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# A Geometrical Approach to Yield Models in Upland Cotton (*Gossypium hirsutum* L.)[1]

B. A. Maner, S. Worley, D. C. Harrell, and T. W. Culp[2]


## ABSTRACT

**Yield models were developed for selected Upland cotton (*Gossypium hirsutum* L.) genotypes. Yield was equated with the volume of a rectangular parallellepiped having the following dimensions: bolls per square meter (X), seeds per boll (Y), and seed cotton per seed (Z). Axis (Z) was divided into its two fractions: lint per seed (L) and weight per seed (S). Yield components of the selected genotypes were expressed as a percentage of 'Coker 201,' when the variance was set at zero.**

**Bolls per square meter (X axis) had the greatest influence on yield. We expect that the greatest gain in yield improvement should come from exerting selection pressure on this character. Concurrent selection pressure should also be placed on seeds per boll (Y) and seed cotton per seed (Z) to maintain these components at levels similar to those of leading commercial varieties grown in the ecological area.**


***Additional index words:*** **Yield components, Bolls per square meter, Seeds per boll, Seed cotton per seed, Lint per seed, Seed weight per seed, Lint yield per square meter, Seed cotton yield per square meter.**

THE purpose of this study was to develop geometric yield models to compare the effects of the various yield components on yield of selected genotypes from the cotton (*Gossypium hirsutum* L.) breeding program at the Pee Dee Experiment Station, Florence, S. C.

The development of high yielding Upland cotton varieties possessing improved fiber properties is a major concern of many breeding programs. Breeders are constantly faced with the adverse relationships encountered with yield when fiber strength and length are increased above certain levels. Methods are sought to improve the yield of strains having the fiber length and strength levels required for improved spinning performance, as compared to conventional varieties. In our breeding program we think this objective can be implemented by applying selection pressure to the major yield components while maintaining fiber length and strength values at the desired levels.

Geometric models for expressing yield and its components of barley and oats were proposed by Grafius (1956, 1964). He noted that the assigning of components must be biologically and geometrically sound for the model to be most meaningful. Grafius and Wiebe (1959) showed the expected genetic gain due to selection on the basis of geometric yield models of small grains. They pointed out that best results were obtained by concentrating on improving one axis when the expected genetic gain for the other two were low; but if all were high, selection for two or even three axes at one time might be the best approach to yield improvement.

Kerr (1966) expressed cotton yield and its components in a geometric model. Seed cotton yield was equated with the volume of a rectangular parallelepiped having dimensions (X), (Y), and (Z), equal to bolls per unit area, seeds per boll, and seed cotton per seed, respectively. Axis (Z) was divided into two fractions: lint per seed (L), and weight per seed (S). Thus, lint yield could be expressed by the rectangular parallelepiped (XYL); the major yield components are bolls per unit area, seeds per boll, and lint per seed, respectively.

## MATERIALS AND METHODS

Four cotton variety tests were grown in South Carolina in both 1968 and 1969, to measure yield, other agronomic characteristics, and fiber properties of varieties and breeding lines. 'Coker 201' (a commercial variety), Pee Dee 2165 (a noncommercial strain release), PD 4381-262, and PD 4381-264 (reselections from Pee Dee 4381, another noncommercial strain release) were chosen as the genotypes for this study. Coker 201 was used as a yield check and Pee Dee 2165 as a quality check in all tests. PD 4381-262 and PD 4381-264, which are considered intermediate in quality, possess yield components that demonstrate the use of yield models in cotton breeding.

Yield models, as proposed by Kerr (1966), were developed for the above genotypes by using the mean yield component values over years. Lint percent, boll size (g/boll), and seed index (g/100 seed) were obtained from unweathered boll samples for each genotype. Twenty-five bolls were picked from each plot and samples from two replicates were bulked before ginning to form 50-boll samples. Seed cotton yield per plot was obtained with a spindle-type picker.

Other yield components were calculated at the University of Tennessee Computing Center utilizing the following equations:

Seed cotton yield in grams per square meter
$$(YSCM^2) = \text{Plot yield (g)/Plot area (m}^2) \quad [1]$$
Bolls per square meter
$$(BM^2) = SCM^2/(\text{Boll size in grams}) \quad [2]$$
Seeds per boll
$$(SB) = \text{Boll size } (100\text{-L}\%)/\text{Seed index} \quad [3]$$
Seed cotton per seed
$$(SCS) = \text{Boll size/SB} \quad [4]$$
Lint per seed
$$(LS) = SCS\,(L\%) \quad [5]$$
Seed weight per seed
$$(SWS) = \text{Seed index}/100 \quad [6]$$
Lint yield in grams per square meter
$$(LYM^2) = YSCM^2\,(L\%) \quad [7]$$

These calculated component values were probably underestimates of the actual field values due to the criteria used in boll sampling. Boll samples included only sound, well developed open bolls, whereas the total seed cotton yield also contained damaged and partial bolls. Therefore, the calculated component values are estimates based on the boll sample and should be viewed as equivalent values, not actual values.

The mean values for the yield components of Coker 201 grown at 25 locations over 2 years, were used as the base for the yield model. Coker 201 component values in each test were expressed as a percentage of the mean values. The different genotypes were expressed as a percentage of Coker 201 grown in the same test. Environmental effects were minimized by equating the Coker 201 test values to the Coker 201 base, and then by applying this adjustment to the different genotypes (i.e., by setting the variance of Coker 201 at 0 and adjusting component values for the genotypes to correspond to this base.)

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[2] Agronomist (Research Assistant) and Research Agronomists, Plant Science Research Division, Agricultural Research Service, US Department of Agriculture, Knoxville, Tenn. 37901 and Florence, S.C. 29501, respectively.

## RESULTS AND DISCUSSION

The yield components for the Coker 201 base model are expressed as 100% (Fig. 1), with X, Y, and Z = 1.0. The yield box and its components for Pee Dee 2165 (Fig. 2) showed that the yield component bolls per square meter caused the greatest departure from the base. The value for this axis (X) was only 85% of the corresponding value for Coker 201. Yield of seed cotton and lint was 86 and 85%, respectively. Another component that also influenced this reduction in yield was 93% for seeds per boll (Y). Seed cotton per seed (Z) was 109% and lint per seed was 108%, showing substantial increases over the base. However, the increase in (Z) was overshadowed by the decrease in (Y), resulting in a significantly lower yield for Pee Dee 2165.

The yield model and its components for PD 4381-264 (Fig. 3) show that component values were of relatively the same magnitude as the base values for Coker 201. Exceptions were 96% for seeds per boll and lint per seed, and 94% for lint yield. This model illustrates the importance of seeds per boll (Y) and lint per seed (L), in cases where the bolls per unit area are about equal to the check. This combination produced a lint yield that was only 94% of Coker 201, even when bolls per square meter was approximately equal to the base.

The yield model and its components for PD 4381-262 (Fig. 4) reiterate the effect of bolls per unit area on yield. When bolls per square meter was 109%, seed cotton and lint yields were 107 and 104% of Coker 201. The other two axes, (Y) and (Z), had relatively the same values as Coker 201, while lint per seed was 96% of the base.

The importance of the (X) axis and the influence of the (Y) and (Z) axes, from the standpoint of the contributions made to yield, are shown in this study. We believe the greatest gain in yield improvement can be made by exerting selection pressure for more bolls per unit area (X axis). This can probably be best implemented in replicated primary and secondary screening tests. Concurrent selection pressure should also be placed on seeds per boll (Y axis) and seed cotton per seed (Z axis) to maintain these components at

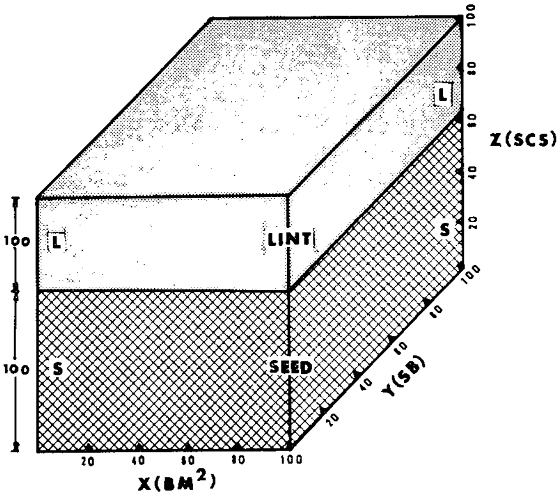


Fig. 1. Yield model for Coker 201 (1968-1969 combined experiment means) expressed as 100%.

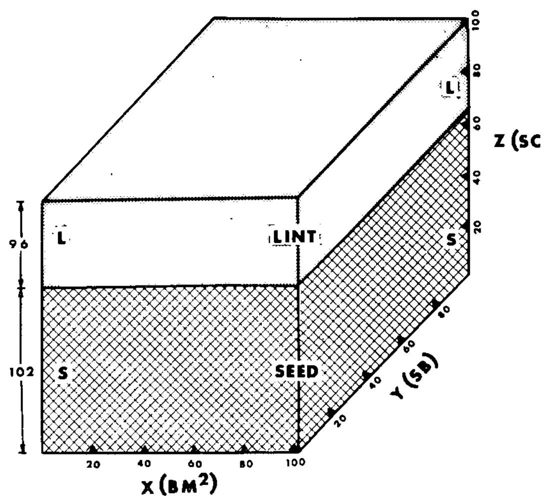


Fig. 3. Yield model for PD 4381-264 (1968-1969 mean) percent of Coker 201.

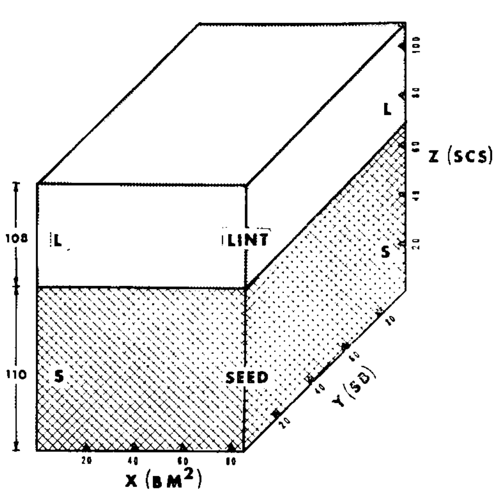


Fig. 2. Yield model for Pee Dee 2165 (1968-1969 mean) percent of Coker 201.

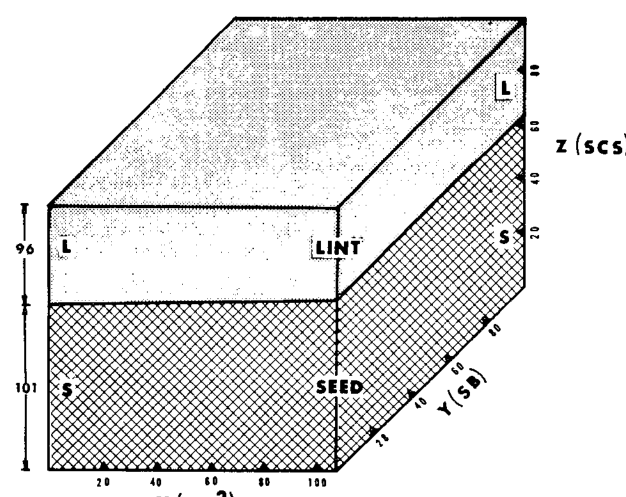


Fig. 4. Yield model for PD 4381-262 (1968-1969 mean) percent of Coker 201.

levels similar to those of the leading commercial varieties grown in the ecological area. It appears that most of the successful commercial varieties grown in any given area generally tend to have similar values for the (Y) and (Z) axes. We assume that these varieties are grown more successfully because their yield components tend to approach the optimum for that ecological area.

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