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Yield models, components, and interrelationships in upland cotton, Gossypium hirsutum L

Buford A. Maner

To the Graduate Council:

I am submitting herewith a thesis written by Buford A. Maner entitled "Yield models, components, and interrelationships in upland cotton, Gossypium hirsutum L." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

L. N. Skold, Major Professor

We have read this thesis and recommend its acceptance:

Smith Worley, Vernon H. Reich

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

November 20, 1970

To The Graduate Council:

I am submitting herewith a thesis written by Buford A. Maner, Jr. entitled "Yield Models, Components, and Interrelationships in Upland Cotton, Gossypium hirsutum L." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

L N Skold

Major Professor

We have read this thesis
and recommend its acceptance:

Smith Worley, Jr

Vernon H Reich

Accepted for the Council:

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Vice Chancellor for
Graduate Studies and Research

YIELD MODELS, COMPONENTS, AND INTERRELATIONSHIPS IN UPLAND COTTON, *GOSSYPIUM HIRSUTUM* L.

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Buford A. Maner, Jr.

December 1970

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ABSTRACT

Studies were carried out to develop yield models for selected Upland cotton genotypes to determine the interrelations of yield components and their relative contributions to cotton yield.

Data used in these investigations were collected in 1968 and 1969 by the cotton breeding and quality investigations program, Pee Dee Experiment Station, Florence, South Carolina.

This yield model study utilized four selected genotypes both individually and collectively, in equating yield to the volume of a rectangular parallelepiped. Axes (X), (Y), and (Z) of the geometric model represented the equivalent number of bolls per square meter, the equivalent number of seeds per boll, and the weight of seed cotton per seed, respectively. The results indicated that the primary gain in yield improvement would be made by exerting selection pressure on the number of bolls per unit area. Concurrent selection pressure should also be placed on the number of seeds per boll and weight of seed cotton per seed in order to maintain these components at acceptable levels.

Data collected for the yield components in each test entry across 13 locations in 1968, 12 locations in 1969, and 25 locations in 1968-1969 combined, were used to calculate simple correlation coefficients between components. These analyses permitted comparisons of the within years results with those obtained when additional component variations were introduced. These analyses indicated that

cause and effect relationships were involved between many of the component pairs. These studies indicated that a large population including several environments would be necessary for drawing conclusions about component relationships.

Multiple regression analyses were used to determine the relative contributions of the components to lint yield, and to rank them in order of importance. The number of bolls per unit area accounted for 81 to 91% of the total lint yield variation. Boll size contributed 6 to 14% and seed weight in grams per 100 bolls 2 to 4% to the total lint yield variation. The remaining components increased the multiple correlation only .0002 to .0004 in these analyses. The total multiple correlation coefficient was .99 in all cases.

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CHAPTER I

INTRODUCTION

Breeders strive to develop cotton varieties having superior fiber quality with wide adaptability to various environmental conditions and cultural, and harvesting methods. These varieties should produce the greatest monetary return per unit area for the cotton producer. This general objective can be accomplished only by the successful combination of a series of specific objectives. These may include selection for acceptable spinning properties, adaptation to mechanical production and harvesting procedures, and other qualities. Progress toward the above objectives has resulted in the development of varieties superior to those previously released by breeders.

This investigation was an attempt to approach one of these specific objectives, yield potential, from the standpoint of the components of yield in addition to the component interrelationships in a situation where selection pressure has been applied for high yield and the lint property of high yarn strength.

Cotton yield is quantitative in nature. Several traits interact to produce the final result. These components of yield are influenced by both genetic and environmental sources of variation. Hence, yield cannot be changed without changes in the expression of one or more components. However, changes in components may tend to counterbalance each other with no resulting change in yield. Information as to the relative contributions and interrelationships of the basic yield components provide the basis for the yield model concept.

There are three general approaches to the problem of selection for yield: the empirical, the theoretical or analytical, and the statistical approaches. The empirical method involves selection on the basis of the judgement of the individual. Criteria for this method include the general plant appearance, lint percent, and quality factors. This type of approach prevails particularly in F_2 to F_4 selections.

The theoretical or analytical approach is exemplified by the yield model and its components, as proposed by Kerr (11). Information which pertained to plant growth and concomitant development was required for Kerr's development of this approach.

The statistical approach to the problem of selection involves fitting the data obtained in field experiments to the proposed yield model. This approach also permits an evaluation of the interrelationships of the various yield components and an estimate of their relative net effect on yield.

The objectives of this study were:

1. To develop yield models for the populations under study,
2. To study the interrelations of cotton yield components,
3. To make comparisons of the relative contributions of yield components to yield.

CHAPTER II

LITERATURE REVIEW

I. YIELD MODEL AND COMPONENTS

The development of a geometry for plant breeding may provide a valuable tool when used as a means of expressing certain reactions and conformations, and for ordering and discussing some of the most complex of relationships. Grafius (6, 7) noted that the assigning of components must be both biologically and geometrically sound for the model to be most meaningful. For example, diseases affect yield, but diesase resistance is not a component of yield. This does not mean that disease resistance would be ignored, but merely that it has its own definite niche in the geometry of plant breeding. He proposed geometric models for expressing yield and its components in barley and oats. The geometric forms were rectangular parallelepipeds, with the total volume representing yield, and the dimensions (X), (Y), and (Z) simulating the yield components involved.

Kerr (11) expressed cotton yield and its components in a geometric model. He equated seed cotton yield with the volume of a rectangular parallelepiped having dimensions (X), (Y), and (Z) equal to the number of bolls per unit area, number of seeds per boll, and weight of seed cotton per seed, respectively. Axis (Z) is divided into two fractions: lint weight per seed (L), and seed weight per seed (S). Thus, lint yield may be expressed by the rectangular parallelepiped (XYL), with the major lint yield components being number of bolls per unit area, number of seeds per boll, and lint weight per seed.

Kerr reported that the components of the boll (YZ) are a unit package of yield. When maximum yields are sought, there appears to be an optimum range for each boll component which in turn may vary with environment, cultural conditions, and probably yield level. The optimum values reached by the different boll components are not only related to yield, but also to each other through their patterns of development. The combination of optimum boll characteristics associated with maximum yields will take place only when germ plasm spanning the different optima is present in the population. This will also occur only when strong selection pressure is placed on lint yield, with no selection pressure on boll and fiber characteristics.

Grafius and Wiebe (8) conducted an experiment on the expected genetic gain due to selection on the basis of the geometry of yield of small grains where (W) was the volume of a rectangular parallelepiped with axes (X), (Y), and (Z) equal to the number of heads per unit area, number of kernels per head, and weight per kernel, respectively. All data were expressed in percent of the sample mean.

Best results were obtained by concentrating on improving one axis when the expected genetic gain for the other two were low, but if these were high, selection for two or even three axes at one time might be the best approach.

Neely (17) demonstrated the ability of the cotton plant to "fill-in," i.e., plants tend to be more fruitful when adjacent to skips in a row, regardless of orientation, and thus approach the bolls per unit area of a plot having a perfect stand.

He studied the effect on cotton yield of perfect stands versus skips in stands. Ten 3-row plots, 40 inches apart and 25 feet long had skips of 0, 2, 3, 4, 5, 6, 7, 8, 9, or 10 feet respectively, in the center row. The 3-year average yield for the series of plots without skips was 9.75 pounds while the plots with 10-feet skips yielded 9.53 pounds.

Elaborate boll counts made on 3-foot segments of all rows showed that the plants at the ends of the skips, and in the sections of rows adjacent to the skips yielded considerably more than other plants, compensating for skips up to 10 feet.

In contrast, Cook (3) advocated close plant spacing, with a population as large as 60,000 plants per acre. He reported that vegetative branches were suppressed, the bolls were set early and over a short period of time, and the plants yielded less indivudually but more per row when grown under close row spacing conditions.

II. INTERRELATIONS OF COTTON LINT YIELD COMPONENTS AND THEIR RELATIVE CONTRIBUTIONS

The interrelationships among lint yield, agronomic properties, and fiber properties are chiefly through the boll and its components as described by the geometric model suggested by Kerr (11).

El-Sourady (4) studied the interrelationships between lint yield and agronomic properties of the four national varieties of the 1966 Regional Cotton Variety Tests (18). The varieties were 'Paymaster 54-B,' 'Acala 1517-D,' 'Stoneville 7A,' and 'Coker 201,' grown at 32 locations. The correlation coefficients between lint yield, boll weight, lint percent, seed index, and lint weight per seed for each variety and for the varieties combined were investigated.

El-Sourady reported that none of the varieties, individually or combined, showed any significant relationship between lint yield and lint percent, seed index or lint weight per seed. Paymaster 54-B showed a significant positive correlation between lint yield and boll weight. No association was found between boll weight and lint percent. However, boll weight had highly significant positive correlations with seed index and lint weight per seed. Acala 1517-D and Stoneville 7A showed a significant negative correlation between lint percent and seed index, whereas the correlations for the other two varieties were not significant; however, when the four varieties were combined, lint percent and seed index had a highly significant positive correlation. Lint percent showed a highly significant positive correlation with lint weight per seed either for the individual varieties or when they were combined, with the exception of Acala 1517-D, which did not reach the level of significance. Seed index was found to have a highly significant positive correlation with lint weight per seed.

Miletello (13) studied the relationships of fiber properties, yield, and yield components among F_3 lines of Upland cotton. He found that the only yield component significantly correlated with yield was number of bolls per plot. It was a highly significant positive correlation.

Feaster and Turcotte (5) studied the relationship between lint color and agronomic and fiber properties using progenies of an F_4 experimental Pima strain, over a 2-year evaluation period. The Pima strain showed no correlation between yield and lint percent or its components (seed index and lint index).

Breaux (2) studied the relationship of lint yield and yield components among F_3 and F_4 lines of a 'Wilds' x 'Half and Half' cross. He found highly significant positive correlations between lint yield with number of bolls per plot and lint yield with lint percent. Seed index showed a highly significant negative association with lint yield, but revealed a highly significant positive relationship with lint index. A significant negative correlation coefficient was obtained between seed index and lint percent.

Limaye (12) calculated total correlation coefficients for selected yield components in three F_2 populations of crosses between Gossypium hirsutum and G. barbadense. He also reported a significant negative correlation between seed index and lint percent and a highly significant positive correlation between seed index and lint index.

Al-jibouri, Miller, and Robinson (1) studied the relationship between selected agronomic and fiber properties, using F_3 progenies from a cross between 'Empire-10' (G. hirsutum) and a high lint strength but low yielding strain extracted from the tri-species hybrid involving G. arboreum, G. thurberi and G. hirsutum. These selected F_3 progenies were grown in three replicates in two environments. A large proportion of the observed phenotypic variance among progeny means was attributed to genotypic effects. Genotypic correlations indicated a positive relationship between lint yield and lint percentage. A negative genotypic association was found between fiber strength and both lint yield and lint percentage.

Miller et al. (16) investigated ten characters in each of three populations of F_4 and F_5 lines of Upland cotton crosses. Lint yield was highly positively correlated with lint percentage and bolls per plant and negatively correlated with seed index and weight per boll. These types of associations were observed in all three populations studied.

Miller (14) and Miller and Rawlings (15) studied correlated responses to selection for both yield and fiber strength in Upland cotton. Selection pressure was placed separately on lint yield and fiber strength. Observations of the behavior of the remaining traits, which were not subject to selection, were noted. They reported an increase in lint yield of 29.7% after three cycles of recurrent selection. Selection response was found to be linear and was predicted to continue at approximately the same rate of gain for an additional cycle. As selection increased yield, simultaneous increases were noted for lint percent and number of seedsper boll. Boll size, fiber strength and seed size decreased with little change in weight of lint per seed.

By contrast, in a parallel population five cycles of selection increased fiber strength by 11.3%. As strength was increased, yield and lint percentage decreased. Increases were noted for boll size and seed index.

The relationship between yield components and lint yield is a complex association. The assumption that some components contribute more to lint yield than other components would probably be valid; however, little literature is available on this subject. Literature is available in related fields applicable to this study.

El-Sourady (4) studied the different sources of variation affecting the relative contributions of different cotton fiber properties to yarn strength. He related three general approaches to the problem which are as follows: the empirical method, the analytical or theoretical approach, and the statistical method. The third method was chosen as the best tool to use for solving his problem.

The statistical approach was also selected for this study, using a program to compute a sequence of multiple linear regression equations in a stepwise manner. Multiple analysis became increasingly important since the yield components were interrelated with each other to the extent that their true relationship with yield could be masked. Therefore, multiple analysis was used to estimate the relative net effect of the yield components on yield.

CHAPTER III

MATERIALS AND METHODS

I. LOCATION AND MATERIALS

The data used in this investigation were obtained from the cotton breeding and quality investigations conducted at the Pee Dee Experiment Station, Florence, South Carolina for the years 1968 and 1969. This project is a cooperative effort of the United States Department of Agriculture, Agricultural Research Service and the South Carolina Agricultural Experiment Station. The objective of research conducted at this station is to develop high yielding breeding lines or varieties with fiber length, strength, and fineness levels that will meet the requirements for modern, automated processing and chemical treatments that are now a part of most fabric finishing processes (9, 10).

The strain evaluation studies (Figure 1) which attempt to establish yield potential and values of fiber properties, are conducted in three distinct phases: The first phase is the primary or new strains tests. Here in one or more replicated tests of no more than 30 entries per test, selected F_4 progenies and reselections from the established breeding lines are systematically tested for the first time. In 1968 and 1969, a test planted on two different soil types and on two different dates was employed to screen these new strains. There were 30 entries in the 1968 test including the varieties Coker 201 and 'Coker 413-68' and the strain release Pee

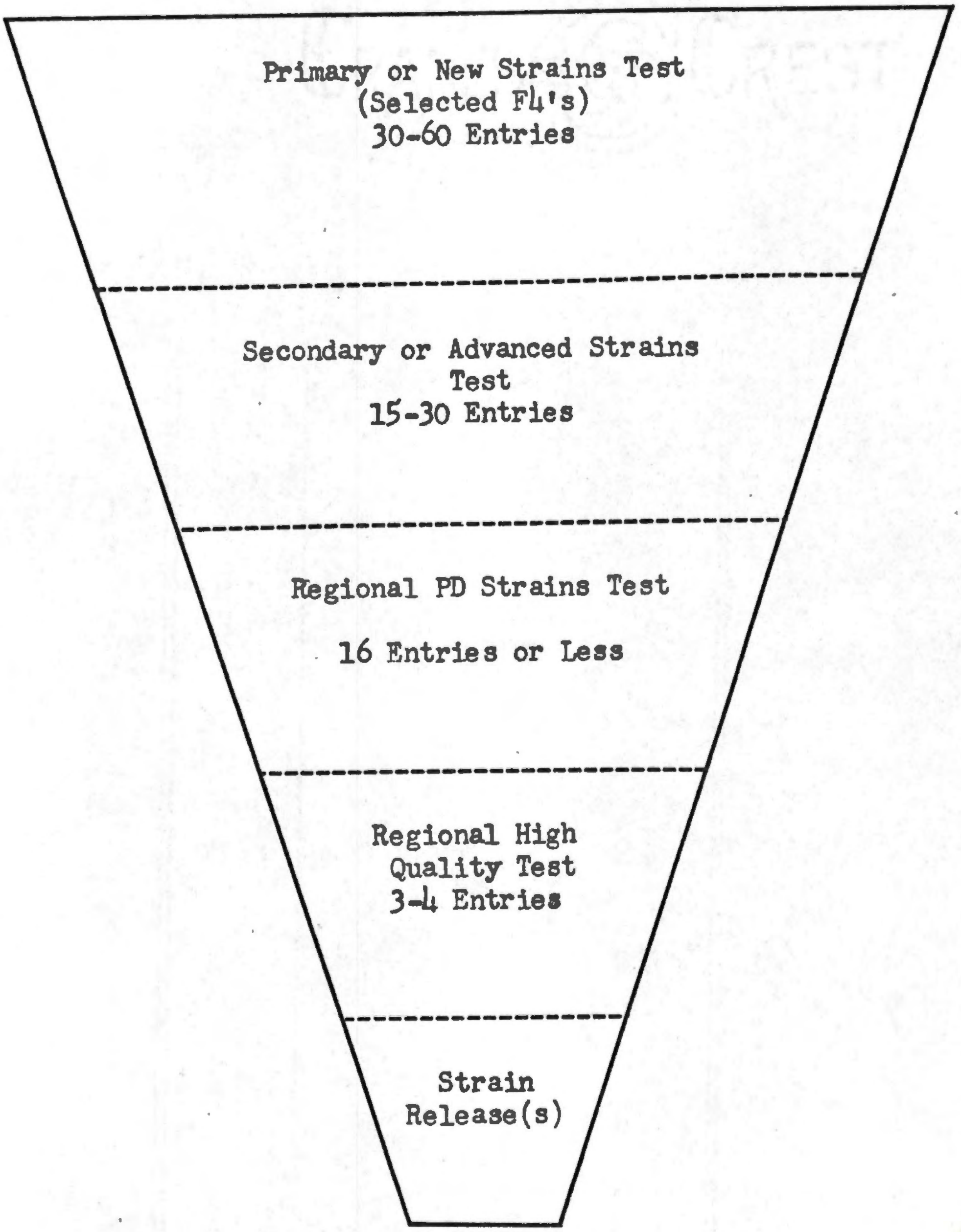

Figure 1. Testing program for PD lines, Pee Dee Exp. Sta., Florence, S. C.

Dee 2165 which were used as checks. For 1969, 25 entries were tested including the checks Coker 201 and Pee Dee 2165.

In the second phase, one or more advanced strains tests are used to further evaluate the strains that performed well in the primary screening. Normally about one-half of the top yielding strains in the primary tests are evaluated in the advanced strains tests. In 1968, four tests with 25 entries per test, were planted approximately two weeks apart on two planting sites. These entries included the checks Coker 201, Coker 413-68 and Pee Dee 2165. Four tests with 25 entries per test, including the checks Coker 201 and Pee Dee 2165, were planted in 1969.

The third phase of testing is the Regional Test of PD Strains conducted at five to seven locations in two or three states. Since this test is limited to 16 entries, including the check varieties, about one-half of the top entries in the secondary test will be evaluated in the regional test. Therefore, only about one-fourth of the strains entering the testing program will be tested regionally, as shown in Figure 1. In 1968, 16 entries, including the checks Coker 201, Coker 413-68 and Pee Dee 2165, were grown at Florence and Blackville, South Carolina, Experiment and Tifton, Georgia, and Stoneville, Mississippi. In 1969, 12 entries, including the checks Coker 201 and Pee Dee 2165, were grown at Florence (2 tests), Edisto and Clemson, South Carolina, and at Experiment, Midville and Tifton, Georgia. Data from one test at Florence and the tests grown at Edisto and Clemson were not used in this investigation because of additional variables of the experimental design.

The field experimental design was a randomized complete block design with four, six or eight replications. However, after harvest, the seed cotton from two, three, or four replications was bulked so that analyses were based on two composite replications in all tests. Plot size varied from 12.37 to 27.84 square meters. The measurements and calculations required for obtaining data on seed cotton yield, boll size, lint percent, and seed index were done at florence. Further development of these data and the calculations necessary for development of the other yield components, namely equivalent number of bolls per square meter, equivalent number of seeds per boll, weight in grams of seeds per 100 bolls, equivalent weight in grams of seed cotton per seed, lint yield in grams per square meter, and the weight in grams of lint per seed, were accomplished at Knoxville. The IBM 360-65 computer was used extensively for development of these data.

II. YIELD COMPONENTS STUDIED

The components used in this study are either measured variables or computed variables. These components are:

Seed cotton yield in grams per square meter: The weight in grams of seed cotton divided by the area in square meters of the experimental unit.

Boll size: The average weight in grams per boll of seed cotton.

Lint fraction: The weight in grams of lint ginned from a sample of seed cotton, divided by the weight of the seed cotton in grams.

Lint percent: Lint fraction multiplied by 100.

Seed index: The weight in grams of 100 seeds, after ginning.

Equivalent number of bolls per square meter: The seed cotton yield in grams per square meter, divided by the boll size in grams.

Weight in grams of seeds per 100 bolls: The boll size multiplied by 100 times the quantity, 1.0 minus the lint fraction.

Equivalent number of seeds per boll: The seed weight in grams per 100 bolls, divided by the seed index in grams.

Equivalent weight in grams of seed cotton per seed: The boll size divided by number of seeds per boll.

Lint yield in grams per square meter: The seed cotton yield in grams per square meter, multiplied by the lint fraction.

Weight in grams of lint per seed: The equivalent weight of seed cotton per seed multiplied by the lint fraction.

III. YIELD MODEL

A gain in perspective of the components of yield is obtained by adapting the geometric model of cotton yield and its components as proposed by Kerr (11), Figure 2. The volume of the rectangular parallelepiped is equated with yield. Dimensions (X), (Y), and (Z) are equal to the equivalent number of bolls per square meter, equivalent number of seeds per boll, and the weight of seed cotton per seed in grams. Axis (Z) is divided into two fractions: weight of lint per seed (L), and seed weight per seed (S). Seed cotton yield is represented by (XYZ); lint yield by (XYL); seed yield by (XYS) and boll weight by (YZ).

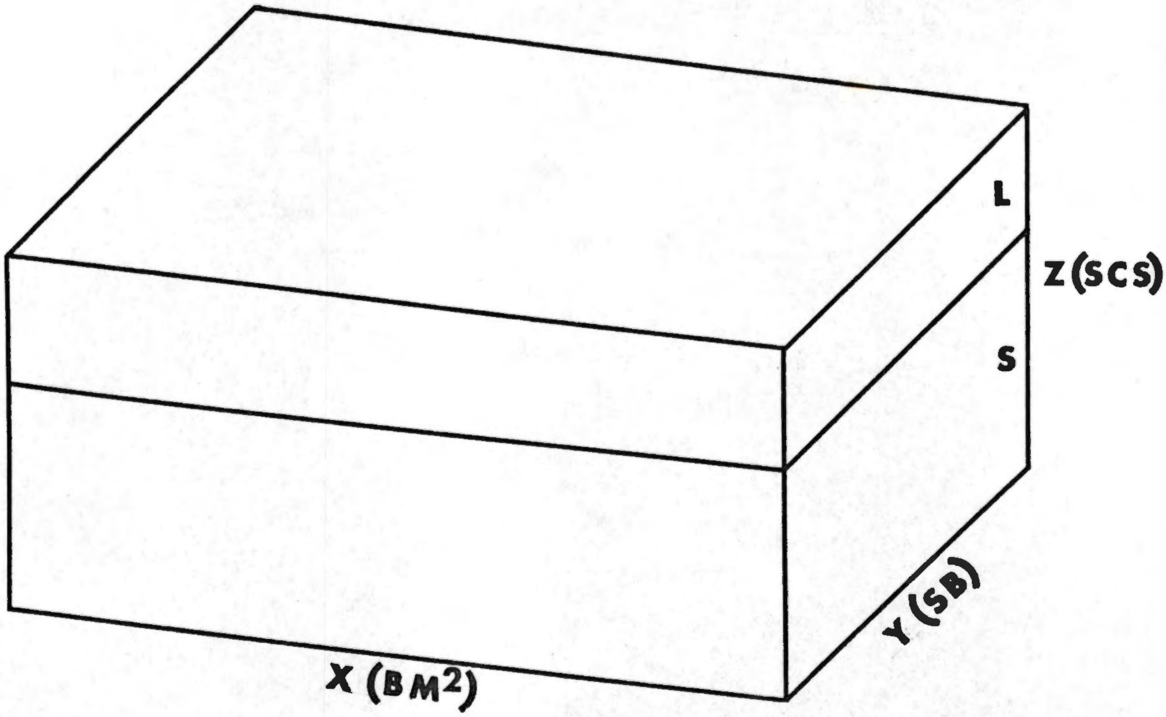

Figure 2. Geometric model showing relation of cotton yield to the various yield components.

X = BOLLS PER UNIT AREA (BM^2)

Y = SEEDS PER BOLL (SB)

Z = SEED COTTON PER SEED (SCS)

L = LINT PER SEED

S = SEED WEIGHT PER SEED

XYZ = SEED COTTON YIELD

XYL = LINT YIELD

YZ = BOLL WEIGHT

Breeders and producers are primarily concerned with lint yield (XYL). This investigation involved the development of yield models and their respective components for the populations under study.

Coker 201 was used as a check variety for all tests grown in both 1968 and 1969. This variety is among the highest yielding commercial varieties grown in the test area. The experimental strain entries and additional check entries should be compared with the leading varieties available. Therefore, for the purpose of comparing different genotypes, each yield component was compared to, and adjusted on, the basis of the corresponding value for Coker 201. The mean values for the yield components of Coker 201 were used as a base. The different genotypes then were expressed as a percent of the Coker 201 base.

Further equations for minimizing the environmental effects were accomplished by comparing the mean values for the yield components of Coker 201 for an environment with the previously mentioned base. This permits comparison across the different environments involved in this study.

IV. STATISTICAL ANALYSES

In this study, the three strain evaluation tests conducted in 1968 and 1969, were analyzed individually and collectively. For each test, the data means for each component were used to calculate simple correlation coefficients for character pairs. In addition, the correlation coefficients were calculated utilizing the means of the tests for each year and over both years.

The variations are expected to show both environmental and genotype x environment interaction within each test. By combining the different tests within years and over years, additional genetic and environmental variations are added to the measurements.

The mathematical model for the analysis is

$$X_{ijkl} = u + v_i + y_j + l_k + (yl)_{jk} + (vy)_{ij} + (vl)_{ik} + (vyl)_{ijk} + r_{ijkl} + e_{ijkl}$$

where X_{ijkl} is the observation on the i^{th} variety in the l^{th} replicate at the k^{th} location in the j^{th} year; u is a common mean of all varieties over all replicates, locations, and years, v_i is a measure of the average genotypic effect of the i^{th} variety, y_j is the average effect of the j^{th} year, l_k is the average effect of the k^{th} location; $(yl)_{jk}$ is the average interaction of the j^{th} year with the k^{th} location; and the other interactions have the appropriate meaning designated by the corresponding subscripts. In these experiments, replicates, years and locations are considered random variables and varieties are fixed variables. Tests of significance of mean squares due to various sources of variation were made. The forms of analysis of variance and the expected mean square composition for within a year and combined years, are shown in Tables 1 and 2, respectively.

Also, the data from these tests were used individually and collectively in multiple regression analyses to predict lint yield from yield components. The nine yield components were used in prediction equations to measure their relative contributions to lint yield and their order of importance. This goal was achieved by using the BMD02R,

Table 1. The form of analysis of variance for 1968 or 1969 tests

Source of Variation	Degrees of Freedom	Mean[a] Square	Mean Square Expectation
Reps. in locs.	p(r-1)		
Locations	(p-1)	P	$\sigma^2_e + r\sigma^2_{vp} + rv\sigma^2_p$
Varieties	(v-1)	V	$\sigma^2_e + r\sigma^2_{vp} + rp\sigma^2_v$
Var. x loc.	(v-1)(p-1)	VP	$\sigma^2_e + r\sigma^2_{vp}$
Error	p(v-1)(r-1)	E	σ^2_e

[a]P, V, VP, and E are the values of the appropriate mean squares, and r, p, and v are the numbers of replicates, locations, and varieties, respectively.

Table 2. The form of analysis of variance for the years combined

Source of Variation	Degrees of Freedom	Mean Square[a]	Mean Square Expectation
Years	y-1		
Locations	p-1		
Locs. x yrs.	(p-1)(y-1)		
Reps. in locs. and yrs.	py(r-1)		
Varieties	(v-1)	V	$\sigma^2_e + r\sigma^2_{vpy} + ry\sigma^2_{vp} + rp\sigma^2_{vy} + rpy\sigma^2_v$
Var. x yrs.	(v-1)(y-1)	VY	$\sigma^2_e + r\sigma^2_{vpy} + rp\sigma^2_{vy}$
Var. x locs. x yrs.	(v-1)(p-1)(y-1)	VPY	$\sigma^2_e + r\sigma^2_{vpy}$
Error	py(r-1)(v-1)	E	σ^2_e

[a]V, VY, VP, VPY, and E are the values of the appropriate mean squares, and r, p, y, and v are the numbers of replicates, locations, years, and varieties, respectively.

(revised June 26, 1969), stepwise regression program of the Health Sciences Computing Facility, University of California at Los Angeles. This program computes a sequence of multiple linear regression equations in a stepwise manner. One variable is added to the regression equation at each step. The variable added is the one which makes the greatest reduction in the error sum of squares. Equivalently, it is also the variable which has the highest partial correlation with the dependent variable on the variables which have already been added; and equivalently, it is the variable which would have the highest F values if added. Furthermore, variables can be forced into the regression equation and automatically removed when their F values become too low.

CHAPTER IV

RESULTS AND DISCUSSION

I. YIELD MODEL AND COMPONENTS

The only pathway for cotton yield improvement is through the securance of a positive change in all factors influencing yield. These factors may include: improved production practices, development of varieties with superior yield potential, and better land selection. This investigation was an attempt to approach one of these factors, yield potential, from the standpoint of the components of yield in addition to the component interrelationships.

Insight was gained by using a geometric model of cotton yield and its components. This was accomplished by equating the volume of a rectangular parallelepiped with yield. Axes (X), (Y), and (Z) represent the equivalent number of bolls per square meter, the equivalent number of seeds per boll, and the weight of seed cotton per seed, respectively. Axis (Z) was further divided into two fractions: weight of lint per seed (L) and seed weight per seed (S). Seed cotton yield was represented by (XYZ) and lint yield by (XYL).

The yield model was used in this study to compare the effects of the magnitude of the various components on yield of selected genotypes. The four genotypes chosen were Coker 201, Pee Dee 2165, PD 4381-262, and PD 4381-264. All were entries in the advanced strains test in 1968, and the regional PD strains test in 1969. These tests were part of the cotton breeding and quality investigations program of the Pee Dee Experiment Station, Florence, South Carolina.

Coker 201 and Pee Dee 2165 were used as checks in the breeding program. Coker 201 was one of the highest yielding commercial varieties grown in the test area. Pee Dee 2165 was released by the Pee Dee Station in 1965, as a non-commercial breeding line. This line has been widely accepted as parent material in breeding programs throughout the cotton belt, due primarily to possession of high lint quality.

PD 4381-262 and PD 4381-264 are reselections from Pee Dee 4381, a non-commercial breeding line released by the Pee Dee Station in 1968. This line has high yield potential and acceptable fiber and spinning properties. These two genotypes were chosen from a group of Pee Dee 4381 reselections on the basis of their relative yield levels, and are not necessarily the reselection having the highest or lowest yield.

The mean values for the yield components of Coker 201 grown at all locations over both years, were used as a base for the yield model. The different genotypes were then expressed as a percentage of the Coker 201 base. In order to compare the different genotypes, each yield component was compared to, and adjusted on, the basis of the corresponding value for Coker 201.

Further equations for minimizing the environmental effects were accomplished by comparing the mean values for Coker 201 for an environment with the previously mentioned base. This permits comparison across the different environments involved in this study.

Four replicated advanced strains tests were tested in 1968, at Florence, South Carolina. There were also four regional PD tests in

1969, tested at Florence, South Carolina and Experiment, Midville, and Tifton, Georgia. The four selected genotypes were common to all tests.

The mean yield component values of the combined tests are presented in Table 3. These values are for each genotype within each year and combined over years. Table 4 shows the mean yield component values of the selected genotypes expressed as percentages of the Coker 201 base.

Figure 3 presents the yield model and its components for the Coker 201 combined experiment means, expressed as 100%. Expression of yield components on a percentage scale permitted comparisons among selected genotypes.

Figure 4 illustrates the yield model and its components of Pee Dee 2165 in 1968. Both seed cotton and lint yield are only 83% of the corresponding values of Coker 201. The component showing the greatest departure was the number of bolls per square meter. The value for this axis (X) was only 82% of the base. Seeds per boll, seed cotton per seed, and weight of lint per seed were 95%, 107% and 107%, respectively.

The yield model and its components of Pee Dee 2165 grown in 1969, are presented in Figure 5. Seed cotton yield was 88% and lint yield 87% of the base values. Again, as was the case in 1968, the number of bolls per square meter (X axis), was the component showing the greatest deviation from the base. This value was 88%. The value for the number of seeds per boll was 91%, weight of seed cotton per seed 110%, and the lint weight per seed 109%.

Table 3. Mean yield component values of selected genotypes

Year	Variety or Strain	Equivalent Bolls per Square Meter	Equivalent Seeds per Boll	Equivalent Seed Cotton per Seed (grams)	Lint per Seed (grams)	Seed Weight per Seed (grams)	Seed Cotton Yield per Square Meter (grams)	Lint Yield per Square Meter (grams)
1968-1969	Coker 201	42.1	33.2	0.188	0.071	0.118	262.8	99.1
1968	Pee Dee 2165	34.5	31.6	0.201	0.075	0.130	218.1	82.2
1969	Pee Dee 2165	37.0	30.2	0.207	0.077	0.131	231.2	85.2
1968-1969	Pee Dee 2165	35.8	30.9	0.205	0.077	0.130	226.0	83.2
1968	PD 4381-262	47.1	33.6	0.182	0.066	0.117	289.0	104.0
1969	PD 4381-262	44.2	32.2	0.192	0.071	0.122	273.3	101.0
1968-1969	PD 4381-262	45.8	32.0	0.186	0.068	0.119	281.1	103.0
1968	PD 4381-264	43.3	32.6	0.184	0.067	0.118	260.1	95.1
1969	PD 4381-264	42.5	31.6	0.190	0.069	0.123	254.9	92.1
1968-1969	PD 4381-264	42.9	31.9	0.188	0.068	0.120	257.5	93.2

Table 4. Mean yield component values of selected genotypes expressed as percentages of the Coker 201 base

Year	Variety or Strain	Equivalent Bolls per Square Meter	Equivalent Seeds per Boll	Equivalent Seed Cotton per Seed	Lint per Seed	Seed Weight per Seed	Seed Cotton Yield per Square Meter	Lint Yield per Square Meter
1968-1969	Coker 201	100	100	100	100	100	100	100
1968	Pee Dee 2165	82	95	107	107	110	83	83
1969	Pee Dee 2165	88	91	110	109	111	88	87
1968-1969	Pee Dee 2165	85	93	109	108	110	86	85
1968	PD 4381-262	112	101	97	93	99	110	105
1969	PD 4381-262	105	97	102	100	103	104	102
1968-1969	PD 4381-262	109	99	99	96	101	107	104
1968	PD 4381-264	103	98	98	95	100	99	96
1969	PD 4381-264	101	95	101	97	104	97	93
1968-1969	PD 4381-264	102	96	100	96	102	98	94

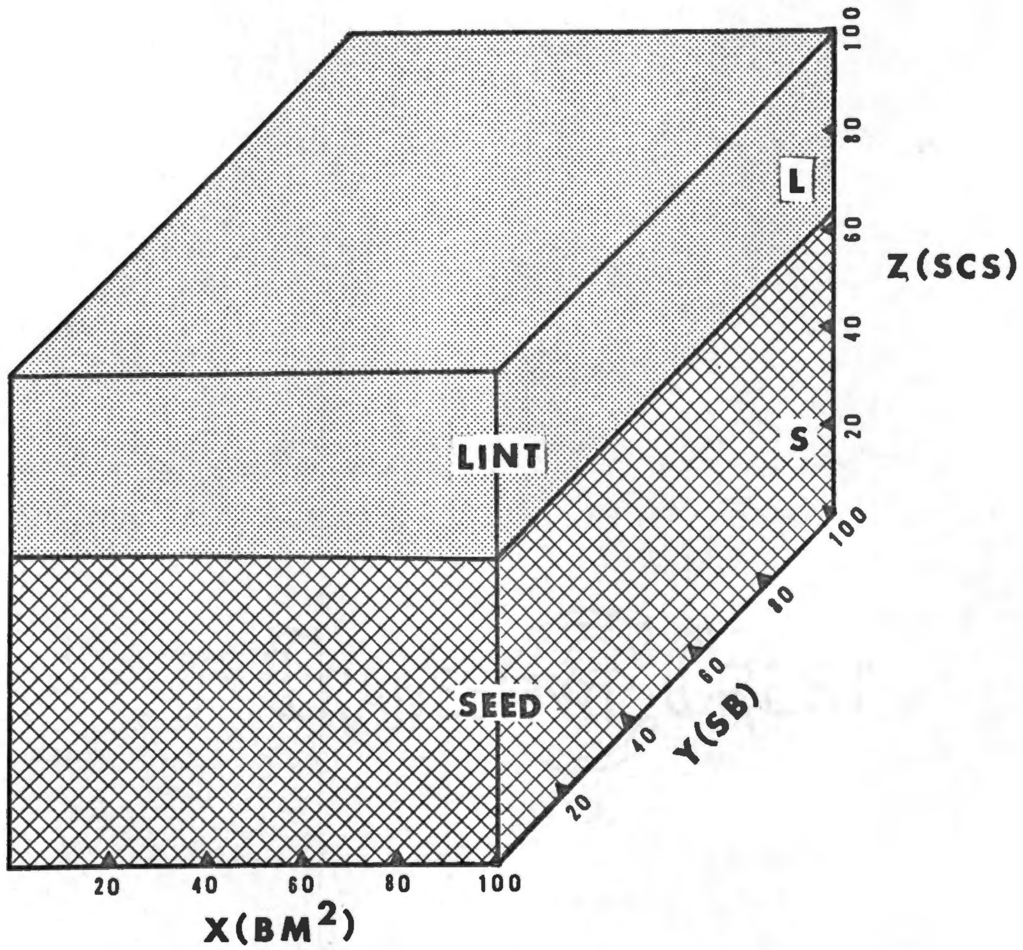

Figure 3. Coker 201 combined experiment means expressed as 100 percent.

XYZ = 1 x 1 x 1 = 1.00

XYL = 1 x 1 x 1 = 1.00

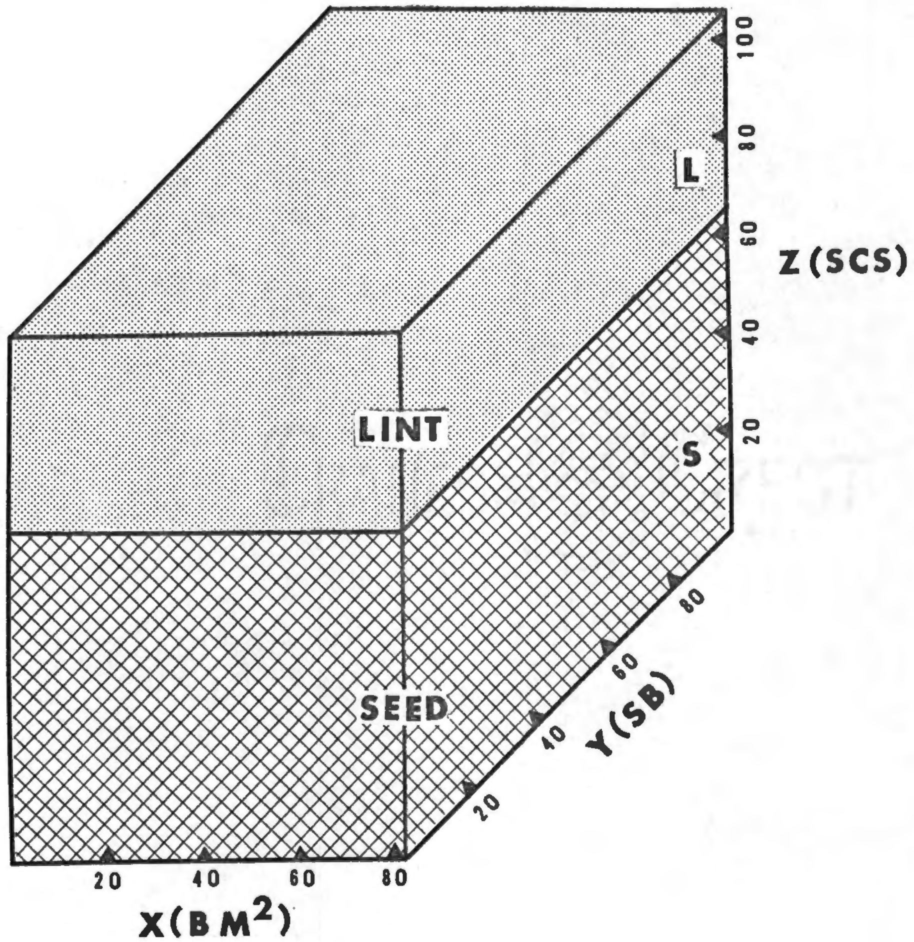

Figure 4. Pee Dee 2165 (1968 mean) percent of Coker 201.

XYZ = .82 x .95 x 1.07 = .83

XYL = .82 x .95 x 1.07 = .83

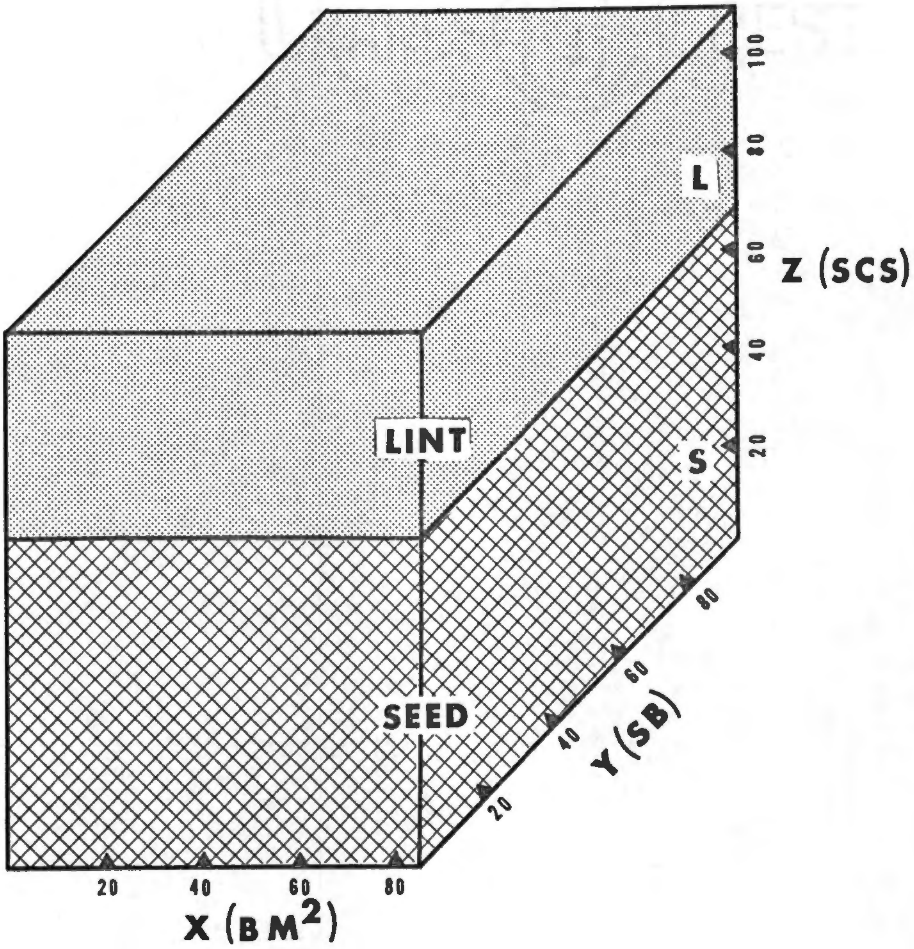

Figure 5. Pee Dee 2165 (1969 mean) percent of Coker 201.

XYZ = .88 x .91 x 1.10 = .88

XYL = .88 x .91 x 1.09 = .87

Figure 6 shows the combined 1968-1969 yield model and mean component values of Pee Dee 2165. This model reiterates the effect of the magnitude of the number of bolls per square meter on yield. This was reflected in the yield reduction of seed cotton and lint. These values were 86% and 85%, respectively. Another component which influenced the reduction in yield, was the 93% value for the number of seeds per boll. Seed cotton per seed had a value of 109% and the lint weight per seed value was 108%, showing a substantial increase over the Coker 201 base.

The model of PD 4381-262 for the 1968 test, is shown in Figure 7. This line was one of the highest yielding reselections from Pee Dee 4381. The seed cotton yield value was 119% and the lint yield 105%, when compared to the base. Bolls per square meter had a value of 112% and seeds per boll 101%, whereas the seed cotton per seed and lint per seed values were lower than the base, having values of 97% and 93%, respectively.

Figure 8 contains the yield box and components of PD 4381-262, for the 1969 test. Seed cotton yield was 104% and lint yield 102% of the base values. The bolls per square meter value was 105%. The other two axes (Y and Z), of the geometric model that equates the volume with yield, showed reversals when compared to the 1968 test values. The seeds per boll were 103% and the seed cotton per seed 102%, as compared to the base.

Figure 9 presents the combined 1968-1969 model and the mean yield component values of PD 4381-262. This model also reflects the importance of the bolls per unit area on yield. This axis (X), had

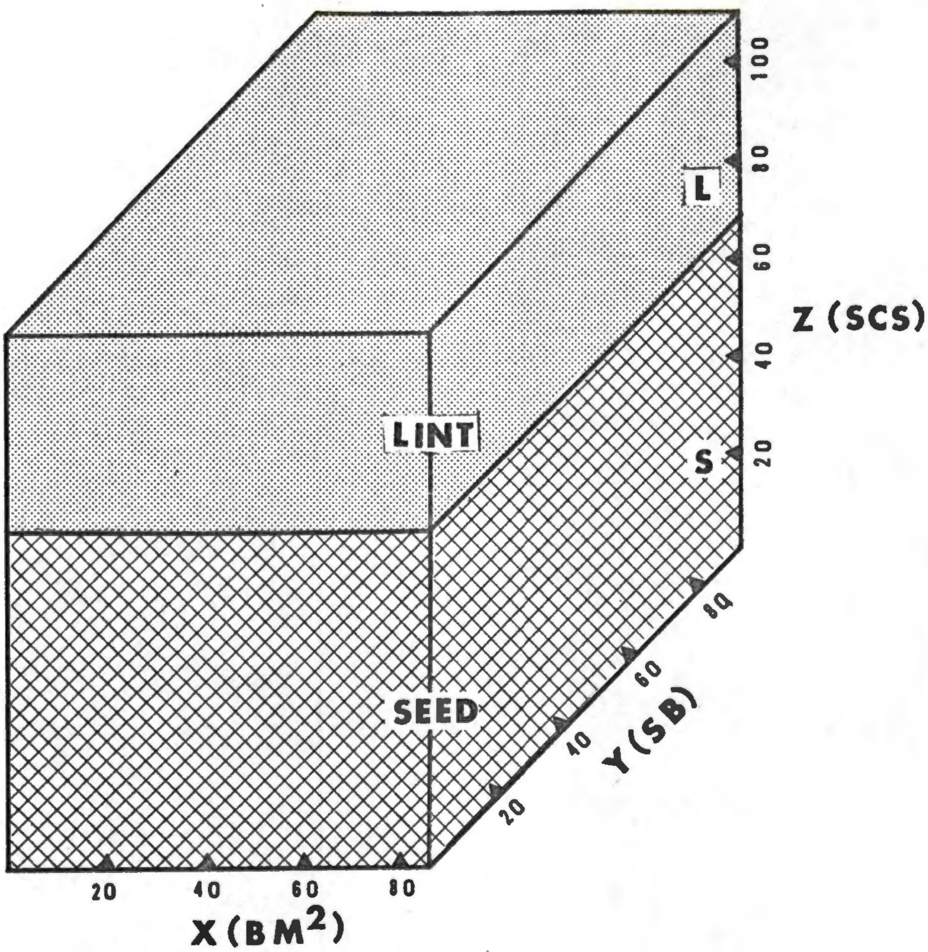

Figure 6. Pee Dee 2165 (1968-1969 mean) percent of Coker 201.

XYZ = .85 x .93 x 1.09 = .86

XYL = .85 x .93 x 1.08 = .85

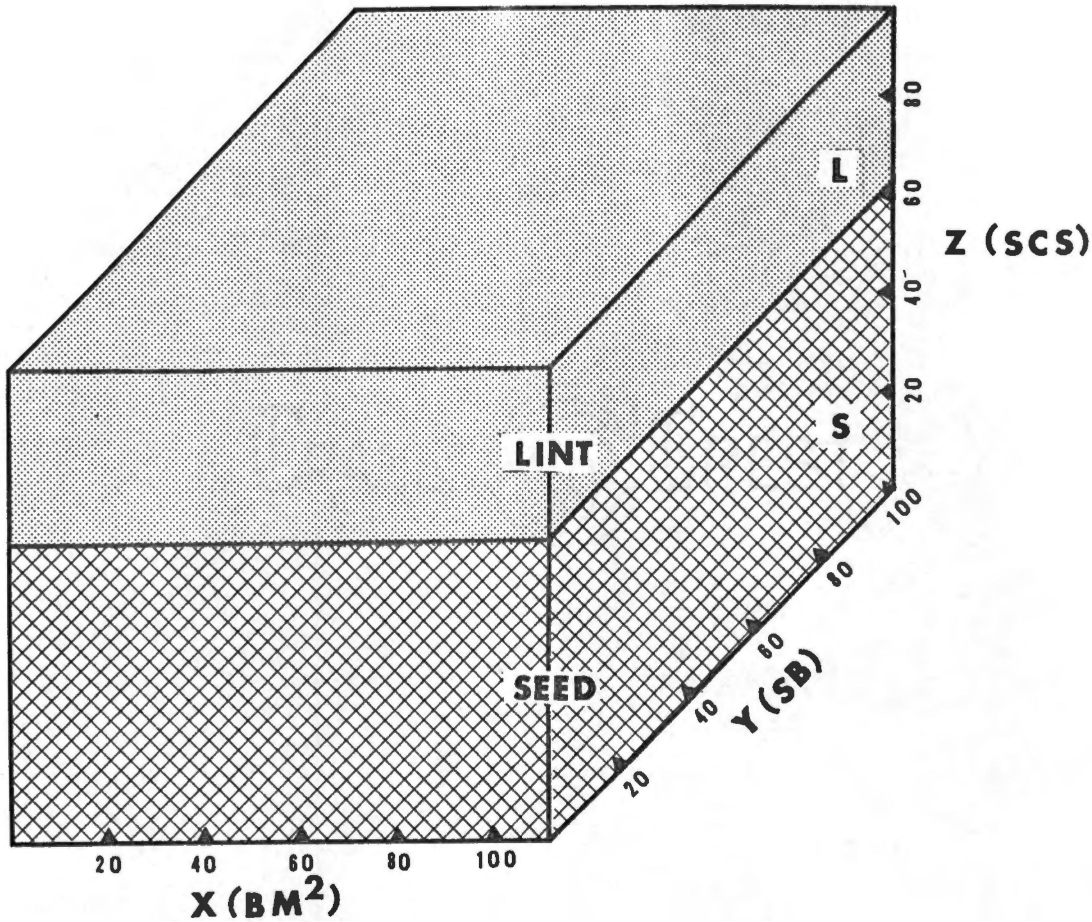

Figure 7. PD 4381-262 (1968 mean) percent of Coker 201.

XYZ = 1.12 x 1.01 x .97 = 1.10

XYL = 1.12 x 1.01 x .93 = 1.05

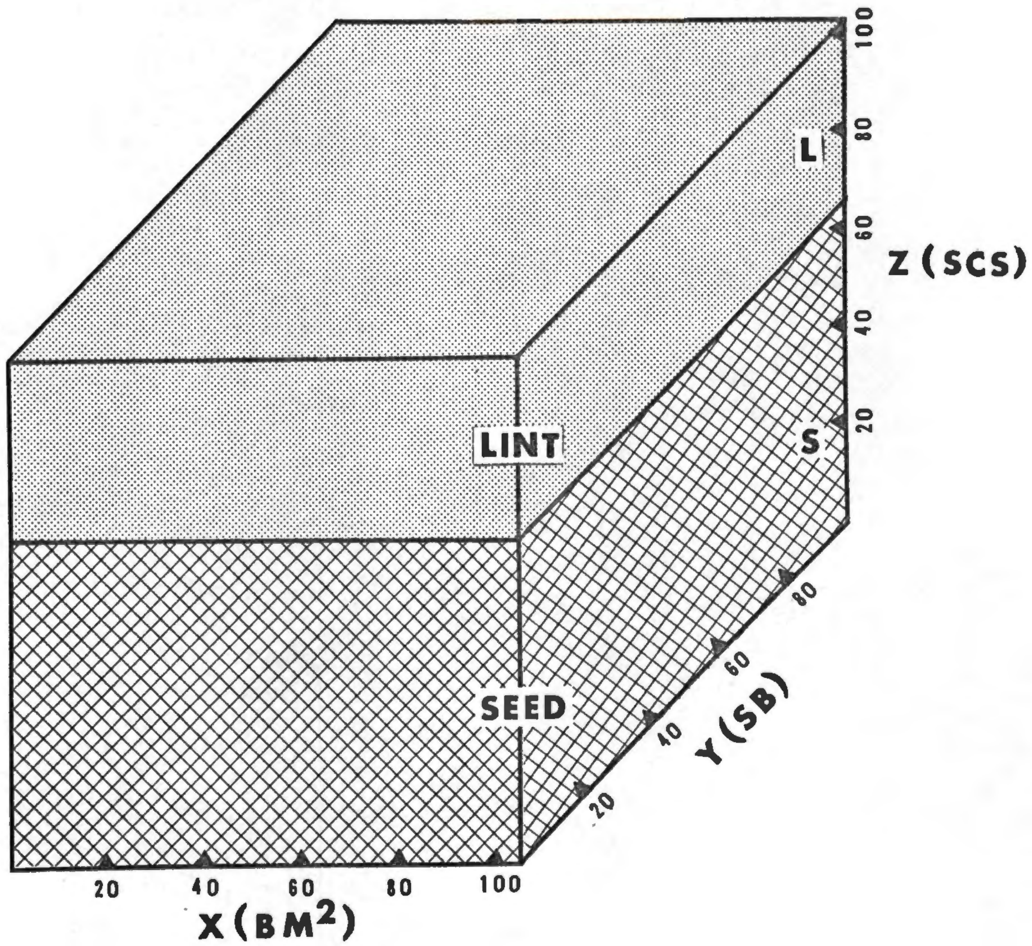

Figure 8. PD 4381-262 (1969 mean) percent of Coker 201.

XYZ = 1.05 x .97 x 1.02 = 1.04

XYL = 1.05 x .97 x 1.00 = 1.02

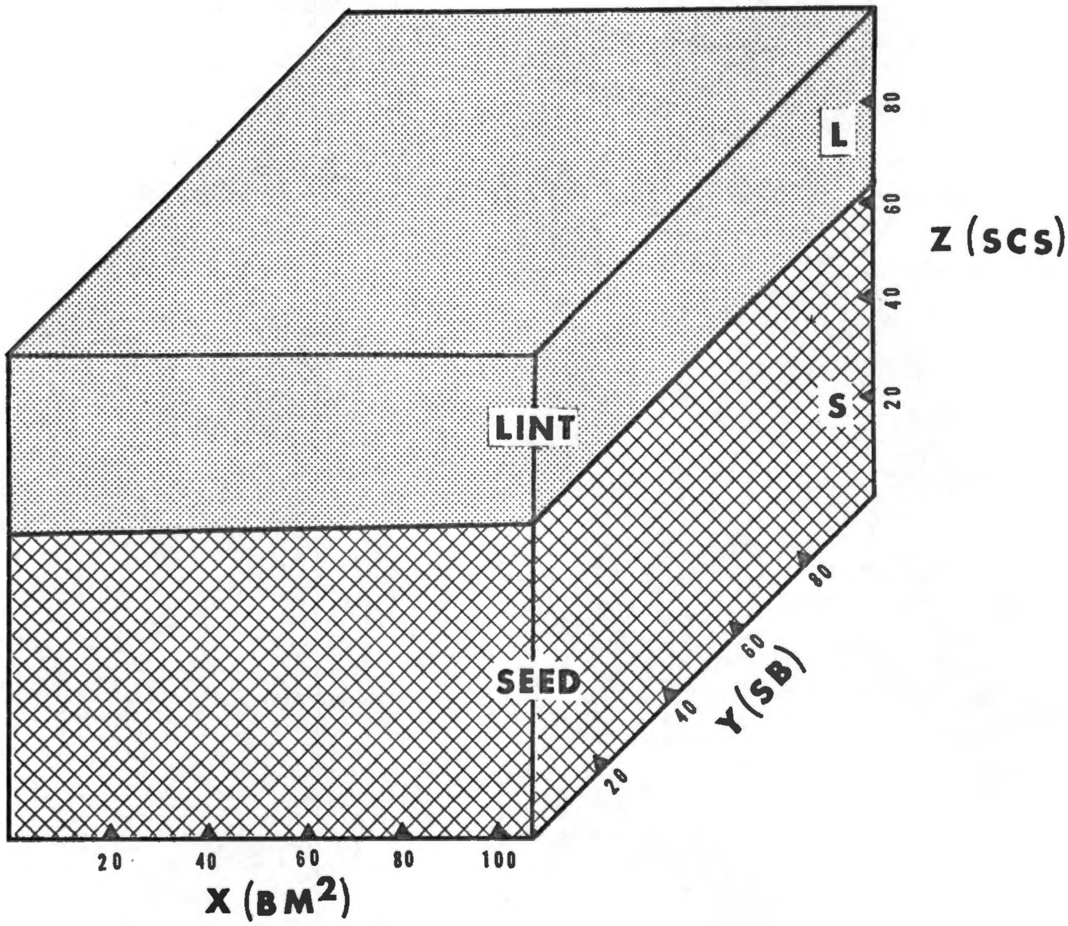

Figure 9. PD 4381-262 (1968-1969 mean) percent of Coker 201.

XYZ = 1.09 x .99 x .99 = 1.07

XYL = 1.09 x .99 x .96 = 1.04

a value of 109%, while the other two axes, seeds per boll (Y) and seed cotton per seed (Z), had relatively the same values as the Coker 201 base. Lint weight per seed was 104% and the two yield variables was 107% and 104% of the base, respectively.

Figure 10 shows the yield box and components of PD 4381-264 for 1968. This genotype was among the lowest yielding reselections from Pee Dee 4381. The bolls per square meter were 103% of the base. Lint weight per seed was 95% of the Coker 201 corresponding value and was the contributing component for the reduced lint yield, which was 96% of the base. All other components approximated the base values.

Figure 11 illustrates the geometric model and its components of PD 4381-264 grown in 1969. The component value of interest in this model was the 95% value, based on Coker 201 for the number of seeds per boll (Y) and the ultimate effect on yield. This component was the main contributor to the 93% value, compared to the base, for lint yield per square meter. The other components were about equal to the similar values of Coker 201.

Figure 12 presents the yield model and its components for PD 4381-264 for 1968-1969. Component values were of relatively the same magnitude as the base values. Exceptions were the 96% value for seeds per boll, a 96% value for lint per seed, and the 94% value for lint yield, based on Coker 201. This model illustrates the importance of the number of seeds per boll (Y) and (Z) seed cotton per seed in cases where the bolls per unit area (X) are about equal to the check.

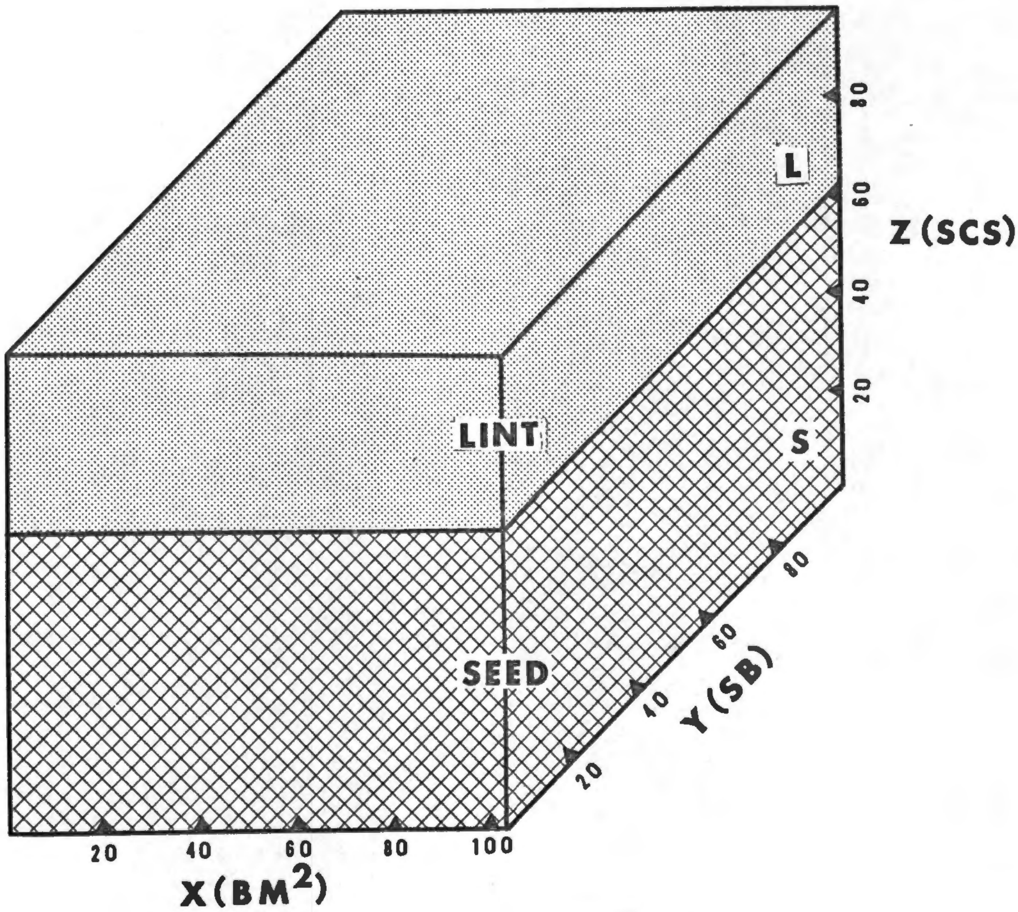

Figure 10. PD 4381-264 (1968 mean) percent of Coker 201.

XYZ = 1.03 x .98 x .98 = .99

XYL = 1.03 x .98 x .95 = .96

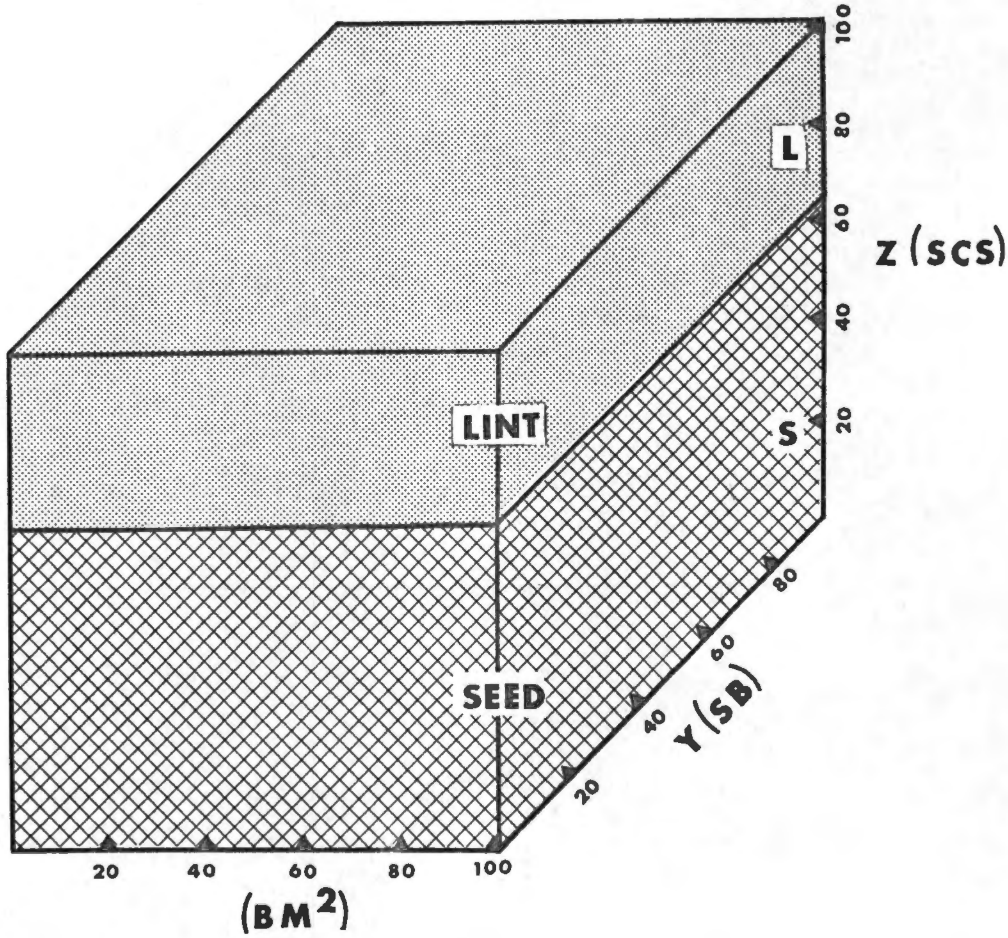

Figure 11. PD 4381-264 (1969 mean) percent of Coker 201.

XYZ = 1.01 x .95 x 1.01 = .97

XYL = 1.01 x .95 x .97 = .93

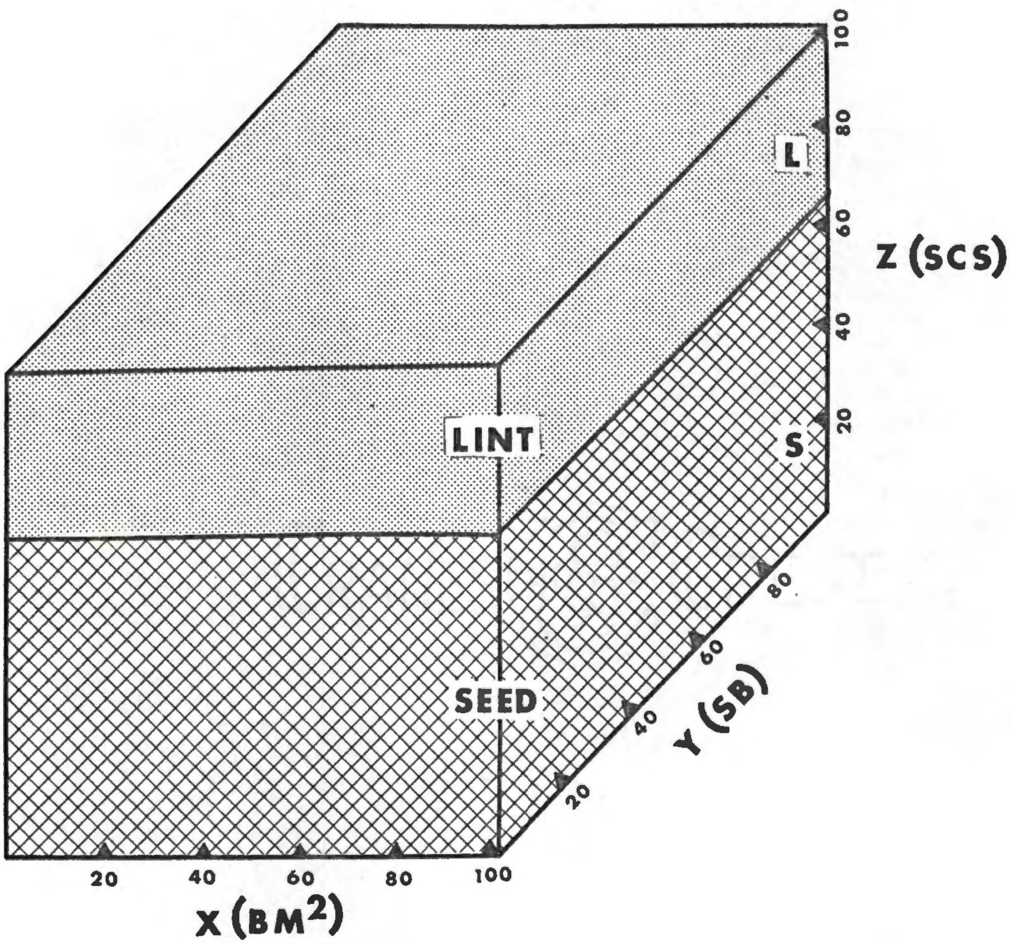

Figure 12. PD 4381-264 (1968-1969 mean) percent of Coker 201.

XYZ = 1.02 x .96 x 1.00 = .98

XYL = 1.02 x .96 x .96 = .94

These data indicated the importance of the number of bolls per unit area and the resulting influence on yield. The genotype with the fewest number of equivalent bolls per square meter was Pee Dee 2165, grown in 1968. This genotype also had the lowest lint yield. By contrast, PD 4381-262 in 1968, had the highest equivalent number of bolls per square meter and also produced the highest lint yield of all genotypes included in the investigation.

The number of seeds per boll (Y) and seed cotton per seed (Z) were of great influence when the bolls per unit area were about equal to the Coker 201 base. This was illustrated with the PD 4381-264 combined years model. Influence of lint weight per seed was also shown in this model.

This study revealed that the (X) axis should not be ignored when breeders apply selection pressure. Usually, most selection pressure is applied to the (Y) and (Z) axes, the product of which is boll size (YZ). Further selection is made on the (Z) axis when lint fraction and seed index are considered. These three components are measured in a boll sample. These data indicate that a genotype could possess the (Y) and (Z) components to the degree of acceptability from the breeder's point of view, and still be low in yield if the state of prolificacy is such that the bolls per unit area is the limiting yield component.

In brief summation of the yield models and their components for the genotypes studied, these data revealed the importance of the (X) axis and also the influence of the (Y) and (Z) axes, from the standpoint of the contributions made to yield. Moreover, these data indicated that the primary gain in yield improvement would be made by exerting selection pressure on the number of bolls per unit area (X axis).

Concurrent selection pressure should also be placed on the number of seeds per boll (Y axis) and the weight of seed cotton per seed (Z axis), in order to maintain the components of boll size and lint fraction at levels similar to those of leading commercial varieties grown in the ecological area.

Breeders have been successful in selecting for the number of seeds per boll (Y axis) and seed cotton per seed (Z axis), however, difficulties have been encountered in selecting for bolls per unit area (X axis). The magnitude of this component appears to be primarily a function of the environmental effects.

II. INTERRELATIONS OF YIELD COMPONENTS

The continuing endeavor to improve cotton yield is enhanced when insight is gained about the interrelations of the components involved. Cotton breeders are aware of the presence of either favorable or unfavorable associations among the major yield components measured in a breeding program. The type and magnitude of these associations depend primarily on the components taken into consideration, the environmental effect and the genetic composition of the population under investigation.

The developmental pattern of a specific component which might enhance or suppress the expression of another component could be explained on the basis of genetic linkage, epistasis, or pleiotropy, as reported by Kerr (11) and Miletello (13). In addition, the association between a given pair of characters might stem from their physical dependency on each other, i.e., part or all of their components being partially or completely similar, as proposed by El-Sourady (4). Furthermore, the association between a pair of components might be a mathematical relationship if one of the components was used in calculating the other component.

The role of genetics on the expression of the major yield components and the association between them has been demonstrated in previous investigations. In many cases, the studies have involved small, segregating populations.

One of the most common methods of expressing the association between two components is by the correlation coefficient. The correlation coefficient can be of two types: One in which the variables vary together in the same direction, which would be considered a positive association. The other type would be in a situation in which the variables vary together in opposite direction and would be considered a negative association. Numerically, its values range from +1.0, which indicates a perfect positive association, to -1.0, which indicates a perfect negative relationship.

This investigation attempted to discern general component relationships from the standpoint of large populations that had undergone primary genetic segregation, and had been grown in several environments. This approach allowed an estimate of the total variation effect on the interrelationships among the various yield components.

Data from 600 samples collected across 13 locations in 1968, were used to calculate simple correlation coefficients for component pairs. A similar analysis was accomplished on the 1969 tests, involving 496 samples collected across 12 locations. In addition, a combined years analysis was done in an attempt to compare the within years results with those obtained when additional component variations were introduced. This combined analysis involved a total of 1096 samples collected across 25 environments.

The yield components studied in the previously discussed yield model were used in the correlation analyses. The correlation coefficients among the yield components, for the 1968, 1969, and combined years tests, are given in Table 5.

The equivalent number of bolls per square meter generally showed a highly significant negative correlation with the other components, with the exception of lint yield per square meter and lint percent. There was no significant relationship between some of the component pairs in the within years analyses; however, in the combined years analysis these component pairs showed negative associations in each case. The equivalent number of bolls per square meter showed a highly significant positive correlation with lint yield per square meter and with lint percent. The combined years correlation coefficient between the equivalent number of bolls per square meter and lint yield was very high .95. This relationship agrees with the results reported by Miletello (13).

Table 5. Correlations among yield components for the 1968, 1969, and 1968-1969 combined tests

Component	Population	Equivalent Seeds per Boll	Equivalent Seed Cotton per Seed	Lint per Seed	Seed Index	Lint Yield per Square Meter	Boll Size	Lint Percent
Equivalent Bolls per Square Meter	1968	.02	-.20**	-.16**	-.22**	.90**	-.17**	.02
	1969	-.18**	.08	.03	-.16**	.96**	-.32**	.27**
	Combined Years	-.10**	-.31**	-.14**	-.39**	.95**	-.41**	.30**
Equivalent Seeds per Boll	1968		-.43**	-.48**	-.34**	.16**	.51**	-.34**
	1969		-.63**	-.56**	-.61**	-.07	.42**	-.02
	Combined Years		-.48**	-.50**	-.42**	-.01	.44**	-.19**
Equivalent Seed Cotton per Seed	1968			.92**	.95**	.08	.56**	.30**
	1969			.91**	.96**	.02	.44**	.08
	Combined Years			.90**	.96**	-.15**	.57**	.06
Lint per Seed	1968				.76**	.15**	.44**	.65**
	1969				.77**	.19**	.41**	.49**
	Combined years				.75**	.05	.46**	.48**

Table 5. (continued)

Component	Population	Equivalent Seeds per Boll	Equivalent Seed Cotton per Seed	Lint per Seed	Seed Index	Lint Yield per Square Meter	Boll Size	Lint Percent
Seed Index	1968					.02	.60**	.01
	1969					-.09*	.42**	-.17**
	Combined Years					-.27**	.59**	-.21**
Lint Yield per Square Meter	1968						.23**	.20**
	1969						-.08	.42**
	Combined Years						.16**	.43**
Boll Size	1968							.02
	1969							.06
	Combined Years							-.11**

* Significant at the 5% level of probability
** Significant at the 1% level of probability

The equivalent number of seeds per boll was generally negatively correlated with the other yield components, with the exception of boll size and lint yield. The number of seeds per boll and boll size had a highly significant positive correlation coefficient in all analyses. Such a relationship would be expected since the number of seeds per boll is one of the major components of boll size. The equivalent number of seeds per boll and lint yield showed no association in the 1969 and combined years analyses, however, there was a highly significant positive association in the 1968 analysis.

The equivalent weight in grams of seed cotton per seed and its two fractions, namely weight of lint per seed and seed index, showed a highly significant positive relationship, as would be expected. The equivalent weight of seed cotton per seed and boll size also had a highly significant positive correlation coefficient. Again, this should be the case since seed cotton per seed is another major component of boll size. There was no significant association between the equivalent weight of seed cotton per seed and lint yield in 1968 or 1969, but the combined years analysis indicated a highly significant negative relationship. The equivalent weight of seed cotton per seed and lint percent had no significant association in 1969 or in the combined analysis, however, the association was positive and highly significant in the 1968 analysis.

The weight in grams of lint per seed showed a highly significant positive association with both seed index and lint percent.

These results were in agreement with those reported by El-Sourady (4) and Feaster and Turcotte (5). Weight in grams of lint per seed showed a highly significant positive relationship with lint yield per square meter in each of the within years analyses. However, in the combined years analysis, there was no significant association. El-Sourady (4) reported no significant relationship between these components. Lint weight per seed and boll size were found to be highly significantly related, as would be expected since lint weight per seed is one of the components of boll size.

In general, seed index had a highly significant negative correlation with both lint yield and lint percent. This relationship generally agrees with results found by other investigators. Seed index and boll size indicated a highly significant positive association. Seed index is a major component of lint percent and therefore this relationship would be expected.

Lint yield per square meter and lint percent showed a highly significant positive correlation. These results are in general agreement with those reported by Miller (14), Miller and Rawlings (15), and Al-Jibouri et al. (1). However, contradictory results were reported by Feaster and Turcotte (3) and El-Sourady (4). These investigators found no significant relationship between yield and lint percent. Lint yield and boll size had a highly significant positive relationship. These results are again contradictory to those reported by El-Sourady (4); however, these results are in agreement with those reported by Al-Jibouri (1) and Miller (14).

Boll size and lint percent were associated in the combined years analysis, having a highly significant negative correlation. However, no significant relationship was found in either of the within years analyses.

Cause and effect relationships were generally involved between many of the component pairs. These data indicated that in order to discuss general yield component relationships in material that has undergone genetic segregation, a large population including several environments is required. The correlation analyses in this investigation dealt with data from genotypes varying in degree of heterogosity from F_4 populations to comparatively stable released varieties.

These data further indicated that in studies of this nature, the population universe and its sub-sets must be defined carefully. The combinations of the sub-sets may influence conclusions that are drawn concerning the universe; i.e., data from 1968, 1969, or the combined years analyses when considered as the universe, may lead to different conclusions about the same component relationships.

Finally, interpretation and application of these data must be approached cautiously. Kerr (11) pointed out that, of the yield components usually measured in a breeding program, namely seed cotton yield, boll size, seed index, and lint percent, only the seed cotton yield component is based on the total plant production. Boll size is commonly determined on a sample of mature bolls from the bottom or central part of the plant. In addition, bolls are selected that are free from structural imperfections and insect punctures. The same bias exists in measuring seed index and lint percent, Kerr (11). These biases introduced by sampling are probably of similar magnitude and direction for all breeding material in a program; however, the breeder must be aware of these effects when attempting to establish the yield component interrelationships.

III. RELATIVE CONTRIBUTIONS OF YIELD COMPONENTS TO COTTON YIELD

The relationships among cotton yield and its components are complex. The components are influenced by both genetic and enviromental sources of variation and also by the interaction between the two sources. In their selection criteria for yield, breeders place more importance on certain components than others, with the degree of importance varying among breeders.

This study, based on large populations grown in several enviroments, was an attempt to determine the relative contributions of the components to lint yield, and to rank them in their order of importance. The empirical, the theoretical or analytical, and the statistical approaches, were previously mentioned in this investigation as the three general approaches to the problem of selection for yield.

The statistical approach used in this study permitted an estimate of the net effect of the yield components on yield. A sequence of multiple linear regression equations were computed in a stepwise manner. Multiple analysis became increasingly important since the yield components were interrelated to the extent that their true relationship with yield could be masked.

The data obtained for each yield component from the 1968 and 1969 tests, were used collectively for this study. A stepwise regression analysis was done on the 1968 combined tests and a similar analysis was accomplished on the 1969 combined tests. These analyses were used to demonstrate the genetic, environmental and the genetic-environmental interaction sources of variation on the contributions of the various yield components to lint yield. In addition, these results were compared with those obtained from a stepwise regression analysis performed on the 1968 and 1969 tests combined across years. In this combined analysis, both locations and years were considered to be components of environment. This analysis provided additional environments and greater variability, although the sources of variation were the same as those of the within years analyses.

The yield components studied in the previously discussed yield model were used in the stepwise regression analyses. For the analyses, lint yield in grams per square meter (XYL) was considered as the dependent variable. Independent variables were: equivalent number of bolls per square meter; equivalent number of seeds per boll; equivalent weight in grams of seed cotton per seed; boll size; seed index; weight of lint in grams per seed; lint percent; and seed weight in grams per 100 bolls.

The relative contributions of eight yield components to lint yield for the 1968 combined tests are presented in Table 6. These results indicated that insofar as the yield components used were

Table 6. The relative contributions of 8 yield components to lint yield for the 1968 combined tests

Number of Independent Variables Entered	Variable Entered	R	R^2	Increase in R^2	F Value to Enter	Standard Error of Estimate
1	Equivalent Number of Bolls per Square Meter	.9005	.8109	.8109	2,563.86**	8.82
2	Boll Size	.9784	.9573	.1464	2,044.86**	4.20
3	Seed Weight per 100 Bolls	.9969	.9939	.0366	3,551.98**	1.59
4	Lint Percent	.9969	.9940	.0001	2.30	1.59
5	Equivalent Number of Seeds per Boll	.9969	.9940	.0000	0.10	1.59
6	Seed Index	.9970	.9941	.0001	19.07**	1.57
7	Lint per Seed	.9970	.9941	.0000	3.58	1.56
8	Equivalent Weight of Seed Cotton per Seed	F-level insufficient for computation				

** Significant at the 1% level of probability

concerned, 99% of the total variation in lint yield could be related linearly to variations in the yield components. The equivalent number of bolls per square meter was found to be the most important single lint yield component, accounting for 81% of the total lint yield variation.

The relative importance of the yield components in 1968 could be placed in the following descending order: equivalent number of bolls per square meter, boll size, and seed weight in grams of 100 bolls. The remainder of the components, namely lint percent, the equivalent number of seeds per boll, seed index, and weight of lint per seed, increased the multiple correlation coefficient between yield components and lint yield only .0002 when incorporated into the equation. The equivalent weight in grams of seed cotton per seed did not enter in the equation because the F-level was insufficient for further computations.

The relative contributions of the yield components to lint yield for the 1969 combined tests are given in Table 7. As was the case with the 1968 analysis, 99% of the total variation could be related to variations in the yield components. The equivalent number of bolls per square meter was again the most important yield component to contribute to lint yield, accounting for 91% of the total lint yield variation. This compares with a 81% value for the corresponding component for the 1968 tests. Boll size and seed weight per 100 bolls made contributions of 6 and 2%, respectively, to the total lint yield variation for the 1969 tests. The corres-

Table 7. The relative contributions of 8 yield components to lint yield for the 1969 combined tests

Number of Independent Variables Entered	Variable Entered	R	R^2	Increase in R^2	F Value to Enter	Standard Error of Estimate
1	Equivalent Number of Bolls per Equare Meter	.9548	.9117	.9117	5,100.91**	6.67
2	Boll Size	.9853	.9708	.0590	995.20**	3.84
3	Seed Weight per 100 Bolls	.9944	.9889	.0181	800.31**	2.37
4	Lint Percent	.9945	.9890	.0001	7.17**	2.36
5	Equivalent Number of Seeds per Boll	.9945	.9891	.0001	1.69	2.36
6	Seed Index	.9946	.9893	.0002	10.26**	2.34
7	Lint per Seed	.9947	.9893	.0000	2.03	2.33
8	Equivalent Weight of Seed Cotton per Seed	F-level insufficient for computation				

** Significant at the 1% level of probability

ponding values of these two components for the 1968 tests were 15 and 4%, respectively.

The order of importance of the yield components for the 1969 tests was the same as the 1968 data indicated. The components making significant contributions to lint yield in descending order of importance were: the equivalent number of bolls per meter, boll size, and the seed weight of 100 bolls. The remaining five yield components increased the multiple correlation coefficient only .0004. As was the case in the 1968 analysis, and for the same reason, the equivalent weight of seed cotton per seed did not enter in the equation.

Table 8 shows the relative contributions of eight yield components to lint yield for the 1968-1969 combined tests. This combined years analysis again indicated that insofar as the yield components utilized in the analysis were concerned, 99% of the total variation in lint yield could be related linearly to variation in the yield components. The yield component contributions compared in magnitude to those of the 1969 tests, with respect to the variation in lint yield that could be attributed to the various yield components. Again, the equivalent weight of seed cotton per seed did not enter in the equation in the combined years analysis.

Seed index had a highly significant F-value for entering the equation in each of the analyses; however, its contribution was of minor importance in the multiple correlation coefficient. This significant F-value occurred only after the seed weight in grams per 100 bolls and the number of seeds per boll were held constant through

Table 8. The relative contributions of 8 yield components to lint yield for the 1968-1969 combined tests

Number of Independent Variables Entered	Variable Entered	R	R^2	Increase in R^2	F Value to Enter	Standard Error of Estimate
1	Equivalent Number of Bolls per Square Meter	.9523	.9070	.9070	10,665.16**	7.94
2	Boll Size	.9858	.9718	.0649	2,517.76**	4.37
3	Seed Weight per 100 Bolls	.9956	.9912	.0194	2,419.17**	2.44
4	Lint Percent	.9957	.9914	.0002	14.03**	2.42
5	Equivalent Number of Seeds per Boll	.9957	.9914	.0000	0.52	2.42
6	Seed Index	.9957	.9915	.0001	15.45**	2.41
7	Lint per Seed	.9957	.9915	.0000	0.96	2.41
8	Equivalent Weight of Seed Cotton per Seed	F-level insufficient for computation				

** Significant at the 1% level of probability

the partial correlations. Less than .02% of the total lint yield variation was accounted for by the seed index component.

These data reiterate the great effect of the number of bolls per unit area (X axis) on yield. Of the total lint yield variation, 81 to 91% could be attributed to this single component. Boll size (YZ axes) had the next greatest effect, contributing 6 to 14% to the total lint yield variation. Seed weight in grams per 100 bolls was third, contributing only 2 to 4%. The remaining components, namely lint percent; the equivalent number of seeds per boll; seed index; and weight of lint per seed, increased the multiple correlation only .0002 to .0004 in these analyses. The equivalent weight of seed cotton per seed did not enter in either equation due to an insufficient F-level.

The additional variation provided in the combined years analysis had little influence on the total variation in lint yield that could be linearly related to the variation in the yield components used in these analyses. Both the within year and combined years analyses indicated the total multiple correlation coefficient between lint yield and the yield components to be an unusually high .99.

CHAPTER V

SUMMARY AND CONCLUSIONS

A study was conducted to develop yield models and their components for selected cotton genotypes. Additional studies were carried out to determine the interrelations of cotton yield components and their relative contributions to yield.

The geometric model of cotton yield was represented by the volume of a rectangular parallelepiped. Axes (X), (Y), and (Z) represented the equivalent number of bolls per square meter, the equivalent number of seeds per boll, and the weight of seed cotton per seed, respectively. Axis (Z) was further divided into two fractions: weight of lint per seed (L) and seed weight per seed (S). Seed cotton yield was represented by (XYZ) and lint yield by (XYL).

The yield model was used to compare the effects of the magnitude of the yield components on yield of genotypes selected from the cotton breeding and quality investigations program, Pee Dee Experiment Station, Florence, South Carolina. The four genotypes chosen were Coker 201, Pee Dee 2165, PD 4381-262, and PD 4381-264. All genotypes were entries in the advanced strains test in 1968, and the PD strains test in 1969. The 1968 tests were grown at Florence, South Carolina and the 1969 tests were conducted at Florence, South Carolina and Experiment, Midville, and Tifton, Georgia.

The mean values for the yield components of Coker 201 grown at all locations over both years, were used as a base for the yield model. The different genotypes were expressed as a percentage of the base. Further equations for minimizing the environmental effects were accomplished by comparing the mean values for Coker 201 for an environment with the previously mentioned base. This permitted comparison across the different environments involved in this study.

Data collected for the yield components in each test entry across 13 locations in 1968, 12 locations in 1969, and 25 locations in 1968-1969 combined, were used to calculate simple correlation coefficients between components. These analyses permitted comparisons of the within years results with those obtained when additional component variations were introduced.

Further, a multiple regression analysis was used to determine the relative contributions of the components to lint yield, and to rank them in their order of importance. The data obtained for each yield component from the 1968 and 1969 tests, were used collectively for this study. These analyses were used to demonstrate the genetic, environmental and the genetic-environmental interaction sources of variation on the contribution of the yield components to lint yield. In addition, these results were compared with those obtained from an analysis performed on the 1968 and 1969 tests combined over years. In this combined analysis, both locations and years were considered to be components of environments. This analysis provided additional environments and additional variability, although the sources of variation were the same as those of the within years analyses.

The results led to the following conclusions pertaining to the populations studied:

1. The primary gain in yield improvement would be made by exerting selection pressure on the number of bolls per unit area (X axis).

2. Concurrent selection pressure should also be placed on the number of seeds per boll (Y axis) and the weight of seed cotton per seed (Z axis) in order to maintain the components of boll size and lint fraction at acceptable levels.

3. Correlation studies indicated that cause and effect relationship were generally involved between many of the component pairs.

4. In attempting to discern general yield component relationships in material that has undergone genetic segregation as was done in the present study, a large population including several environments is probably required. Results reported in the literature were erratic or contradictory when smaller different genetic populations were investigated.

5. In correlation studies, the population universe and its sub-sets must be carefully defined. Different populations may lead to different conclusions about the same component relationships.

6. Of the total lint yield variation, 81 to 91% could be attributed to the number of bolls per unit area (X axis).

7. Boll size (YZ axes) had the next greatest effect on lint yield contributing 6 to 14% to the total lint yield variation.

8. Seed weight in grams per 100 bolls contributed only 2 to 4% to the total lint yield variation.

9. The remaining components, namely lint percent, the equivalent number of seeds per boll, seed index, and the weight of lint per seed, increased the multiple correlation only .0002 to .0004 in these analyses.

10. The equivalent weight of seed cotton per seed did not enter in either equation due to an insufficient F-level for inclusion in the prediction equations.

11. In the combined analyses, the total explainable variation in lint yield was the same as that found for either within years analysis. The total multiple correlation coefficient was .99 in all cases.

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VITA

Buford Alonzo Maner, Jr. was born in Jefferson City, Tennessee, on August 6, 1935. He moved to Blount County in 1941, attended elementary and secondary schools in that county, and was graduated from Porter High School in 1953. He entered the United States Army in November, 1954, and was discharged in August, 1957. He began work on a Bachelor of Science degree in Agriculture in 1958, and received the degree from the University of Tennessee, in June, 1963.

He was employed by the Sevier County Board of Education, teaching Vocational Agriculture, for two years after graduation. Beginning in 1965, he was employed by the University of Tennessee for two years, and has been employed by the United States Department of Agriculture since July, 1967.

He entered the Graduate School on a part-time basis at the University of Tennessee in September, 1965, and received the Master of Science degree with a major in Agronomy in December, 1970.

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