Lank. 611 | Lock. No. 1 | (Lock. No. 1 X Lank. 611) |
|---|---|---|---|---|
| (a) plant height at the beginning of the fruiting season | $\bar{x}$ | 41.37± 0.39 | 47.34±0.49 | 45.00± 0.43 |
| | C.V. | 10.13% | 10.90% | 10.02% |
| (b) plant height at maturity | $\bar{x}$ | 50.41±0.46 | 61.65±0.62 | 55.39±0.68 |
| | C.V. | 9.74% | 10.69% | 12.85% |
| (c) length of first internode on the first productive fruiting branch | $\bar{x}$ | 43.78±2.20 | 63.27±2.79 | 54.36±2.05 |
| | C.V. | 53.97% | 46.83% | 39.29% |
| (d) number of nodes to the node which bore the first productive fruiting branch | $\bar{x}$ | 7.73±0.13 | 9.58±0.26 | 8.32±0.18 |
| | C.V. | 17.34% | 28.19% | 28.84% |
| (e) 10 day bloom count totals | $\bar{x}$ | 1.82±0.14 | 0.65±0.10 | 1.70±0.15 |
| | C.V. | 81.87% | 158.46% | 93.53% |
| (f) 20 day bloom count totals | $\bar{x}$ | 5.80±0.31 | 2.48±0.22 | 5.07±0.34 |
| | C.V. | 56.90% | 95.56% | 69.82% |

TABLE II (Continued)

| | | Lank. 611 | Lock. No. 1 | (Lock. No. 1 X Lank. 611) |
|---|---|---|---|---|
| (g) 30 day bloom count totals | $\bar{x}$ | 10.39 ± 0.43 | 7.11 ± 0.35 | 10.90 ± 0.54 |
| | C.V. | 44.75% | 52.46% | 51.38% |
| (h) 50 day bloom count totals | $\bar{x}$ | 10.18 ± 0.50 | 20.09 ± 0.74 | 19.37 ± 0.63 |
| | C.V. | 52.75% | 38.97% | 34.02% |

The means and C.V.'s indicated no differences in mean value or variation among the parents and the crosses in most of the characters measured. Under more favorable growing conditions more differences might have been observed.

The C.V.'s for the 10, 20, and 30 day bloom count totals were unusually high. This was attributed to the large number of zeros in the data taken from these three periods of counting blooms.

Simple correlation coefficients were determined among 11 variables in 7 entries. Two sets of correlation coefficients are presented: (1) r values with replication effects removed, and (2) r values ignoring replication effects.

The r's ignoring effects of replication do not differ significantly from those calculated with replication effects removed. This indicates there were no differences in correlation due to replications in this environment. The r values considered in the text will be those with replication effects removed. All correlation coefficients appear in table I of the appendix. Those correlation coefficients of most interest are presented in smaller tables in the body of the thesis.

There was an indication of little or no significant correlation, either genetic or non-genetic, between the following pairs of characters in any of the seven entries as indicated by their respective r values (table I of the appendix).

I. Length of the internode on the main axis below the node which bore the first productive fruiting branch and length of the internode on the first productive fruiting branch were not correlated significantly with:

(a) height of the plant at the beginning of the fruiting season

(b) height of the plant at maturity

(c) total nodes at the beginning of the fruiting season

(d) total nodes at maturity

(e) number of nodes from the cotyledonary node to the node which bore the first productive fruiting branch

(f) 10 day bloom count totals

(g) 20 day bloom count totals

(h) 30 day bloom count totals

(i) 50 day bloom count totals

The measurements of internode length, either on the main axis or on the fruiting branch, showed no significant relationship with any other character measured or with each other.

II. The number of nodes from the cotyledonary node to the node which bore the first fruiting branch was not significantly correlated with:

(a) plant height at the beginning of the fruiting season

(b) plant height at maturity

(c) total number of nodes at the beginning of the fruiting season

(d) total number of nodes at maturity

(e) length of internode on the first productive fruiting branch

(f) length of the internode on the main axis directly below the node which bore the first fruiting branch

(g) 50 day bloom count total

III. Ten, 20, 30, and 50 day bloom count totals were not significantly correlated with:

(a) length of internode on the first productive fruiting branch

(b) length of internode on the main axis directly below the node which bore the first productive fruiting branch

The 10 and 30 day bloom count totals were not significantly related to plant height at maturity.

The correlations of certain pairs of characters resulted from mechanical relationship of the characters in question. Nine pairs of characters in this study were related in this manner. These are presented in table III with the r values for each entry for the characters which showed this relationship. All r values express a significant positive relationship in all seven entries between the pairs of characters in the table.

The correlations between the number of nodes to the node which bore the first fruiting branch, and 10, 20, 30, and 50 day bloom count totals are given in table IV. The significant negative relationship was weaker with the total nodes to the first productive fruiting branch than with later total bloom counts taken. There did not seem to be a significant difference between r values of varieties

TABLE III

GROWTH CHARACTERS SIGNIFICANTLY CORRELATED BECAUSE OF MECHANICAL RELATIONSHIP, EXPRESSED BY r, IN 7 ENTRIES

| | Delt. 15 | Sto. 62 | Lank. 611 | Lock. No. 1 | Delt.15 X Sto.62 | Lank.611 X Lock. No.1 | D.C. |
|---|---|---|---|---|---|---|---|
| Height at the beginning of flowering with: | | | | | | | |
| Height at maturity | 0.47 | 0.61 | 0.52 | 0.61 | 0.60 | 0.50 | 0.57 |
| total node no. at first flowering | 0.66 | 0.68 | 0.54 | 0.55 | 0.75 | 0.64 | 0.65 |
| Height at maturity with: | | | | | | | |
| total node no. at first flowering | 0.46 | 0.49 | 0.41 | 0.50 | 0.45 | 0.36 | 0.34 |
| total nodes at maturity | 0.70 | 0.74 | 0.64 | 0.69 | 0.72 | 0.74 | 0.72 |
| Total nodes at beginning of flowering with: | | | | | | | |
| total nodes at maturity | 0.36 | 0.48 | 0.31 | 0.51 | 0.57 | 0.38 | 0.42 |
| 10 day bloom count totals with: | | | | | | | |
| 20 day totals | 0.68 | 0.82 | 0.74 | 0.76 | 0.84 | 0.82 | 0.75 |
| 30 day totals | 0.57 | 0.63 | 0.65 | 0.50 | 0.76 | 0.63 | 0.59 |
| 20 day bloom count totals with: | | | | | | | |
| 30 day totals | 0.86 | 0.82 | 0.78 | 0.66 | 0.91 | 0.82 | 0.85 |
| 30 day bloom count totals with: | | | | | | | |
| 50 day bloom count totals | 0.75 | 0.60 | 0.72 | 0.40 | 0.78 | 0.52 | 0.70 |

and the hybrids of these varieties.

TABLE IV

THE RELATIONSHIP OF NUMBER OF NODES TO THE NODE WHICH BORE THE FIRST PRODUCTIVE FRUITING BRANCH WITH 10, 20, 30, AND 50 DAY BLOOM COUNT TOTALS, EXPRESSED BY r, IN 7 ENTRIES

| | Delt. 15 | Sto. 62 | Lank. 611 | Lock. No. 1 | (Delt. 15. X Sto.62) | (Lank. 611 XLock.No.1) | D.C. |
|---|---|---|---|---|---|---|---|
| No. of nodes with: 10 day bloom totals | -0.33 | -0.37 | -0.32 | -0.40 | -0.27 | -0.42 | -0.30 |
| 20 day bloom totals | -0.32 | -0.28 | -0.25 | -0.47 | -0.35 | -0.41 | -0.27 |
| 30 day bloom totals | -0.31 | -0.19 | -0.18 | -0.20 | -0.23 | -0.39 | -0.18 |
| 50 day bloom totals | -0.16 | 0.06 | -0.04 | -0.05 | -0.01 | -0.02 | 0.02 |

The height of the plant at the beginning of the fruiting period and total nodes at the beginning of the fruiting period are significantly related, as stated previously, because of mechanical relationships. These two characters were significantly correlated with total bloom counts (tables V and VI). It was noted that the magnitude of the r's differed among the entries. Correlations computed within Deltapine 15 and Stoneville 62 of plant height at beginning and 10, 20, 30, and 50 day bloom counts were not significantly different, but the r value for the $F_2$ of their single cross was significantly higher than either parent according to Snedecor's "Z" test (13).

In the case of Lankart 611 and Lockett No. 1 the $F_2$ of the single cross did not differ from its parents in degree of correlation between height and bloom counts. The double cross r was not significantly

TABLE V

THE RELATIONSHIP OF HEIGHT OF THE PLANT AT THE BEGINNING OF THE FRUITING SEASON WITH 10, 20, 30, and 50, DAY BLOOM COUNT TOTALS, EXPRESSED BY r, IN 7 ENTRIES

| | Delt. 15 | Sto. 62 | Lank. 611 | Lock. No. 1 | (Delt.15 X Sto.62) | (Lank.611 X Lock. No. 1) | D.C. |
|---|---|---|---|---|---|---|---|
| Height with: 10 day bloom count totals | 0.35 | 0.31 | 0.33 | 0.28 | 0.54 | 0.28 | 0.20 |
| 20 day bloom count totals | 0.48 | 0.45 | 0.40 | 0.23 | 0.54 | 0.34 | 0.32 |
| 30 day bloom count totals | 0.51 | 0.56 | 0.47 | 0.38 | 0.59 | 0.42 | 0.34 |
| 50 day bloom count totals | 0.46 | 0.57 | 0.47 | 0.28 | 0.54 | 0.31 | 0.39 |

TABLE VI

THE RELATIONSHIP OF TOTAL NUMBER OF NODES OF THE PLANT AT THE BEGINNING OF THE FRUITING SEASON WITH 10, 20, 30, AND 50 DAY BLOOM COUNT TOTALS, EXPRESSED BY r, IN 7 ENTRIES

| | Delt. 15 | Sto. 62 | Lank. 611 | Lock. No. 1 | (Delt.15 X Sto.62) | (Lank.611 X Lock.No. 1) | D.C. |
|---|---|---|---|---|---|---|---|
| Total No. of nodes with: 10 day bloom count totals | 0.27 | 0.21 | 0.25 | 0.01 | 0.47 | 0.37 | 0.18 |
| 20 day bloom count totals | 0.33 | 0.24 | 0.27 | 0.04 | 0.45 | 0.41 | 0.26 |
| 30 day bloom count totals | 0.37 | 0.28 | 0.42 | 0.19 | 0.51 | 0.52 | 0.32 |
| 50 day bloom count totals | 0.45 | 0.34 | 0.47 | 0.27 | 0.46 | 0.45 | 0.28 |

higher than any of the parents, and the r value was smaller than either of the single crosses, showing a significantly smaller value than the $F_2$ of (Deltapine 15 X Stoneville 62).

Correlations computed within Deltapine 15 and Stoneville 62 of total number of nodes at the beginning of the fruiting season and 10 day bloom count totals were not significantly different, but the r value of the $F_2$ of (Deltapine 15 X Stoneville 62) was significantly higher than Deltapine 15 at the 5% level of probability and significantly higher than Stoneville 62 at the 1% level of probability. There was no significant difference between the r's of Lockett No. 1 and Lankart 611 between total number of nodes at the beginning of the fruiting season and 10 day bloom count totals, but the r value for the $F_2$ of (Lockett No. 1 X Lankart 611) was significantly higher than Lankart at the 10% level of probability and significantly higher than Lockett No. 1 at the 1% level of probability. The double cross was significantly lower than the $F_2$ of (Deltapine X Stoneville 62) at the 1% level of probability and significantly lower than the $F_2$ of (Lankart 611 X Lockett No. 1) at the 5% level of probability.

## DISCUSSION

Simple correlation coefficients have been determined in cotton dealing with lint, fiber, and boll properties by such workers as Dunlavy (3), Brannon (1), Kearney (9), Green (5), and Stroman (15), but, to the knowledge of the writer, only one study of the morphological characters, using simple correlations, has been reported. Hodson (8) determined simple correlations of the characters that make up plant type.

The morphological characters involved in this study were tested for correlation in all possible combinations. The relationship of these characters will be discussed by sections, with respect to the degree of significance of the r's determined.

### No Significant Correlations Between Characters.

Several characters appeared to be unrelated in this experiment. Lengths of the internode measured on the main axis and on the fruiting branch were not correlated with each other or with any of the other characters measured. This lack of correlation was unexpected, since the length of the internode on the main axis was expected to be related to height. Apparently the internode measured was not representative of average internode length.

The total number of nodes to the node which bore the first productive fruiting branch was not significantly related to the other structural characters measured. This character was independent of total nodes at the beginning of the fruiting season or at maturity, and internode length, either on the main axis or on the fruiting branch.

No significant relationship between bloom counts and internode length, either on the main axis or the first productive fruiting branch, was observed. This indicated that the total number of blooms at the 10, 20, 30, and 50 day counting periods did not depend upon the length of the internode. Considering that McClelland and Neely (11) found that the blooms appeared in regular intervals upward on the plant and outward on the fruiting branches, it would appear that the internode, whether short or long, would require the same period of time to form. In this study the internode length was independent of total blooms at 10, 20, 30, and 50 days.

<u>Occasional Significant Simple Correlations Between Characters.</u>

The positive significant r values observed in Lankart 611 (0.21), Stoneville 62 (0.27), Lockett No. 1 (0.23), and (Delt. 15 X Sto. 62) (0.23), between height of the plant at the beginning of the fruiting season and length of the internode on the main axis directly below the node which bore the first fruiting branch, signifies that as height increased the internode length increased. The relatively low r values, with significance only at the 5% level of probability, may well have been due to chance, especially since these characters were not correlated in the other entries. The length of the internodes on the main axis contribute to the height of the plant, and if the internode measured was an average of all the internodes on the main axis then the possibility of significance is more likely.

The positive significant relationship at the 5% level of probability in Lockett No. 1 (0.24) and (Delt. 15 X Sto. 62) (0.22) of total nodes at the beginning of the fruiting season, and in (Delt. 15 X Sto. 62) (0.25) of total nodes at maturity, with length of the internode on the first fruiting branch is apparently an expression of plant vigor. As the total nodes increased the internode length of the fruiting branch increased. All varieties showing this relationship had a rather wide spreading type of growth; the tendency toward extensive vegetation probably played a role in the significant r values.

Significant negative relationships in Lankart 611 (10 days: -0.24, 20 days: -0.34) and the double cross (10 days: -0.25, 20 days: -0.23) between total nodes at maturity and 10 and 20 day bloom count totals signifies that as total blooms at 10 and 20 days increased the number of nodes did not increase as rapidly. Lankart 611 is a determinate type variety which blooms rather early, as indicated by the 10 and 20 day bloom count means in table I; the double cross mean for the same character is also high and a similar characteristic may be present in the hybrid.

The double cross plants bearing the first flower on a higher fruiting branch tend also to have a longer first internode on the first productive fruiting branch, as indicated by significant r values. This correlation appears to be a result of chance. It is generally understood that the cotton plant has a pyramidal branch structure, i. e., the branches tend to become shorter toward the apex of the plant. In this experiment, branch length and internode length varied together in most of the entries, and these characters are highly influenced by environment. In 1956. the most favorable conditions were prevalent at the beginning of the growing season; thus the internodes on branches at the lower nodes were longer.

In summarizing, the occasional significant correlations observed for character pairs, not usually correlated in this study, may be attributed to chance, differential vigor of the plants, or environmental influence.

Significant Correlations Due to Mechanical Relationships Among Characters.

The high positive correlations observed between the height of the plant at the beginning of the fruiting season and the total number of nodes at the beginning of the fruiting season were expected because they are components of the same structural part, the main axis. Both are measurements of growth, and as total height increased the total number of nodes increased also. The total number of nodes and total height are dependent upon one another to a large degree, and a close relationship would exist.

A high positive correlation between height of the plant at maturity and total number of nodes at maturity can be interpreted the same as the height and total number of nodes at the beginning of the fruiting season. The correlation expressed between the characters of maturity would only be changed by the environment.

Positive correlations of 10, 20, 30, and 50 day bloom count totals with one another is attributed to the accumulations of the total number of blooms. The 10 and 20 day totals were not significantly correlated with 50 day totals in (Lankart 611 X Lockett No. 1) and Lockett No. 1, and 10 day bloom count totals were not significantly related to 50 day totals in Stoneville 62. This was considered to be due to chance.

The relationships observed, as indicated by the r value, declined between bloom count totals of 10 days and the later totals of 20, 30, and 50 days, in that order. According to Buie (2)"... . there is apparently a negative correlation between the number of flowers produced during early and late season periods. That is to say, a variety which produces a large number of early flowers will have but few late in the season, and vice versa." These results are in agreement with Buie's conclusions; the determinate and indeterminate entries both followed such a pattern. The bloom counts were accumulative, and a leveling off of the entries was observed at 50 days, i. e., all varieties had approximately the same 50 day bloom count mean.

Correlations of Possible Value in Selection.

The number of nodes to the first fruiting branch may be a good criterion for selecting for earliness. A low main axis node to the first fruiting branch is accompanied by an increase in number of blooms at 10 and 20 days, indicated by the r values in table IV. This character was found to be a convenient basis of comparison between varieties or types by McNamara *et al.* (12). They found: (1) the number of nodes to the first fruiting branch is apparently genetically controlled, (2) each variety seemed to be rather constant in node number of the main axis to the node which bore the first productive fruiting branch regardless of extremes in the environment, and (3) upland varieties could be expected to begin blooming after the sixth to eighth true leaf appeared on the plant, and even though cotton growers frequently refer to cotton as one which "fruits high" or "fruits low" this height is attributed to internode length and not internode number. A range of $7.51 \pm 0.14$ to $9.58 \pm 0.26$ was observed in number of nodes to the node which bore the first productive fruiting branch in this study.

The negative significant correlations observed in this study between number of nodes to the first productive fruiting branch and 10, 20, 30, and 50 day bloom count totals decreased as the season progressed. McClelland and Neely (11) found that the order of blooming was vertical and horizontal, but in a regular pattern. The decreasing r values seem to correspond to the order and rate of blooming. The significant r's are relatively high at 10, and 20 day bloom counts and this signifies that this character may be a useful aid in selection for earliness. For mechanical harvest, where a high first productive fruiting branch is best for machine efficiency, it is desirable to have earliness and a high node number combined into a single variety. The correlation observed would work to the breeder's disadvantage in such a situation.

Significant positive relationships observed in all entries between height at the beginning of the fruiting period and 10, 20, and 50 day bloom count totals showed a possibility of a genetic relationship. This is a growth, structural, or morphological, plant growth relationship and the inherent ability to produce a vigorous plant at time of flowering could be the factor genetically controlled. The occurrence of more height and more fruiting branches on the plant would increase the possibility of a higher number of total blooms. This relationship of number of blooms would be a secondary one, and is confounded with many factors. The r values were higher in the single crosses and were lower in the double cross (table V). This poses a genetic problem in the relationship of these characters of the parents when combined into hybrids. Significant differences would have to occur between the parents and both single crosses of these parents before positive statements could be made about the genetic mechanism involved. When the r's were tested by Snedecor's "Z" test (14), the r values for the $F_2$ of the single cross (Deltapine 15 X Stoneville 62) was significantly higher than the parents. Such an increase in a segregating population over parent varieties could be considered to be evidence of a genetic correlation. The fact that the r in the double cross was lower would indication that the genetic relationship was caused by linkage, and that the additional generation of segregation resulted in recombinations of crossover types. The fact that the $F_2$ of (Lankart 611 X Lockett No. 1) did not differ significantly from the parents tends to weaken any conclusion drawn from the other cross and would make the double cross of little value as a check on recombinations.

The significant positive correlations in 5 entries between total number of nodes of the plant at the beginning of the fruiting season and 10, 20, 30, and 50 day bloom count totals indicated a relationship similar to that of total height and bloom counts. No significant difference was observed between the r's of Lankart 611 and Lockett No. 1, but the $F_2$ of the single cross (Lankart 611 X Lockett No. 1) was significantly higher than Lankart 611 at the 10% level of probability and significantly higher than Lockett No. 1 at the 1% level of probability. This suggests the possibility of linkage and the use of the double cross as a check on the recombinations of crossover types.

The evidence presented thus far suggests that the height of the plant at the beginning of the fruiting season and the total number of nodes at the beginning of the fruiting season were an expression of vigor. This relationship may be helpful in selecting for earliness.

## SUMMARY


The relationships, measured by the simple correlation coefficient, of all possible combinations of 7 morphological and 4 flowering characters of the cotton plant (Gossypium hirsutum L.), were studied in a double cross (Deltapine 15 X Stoneville 62) X (Lankart 611 X Lockett No. 1), its component single crosses, and its parents.

Several pairs of characters appeared to be unrelated in this study: (1) length of internode, on the first productive fruiting branch or on the main axis directly below the node which bore the first fruiting branch was not significantly related to any of the other characters studied, (2) the total number of nodes to the first productive fruiting branch appeared to be unrelated to other measurements of structure, and (3) bloom counts of 10, 20, 30, and 50 days were not significantly related to internode length, either on the fruiting branch or the main axis.

Occasional significant relationships were observed between characters not usually correlated and these were attributed to environment, differential vigor of the plants, or to chance.

The characters, height at the beginning of the fruiting season, total number of nodes at the beginning of the fruiting season, height at maturity, and total number of nodes at maturity, appear to have a mechanical relationship. Highly significant r values indicated that a close positive relationship is to be expected in these characters.

Bloom count totals at 10, 20, 30, and 50 days would be expected

to be significantly associated because counts were accumulative. This was apparently the case in this study, but there was a weaker relationship between early and late period bloom counts than between counts of closer intervals.

The number of nodes of the main axis to the node which bore the first productive fruiting branch appears to be genetically controlled. This measurement could be a good criterion to use when selecting for earliness, as indicated by a negative correlation with 10 and 20 day bloom counts.

Height and total nodes at the beginning of the fruiting season were significantly correlated with 10 and 20 day bloom count totals. Differences in height are genetically controlled, but it is probable that such differences result from inherited differences in vigor.

Seasonal conditions were generally unfavorable for plant growth in 1956. Only the early season measurements were taken under what could be called favorable growth conditions. Extreme summer drouth conditions suppressed growth during the later part of the season, and genetic differences that may have existed in total bloom number, plant height, and node number at maturity were undoubtedly obscured. Since the main objective was to study relationships of earliness, the early growth measurements and their correlations are considered to be of most value.

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## APPENDIX

The variables, coded 1 through 11, found in appendix tables I and II are as follows:

(1) Height at the beginning of the flowering season

(2) Height at maturity

(3) Total nodes at the beginning of the flowering season

(4) Total nodes at maturity

(5) Length of the first internode on the first productive fruiting branch

(6) Length of the internode of the main axis directly below the node which bore the first fruiting branch

(7) Number of nodes from the cotyledonary node to the node which bore the first fruiting branch

(8) 10 day bloom count totals

(9) 20 day bloom count totals

(10) 30 day bloom count totals

(11) 50 day bloom count totals

# APPENDIX TABLE I

SIMPLE CORRELATION COEFFICIENTS (r's) DETERMINED AMONG 11 VARIABLES CALCULATED BY: (1) r VALUES WITH EFFECTS DUE TO REPLICATION REMOVED, ABOVE THE DIAGONAL; AND (2) r VALUES WITH EFFECTS DUE TO REPLICATION IGNORED, BELOW THE DIAGONAL

(a) Deltapine 15

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.47** | 0.66** | 0.20 | 0.15 | 0.14 | -0.10 | 0.35** | 0.48** | 0.51** | 0.46** |
| 2 | 0.47** | | 0.46** | 0.70** | 0.20 | 0.10 | 0.12 | 0.02 | 0.00 | 0.06 | 0.22* |
| 3 | 0.63** | 0.39** | | 0.36** | -0.06 | 0.07 | 0.04 | 0.27** | 0.33** | 0.37** | 0.45** |
| 4 | 0.21* | 0.70** | 0.36** | | 0.09 | 0.09 | 0.18 | -0.10 | -0.15 | -0.12 | -0.04 |
| 5 | 0.11 | 0.16 | -0.06 | 0.09 | | 0.11 | -0.08 | -0.12 | -0.08 | -0.07 | -0.11 |
| 6 | 0.08 | 0.09 | -0.06 | 0.07 | 0.11 | | 0.05 | -0.03 | 0.05 | 0.05 | 0.01 |
| 7 | -0.12 | 0.11 | 0.06 | 0.21 | -0.03 | 0.07 | | -0.33** | -0.32** | -0.31** | -0.16 |
| 8 | 0.34** | 0.01 | 0.25** | -0.12 | -0.13 | -0.04 | -0.34** | | 0.68** | 0.57** | 0.37** |
| 9 | 0.45** | 0.01 | 0.25** | -0.14 | -0.11 | 0.07 | -0.34** | 0.67** | | 0.86** | 0.58** |
| 10 | 0.51** | 0.13 | 0.28** | -0.08 | -0.11 | 0.05 | -0.33** | 0.55** | 0.84** | | 0.75** |
| 11 | 0.43** | 0.33** | 0.33** | 0.05 | -0.10 | 0.03 | -0.14 | 0.32** | 0.54** | 0.74** | |

Significant r values:

(1) above the diagonal, 95 d.f. : significance at the 5% level of probability = 0.21* and at the 1% level = 0.26.**

(2) below the diagonal, 100 d.f. : significance at the 5% level of probability = 0.20* and at the 1% level = 0.25.**

TABLE I (Continued)

(b) Stoneville 62

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.61** | 0.68** | 0.38** | 0.09 | 0.27** | 0.20 | 0.31** | 0.45** | 0.56** | 0.57** |
| 2 | 0.63** | | 0.49** | 0.74** | -0.04 | 0.18 | 0.28** | -0.10 | -0.03 | 0.10 | 0.44** |
| 3 | 0.62** | 0.45** | | 0.48** | -0.03 | 0.11 | 0.17 | 0.21** | 0.24* | 0.28** | 0.34** |
| 4 | 0.40** | 0.75** | 0.44** | | -0.08 | 0.19 | 0.14 | -0.05 | -0.08 | -0.02 | 0.21* |
| 5 | 0.06 | -0.05 | -0.01 | -0.08 | | 0.16 | -0.04 | -0.17 | -0.11 | 0.00 | 0.13 |
| 6 | 0.28** | 0.17 | 0.11 | 0.19 | 0.14 | | 0.11 | 0.00 | 0.07 | 0.24* | 0.25* |
| 7 | 0.18 | 0.27** | 0.14 | 0.17 | -0.04 | 0.09 | | -0.37** | -0.28** | -0.19 | 0.06 |
| 8 | 0.32** | -0.09 | 0.20* | -0.06 | -0.17 | 0.01 | -0.38** | | 0.82** | 0.63** | 0.20 |
| 9 | 0.48** | 0.02 | 0.19 | -0.05 | -0.13 | 0.08 | -0.27** | 0.81** | | 0.82** | 0.32** |
| 10 | 0.59** | 0.16 | 0.23* | 0.04 | -0.02 | 0.24* | -0.16 | 0.62** | 0.83** | | 0.60** |
| 11 | 0.58** | 0.44** | 0.28** | 0.24* | 0.10 | 0.25** | 0.11 | 0.19 | 0.34** | 0.61** | |

(c) Lankart 611

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.52** | 0.54** | 0.19 | 0.14 | 0.21* | -0.02 | 0.33** | 0.40** | 0.47** | 0.47** |
| 2 | 0.42** | | 0.41** | 0.64 | 0.26** | 0.25* | 0.06 | -0.07 | -0.11 | 0.04 | 0.36** |
| 3 | 0.56** | 0.34** | | 0.31** | 0.11 | 0.04 | -0.01 | 0.25* | 0.27** | 0.42** | 0.47** |
| 4 | 0.16 | 0.68** | 0.28** | | 0.17 | 0.05 | 0.12 | -0.24* | -0.34** | -0.16 | 0.13 |
| 5 | 0.12 | 0.30** | 0.12 | 0.21* | | -0.10 | -0.08 | -0.11 | -0.15 | -0.20 | 0.03 |
| 6 | 0.19 | 0.12 | -0.02 | -0.02 | -0.12 | | -0.02 | -0.03 | 0.08 | 0.13 | 0.13 |
| 7 | -0.01 | 0.06 | 0.07 | 0.07 | -0.09 | -0.07 | | -0.32** | -0.25* | -0.18 | -0.04 |
| 8 | 0.34** | -0.16 | 0.28** | -0.27** | -0.12 | 0.02 | -0.26** | | 0.74** | 0.65** | 0.33** |
| 9 | 0.39** | -0.24* | 0.28** | -0.40** | -0.16 | 0.14 | -0.18 | 0.76** | | 0.78** | 0.40** |
| 10 | 0.46** | -0.11 | 0.38** | -0.25** | -0.22 | 0.19 | -0.13 | 0.67** | 0.81** | | 0.72** |
| 11 | 0.41** | 0.30** | 0.38** | 0.09 | 0.04 | 0.14 | -0.04 | 0.31** | 0.39** | 0.68** | |

TABLE I (Continued)

(d) Lockett No. 1

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.61** | 0.55** | 0.33** | 0.04 | 0.23* | -0.08 | 0.28** | 0.23* | 0.38** | 0.28** |
| 2 | 0.59** | | 0.50** | 0.69** | 0.06 | -0.01 | 0.16 | -0.11 | -0.12 | 0.00 | 0.28** |
| 3 | 0.50** | 0.46** | | 0.51** | 0.24* | 0.07 | 0.07 | 0.01 | 0.04 | 0.19 | 0.27** |
| 4 | 0.31** | 0.68** | 0.53** | | 0.09 | -0.08 | 0.29** | -0.16 | -0.14 | -0.11 | 0.05 |
| 5 | 0.03 | -0.03 | 0.21* | 0.08 | | 0.16 | 0.01 | -0.15 | -0.10 | -0.11 | 0.03 |
| 6 | 0.24* | 0.04 | 0.03 | -0.06 | 0.13 | | -0.04 | -0.05 | 0.02 | 0.03 | 0.07 |
| 7 | -0.08 | 0.14 | 0.10 | 0.26** | 0.02 | -0.05 | | -0.40** | -0.47** | -0.20 | 0.05 |
| 8 | 0.27** | -0.15 | -0.02 | -0.17 | -0.09 | -0.08 | -0.41** | | 0.76** | 0.50** | -0.06 |
| 9 | 0.23* | -0.11 | 0.00 | -0.16 | -0.11 | 0.00 | -0.46** | 0.74** | | 0.66** | 0.00 |
| 10 | 0.37** | 0.00 | 0.17 | -0.11 | -0.11 | -0.02 | -0.19 | 0.49** | 0.66** | | 0.40** |
| 11 | 0.29** | 0.26** | 0.25** | 0.02 | 0.00 | 0.04 | 0.07 | -0.06 | 0.02 | 0.43** | |

(e) Stoneville 62 x Deltapine 15)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.60** | 0.75** | 0.44** | 0.08 | 0.23* | -0.08 | 0.54** | 0.54** | 0.59** | 0.54** |
| 2 | 0.63** | | 0.45** | 0.72** | 0.16 | 0.05 | -0.03 | 0.14 | 0.21* | 0.25* | 0.45** |
| 3 | 0.74** | 0.50** | | 0.57* | 0.22* | 0.10 | -0.07 | 0.47** | 0.45** | 0.51** | 0.46** |
| 4 | 0.49** | 0.76** | 0.60** | | 0.25* | -0.05 | 0.14 | 0.08 | 0.10 | 0.19 | 0.33** |
| 5 | 0.11 | 0.22* | 0.22* | 0.28** | | 0.08 | 0.12 | -0.06 | -0.07 | -0.01 | 0.23* |
| 6 | 0.25** | 0.06 | 0.06 | -0.03 | 0.14 | | 0.05 | 0.05 | 0.00 | 0.00 | 0.06 |
| 7 | -0.06 | 0.01 | -0.03 | 0.18 | 0.15 | 0.06 | | -0.27** | -0.35** | -0.23* | 0.01 |
| 8 | 0.54** | 0.17 | 0.48** | 0.12 | -0.09 | 0.01 | -0.26** | | 0.84** | 0.76** | 0.46** |
| 9 | 0.55** | 0.24* | 0.45** | 0.14 | -0.09 | -0.05 | -0.34** | 0.84** | | 0.91** | 0.61** |
| 10 | 0.59** | 0.28** | 0.49** | 0.20* | -0.04 | -0.01 | -0.25** | 0.75** | 0.91** | | 0.78** |
| 11 | 0.58** | 0.51** | 0.46** | 0.37** | 0.25** | 0.09 | 0.00 | 0.45** | 0.61** | 0.78** | |

TABLE I (Continued)

(f) (Lankart 611 x Lockett No. 1)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.50** | 0.64** | 0.28** | -0.06 | 0.16 | -0.07 | 0.28** | 0.34** | 0.42** | 0.31** |
| 2 | 0.47** | | 0.36** | 0.74** | 0.17 | 0.19 | 0.16 | -0.24* | -0.23* | -0.10 | 0.38** |
| 3 | 0.63** | 0.31** | | 0.38** | -0.10 | 0.05 | -0.13 | 0.37** | 0.41** | 0.52** | 0.45** |
| 4 | 0.25** | 0.74** | 0.33** | | 0.01 | 0.04 | 0.11 | -0.17 | -0.18 | -0.06 | 0.40** |
| 5 | 0.05 | 0.21* | 0.02 | 0.03 | | -0.10 | 0.15 | -0.17 | -0.22* | -0.20 | 0.05 |
| 6 | 0.21* | 0.18 | 0.14 | 0.05 | -0.02 | | -0.26** | 0.08 | 0.10 | 0.06 | -0.07 |
| 7 | -0.03 | 0.21* | -0.04 | 0.13 | 0.20* | -0.20* | | -0.42** | -0.41** | -0.39** | -0.02 |
| 8 | 0.26** | -0.24* | 0.34** | -0.17 | -0.16 | 0.06 | -0.38** | | 0.82** | 0.63** | 0.06 |
| 9 | 0.31** | -0.25** | 0.41** | -0.19 | -0.22* | 0.07 | -0.38** | 0.82** | | 0.82** | 0.20 |
| 10 | 0.33** | -0.13 | 0.46** | -0.07 | -0.24* | 0.00 | -0.38** | 0.63** | 0.83** | | 0.52** |
| 11 | 0.22* | 0.34** | 0.36** | 0.38** | -0.01 | -0.12 | -0.04 | 0.07 | 0.22* | 0.54** | |

(g) (Deltapine 15 x Stoneville 62) x (Lankart 611 x Lockett No. 1)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.57** | 0.65** | 0.35** | -0.04 | 0.08 | 0.20 | 0.20 | 0.32** | 0.34** | 0.39** |
| 2 | 0.52** | | 0.34** | 0.72** | -0.08 | 0.13 | 0.34** | -0.21* | -0.10 | -0.08 | 0.20 |
| 3 | 0.63** | 0.27** | | 0.42** | 0.00 | -0.13 | 0.18 | 0.18 | 0.26** | 0.32** | 0.28** |
| 4 | 0.30** | 0.75** | 0.32** | | 0.01 | -0.17 | 0.41** | -0.25* | -0.23* | -0.11 | 0.13 |
| 5 | -0.02 | 0.06 | -0.03 | 0.09 | | -0.06 | -0.23* | -0.14 | -0.10 | -0.08 | 0.00 |
| 6 | 0.07 | 0.11 | -0.13 | -0.17 | -0.03 | | 0.00 | 0.00 | -0.03 | -0.05 | -0.18 |
| 7 | 0.23* | 0.37** | 0.18 | 0.34** | -0.13 | 0.01 | | -0.30** | -0.27** | -0.18 | 0.02 |
| 8 | 0.17 | -0.34** | 0.16 | -0.37** | -0.21* | 0.00 | -0.31** | | 0.75** | 0.59** | 0.27** |
| 9 | 0.29** | -0.22* | 0.24* | -0.33** | -0.14 | -0.02 | -0.29** | 0.76** | | 0.85** | 0.48** |
| 10 | 0.31** | -0.18 | 0.28** | -0.27** | -0.07 | -0.01 | -0.16 | 0.61** | 0.85** | | 0.70** |
| 11 | 0.40** | 0.20** | 0.26** | 0.06 | 0.06 | -0.14 | 0.08 | 0.23* | 0.45** | 0.68** | |

TABLE II

THE MEANS, STANDARD ERRORS OF THE MEANS, AND COEFFICIENTS OF VARIATION CALCULATED FOR 11 VARIABLES FOR SEVEN ENTRIES

| Coded Variable | Source | Delt. 15 | Sto. 62 | Lank. 611 | Lock. No. 1 |
|---|---|---|---|---|---|
| 1 | $\bar{x} \pm s_{\bar{x}}$ | 43.89 ± .46 | 43.90 ± .52 | 41.37 ± .39 | 47.34 ± .49 |
| | C.V. | 10.94% | 12.21% | 10.13% | 10.90% |
| 2 | $\bar{x} \pm s_{\bar{x}}$ | 58.20 ± .69 | 53.14 ± .59 | 50.41 ± .46 | 61.65 ± .62 |
| | C.V. | 12.34% | 11.37% | 9.74% | 10.69% |
| 3 | $\bar{x} \pm s_{\bar{x}}$ | 16.19 ± .11 | 15.06 ± .11 | 15.23 ± .10 | 16.76 ± .11 |
| | C.V. | 7.22% | 7.84% | 6.89% | 7.22% |
| 4 | $\bar{x} \pm s_{\bar{x}}$ | 21.27 ± .17 | 19.07 ± .14 | 19.20 ± .12 | 21.81 ± .16 |
| | C.V. | 8.27% | 7.66% | 6.51% | 7.79% |
| 5 | $\bar{x} \pm s_{\bar{x}}$ | 71.64 ± 1.91 | 61.89 ± 1.98 | 43.78 ± 2.20 | 63.27 ± 2.79 |
| | C.V. | 27.57% | 32.88% | 53.97% | 46.83% |
| 6 | $\bar{x} \pm s_{\bar{x}}$ | 28.04 ± .86 | 29.58 ± .73 | 27.61 ± .88 | 28.94 ± .74 |
| | C.V. | 31.56% | 25.29% | 34.08% | 27.02% |
| 7 | $\bar{x} \pm s_{\bar{x}}$ | 8.69 ± .19 | 7.61 ± .14 | 7.73 ± .13 | 9.58 ± .26 |
| | C.V. | 22.67% | 19.05% | 17.34% | 28.91% |
| 8 | $\bar{x} \pm s_{\bar{x}}$ | .87 ± .10 | 1.52 ± .14 | 1.82 ± .14 | .65 ± .10 |
| | C.V. | 124.14% | 96.05% | 81.87% | 158.46% |
| 9 | $\bar{x} \pm s_{\bar{x}}$ | 2.77 ± .24 | 5.74 ± .33 | 5.80 ± .31 | 2.48 ± .22 |
| | C.V. | 89.89% | 58.89% | 56.90% | 95.56% |
| 10 | $\bar{x} \pm s_{\bar{x}}$ | 6.10 ± .45 | 11.69 ± .50 | 10.39 ± .43 | 7.11 ± .35 |
| | C.V. | 76.39% | 44.31% | 44.75% | 52.46% |
| 11 | $\bar{x} \pm s_{\bar{x}}$ | 14.92 ± .61 | 20.67 ± .65 | 10.18 ± .50 | 20.09 ± .74 |
| | C.V. | 42.29% | 32.51% | 52.75% | 38.97% |

TABLE II (Continued)

| Coded Variable | Source | (Delt.15 X Sto. 62) | (Lank. 611 X Lock. No. 1) | D.C. |
|---|---|---|---|---|
| 1 | $\bar{x} \pm s_{\bar{x}}$ | 41.72 ± .59 | 45.00 ± .43 | 43.97 ± .48 |
| | C.V. | 13.88% | 10.02% | 11.14% |
| 2 | $\bar{x} \pm s_{\bar{x}}$ | 49.61 ± .61 | 55.39 ± .68 | 56.58 ± .64 |
| | C.V. | 12.13% | 12.85% | 11.61% |
| 3 | $\bar{x} \pm s_{\bar{x}}$ | 14.95 ± .15 | 15.95 ± .11 | 15.78 ± .13 |
| | C.V. | 9.57% | 7.01% | 8.17% |
| 4 | $\bar{x} \pm s_{\bar{x}}$ | 18.59 ± .13 | 20.12 ± .18 | 20.53 ± .15 |
| | C.V. | 6.94% | 9.34% | 7.65% |
| 5 | $\bar{x} \pm s_{\bar{x}}$ | 51.25 ± 2.52 | 54.36 ± 2.05 | 55.71 ± 1.94 |
| | C.V. | 48.27% | 39.29% | 35.92% |
| 6 | $\bar{x} \pm s_{\bar{x}}$ | 27.55 ± .82 | 27.98 ± .75 | 27.69 ± .75 |
| | C.V. | 29.22% | 28.09% | 27.88% |
| 7 | $\bar{x} \pm s_{\bar{x}}$ | 7.32 ± .17 | 8.32 ± .18 | 7.82 ± .14 |
| | C.V. | 22.81% | 22.84% | 18.16% |
| 8 | $\bar{x} \pm s_{\bar{x}}$ | 1.29 ± .17 | 1.70 ± .15 | 1.39 ± .13 |
| | C.V. | 125.58% | 93.53% | 93.53% |
| 9 | $\bar{x} \pm s_{\bar{x}}$ | 4.54 ± .40 | 5.07 ± .34 | 4.88 ± .30 |
| | C.V. | 85.46% | 69.82% | 63.73% |
| 10 | $\bar{x} \pm s_{\bar{x}}$ | 9.42 ± .64 | 10.90 ± .54 | 10.05 ± .57 |
| | C.V. | 66.03% | 51.38% | 58.71% |
| 11 | $\bar{x} \pm s_{\bar{x}}$ | 15.68 ± .75 | 19.37 ± .63 | 19.34 ± .77 |
| | C.V. | 46.68% | 34.02% | 41.05% |

# VITA

LONNIE GENE DALTON

Candidate for degree of

Master of Science

Thesis: RELATIONSHIPS AMONG CERTAIN MORPHOLOGICAL AND FLOWERING CHARACTERS IN GOSSYPIUM HIRSUTUM L.

Major Field: Field Crops

Biographical:

Personal data: Born near Carter, Oklahoma, July 20, 1934, the son of Glen F. and Billie B. Dalton.

Education: Attended grade school in Carter and Weatherford, Oklahoma and also Gallup, New Mexico; attended Junior High School in Gallup and Belin, New Mexico and also Carter, Oklahoma; graduated from Carter High School in May 1952; received the Bachelor of Science degree from Oklahoma Agricultural and Mechanical College, with a major in Field Crops, in May, 1956; completed requirements for the Master of Science degree in May, 1957.