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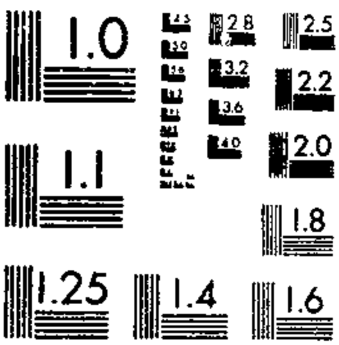

MICROCOPY RESOLUTION TEST CHART
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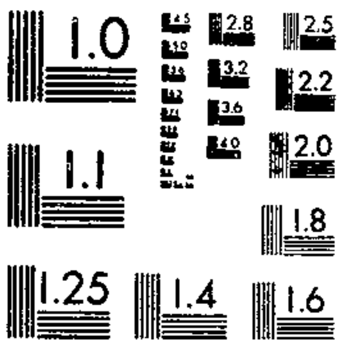

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Effect of Variety, Location, and Season on Oil, Protein, and Fuzz of Cottonseed and on Fiber Properties of Lint

By

O. A. POPE
Agronomist

and

J. O. WARE
Senior Agronomist
Division of Cotton and Other Fiber Crops and Diseases
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration

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Effect of Variety, Location, and Season on Oil, Protein, and Fuzz of Cottonseed and on Fiber Properties of Lint [1]

By O. A. POPE, *agronomist*, and J. O. WARE, *senior agronomist, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

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SUMMARY

Studies were carried out on samples of 16 varieties of cotton grown in 8 replicates at 11 to 14 locations for a 3-year period. The design of the study provided an opportunity for testing the relative effect of variety, location, and season, and the interactions of these main effects on each of the variables, the oil and the protein content of cottonseed, and the amount of fuzz on the seed.

Comparatively wide differences were identified in each year among locational means and varietal averages for each of the three variables. The order of varieties was found to be relatively consistent from year to year in average percentage of oil, protein, and fuzz. The order or rank of station averages, however, varied widely among years, indicating that levels of oil, protein, and

[1] Submitted for publication January 1945. Field samples used for oil, protein, and fuzz determinations were obtained through the assistance of various division and agricultural experiment station workers, and the contributions of the following from the agricultural experiment station of the States named are gratefully acknowledged: J. B. Dick and H. B. Tisdale, Alabama; Martin Nelson and L. S. Bennett, Arkansas; W. W. Ballard and R. P. Bledsoe, Georgia; H. B. Brown and J. R. Cotton, Louisiana; J. W. Neely and H. C. McNamara, Delta Branch Station, Mississippi; P. H. Kime and R. H. Tilley, North Carolina; L. L. Ligon, Oklahoma; W. H. Jenkins and E. E. Hall, South Carolina; N. I. Hancock and R. P. Hazlewood, Tennessee; D. T. Killough and G. T. McNess, Texas; and D. L. Jones, Substation No. 8, of the Texas station; and of the following from U. S. Cotton Field Stations: D. M. Simpson, Knoxville, Tenn.; and H. C. McNamara and D. R. Hooton, Greenville, Tex.
Chemical analyses were made under the supervision of D. G. Sturkie, at the Alabama Agricultural Experiment Station.
Fiber laboratory determinations were made through cooperative arrangements in fiber laboratories of what is now the Research and Testing Division of the Cotton and Fiber Branch, Office of Marketing Services, U. S. Department of Agriculture. R. W. Webb, C. M. Conrad, and Enoch Karrer, of that organization, were responsible for the leadership and supervision of the laboratory work.

fuzz, as affected by ecological factors, depend rather largely on the weather conditions prevailing at the place of growth and comparatively little on the soil series or type represented.

In both oil and protein percentage, the effect of locations was numerically larger and, with the exception of percentage of oil in 1935, significantly greater than the effect of varieties. In percentage of fuzz, the relative contributions for varieties and locations were of similar order. In all three variables, the effects of varieties were much greater than the interactions of varieties by locations or seasons, indicating that chemical composition and amount of fuzz are basically varietal characteristics and that the order of varieties tends to be consistent when the same group is grown over a wide range of environmental conditions. Consequently it is clear that oil, protein, and fuzz are all dependent on genetic constitution and that a consideration of these variables in the breeding program should result in the isolation of lines superior in any one or all of the characteristics.

A comparison of oil and protein data shows rather clearly that these characteristics are substantially independent as far as genetic constitution is concerned, but that they are negatively associated when the effects of environment are considered.

Studies on fiber properties were made on samples from 16 varieties grown at 14 locations for 1 year.

Length of fiber is largely dependent on the genetic constitution of varieties, although the effect of growth conditions may materially modify the general length in all varieties.

Tensile strength is dependent largely on weather conditions. Important varietal differences in strength were identified and these tend to be consistent over a wide range of environmental conditions. It follows that comparative tensile strength is dependent basically on the genetic constitution of varieties, but that genetic potentialities may be modified greatly by environment.

In weight per inch of fiber, varietal differences were found to be the most important factor, although in some cases growth conditions had rather important effects.

The percentage of immature fibers was found to depend largely on growth conditions, although varietal differences were identified.

Coefficients of variability for the various fiber properties were found to be less efficient measures of varietal or environmental differentiation than the respective properties.

In all the fiber properties studied it is clearly evident that the genetic constitution of varieties is the most important controllable factor. Consequently, fiber characteristics should be carefully examined in any breeding program, so that those that contribute to the quality of the manufactured product may be associated with desirable yield factors in the development of new strains and varieties.

Environmental factors are important in the development of all fiber properties, but with the exception of moisture supply in the irrigated part of the Cotton Belt, weather conditions are largely fortuitous. Consequently, it is important that the variation due to environment be evaluated in any comprehensive study and that these effects be removed from estimates of varietal differences.

NEED FOR COTTON VARIETY STUDIES

Cottonseed provides an important part of our national supply of edible oils and fats, and after the war demands created an acute shortage of both, information on varietal differences and the effects of environmental conditions became of critical value to those concerned with cotton production and cottonseed processing, as well as of importance to those responsible for allocating available supplies to consumers.

As a part of the regional cotton variety study conducted in cooperation with State agricultural experiment stations by the Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, a study was made on the oil and protein content of cottonseed from representative varieties grown under a wide range of environmental conditions. The general scope of the study included a measurement of agronomic and gin data variables, fiber properties, and spinning performance on varieties grown in the main Cotton Belt to determine the relative importance of varietal differences, ecological factors, and interactions.

A general report on the whole study is being prepared for publication, but since data on oil, protein, linters, and fiber properties is urgently needed, a summary of results on these variables is being presented in advance of the general report.

RESULTS OF PREVIOUS INVESTIGATIONS

Previous investigators have reported the range in oil and protein content of cottonseed in breeding material, varietal studies, and commercial samples at various locations. Ware (*9*),[2] in summarizing the results of continuous selection in Arkansas for oil and protein content of cottonseed, reported an average difference of 4.8 percent between the high-oil and low-oil groups. An average difference of 3.7 percent was found between the groups of plants selected continuously for high and low protein. Selection for a high or low level of either oil or protein resulted in an opposite response for the other variable, indicating a negative association of oil and protein percentage. Brown and Anders (*1*) found differences exceeding 12 gallons of oil per ton (4.8 percent) among varieties grown at State College, Miss., and Rast (*7*) found differences greater than 16 gallons per ton (6.4 percent) among varieties grown in Georgia.

Creswell and Bidwell (*2*), in a summary of results from a large number of analyses made by company and commercial chemists, reported the range of State averages for 3 successive years as 292 to 337, 285 to 330, and 267 to 319 pounds of oil per ton (14.60 to 16.85, 14.25 to 16.50, and 13.35 to 15.95 percent), indicating differences between seasons and among States, but the variation is difficult to interpret, as it represents a composite of varietal and ecological factors. Comparable ranges in yield of cottonseed meal were found between seasonal and State averages.

Studies by Meloy (*6*) showed a progressive decline in percentage of oil through the picking and ginning season in six Texas counties for 1942-43. No consistent trends in protein were identified in the same samples. In another study, Meloy[3] reported rather wide variations in both oil and protein percentages in samples of cottonseed from a single county and pointed out that oil and protein are not always related in an inverse ratio.

Sievers and Lowman[4] concluded after an extensive study that percentage of oil in the seed depends on two factors: (1) Percentage of meats in the

[2] Figures in parentheses refer to Literature Cited, p. 41.

[3] MELOY, G. S. THE EFFECT OF WEATHER ON THE RELATIVE DEVELOPMENT OF OIL AND PROTEIN IN COTTONSEED. Natl. Cottonseed Prod. Assoc., Hot Springs, Ark. 5 pp. 1941. [Processed.]

[4] SIEVERS, A. F. and LOWMAN, M. S. A STUDY OF COTTONSEED WITH REFERENCE TO VARIETAL CHARACTERISTICS AND SOURCES OF PRODUCTION. U. S. Dept. Agr. 12 pp. 1932. [Processed.]

seed and (2) percentage of oil in the meats. Some varieties were found to contain meats with a higher oil content than others, and this characteristic appeared to have no relation to geographic source. No definite conclusions were drawn concerning ammonia content of the seed.

Garner, Allard, and Foubert (*4*), in studies on samples grown in Georgia and South Carolina, found small differences in percentage of oil among varieties but greater differences among locations and seasons.

Hancock (*5*), in the analysis of data from four varieties grown for 3 years at three locations in Tennessee, found the order of factors contributing to oil content to be location, variety, and season, while for nitrogen content the order was location, season, and variety. The variance for seasons × locations was considerably greater than that of other interactions for both nitrogen and oil.

Tharp (*8*) found an increase in oil percentage in cottonseed grown on soils in which potash was deficient and called attention to the importance of varietal choice and proper fertilizer application as a means of increasing total oil production.

Samples used in the foregoing studies were not generally the same with respect to varieties, locations, and seasons of growth, and consequently the data could not be examined readily for interrelation of varietal and ecological factors.

Laboratory measurements of fiber properties were made on lint samples from the majority of locations in 1935. These data offer substantial evidence on the effect of location of growth on various fiber properties and are of particular interest at a time when special fiber quality is of importance.

EXPERIMENTAL PROCEDURE

In a pilot study, chemical analyses were made on seed from both 4- and 5-lock 100-boll samples from 2 locations. Varietal means for oil, protein, and fuzz were substantially the same for the 2 kinds of samples; consequently, in the rest of the study analyses were made on seed from 4-lock-boll samples only. The following data, unless otherwise indicated, were taken from the 4-lock 100-boll samples. Oil, protein, and fuzz determinations were made through cooperative arrangements with the Alabama Agricultural Experiment Station, under the supervision of D. G. Sturkie, using the following methods of procedure.

In determining the percentage of fuzz, the seed was dried in the oven at 110° C. for 4½ hours, cooled to room temperature, weighed, delinted with sulfuric acid, washed free of acid, heated again in an oven at 110° for 4½ hours, allowed to cool again to room temperature, and reweighed. The loss in weight was expressed as the percentage of fuzz, using weight of oven-dried delinted seed as the basis for calculations.

The percentage of oil was determined by running the seed through a coffee mill, first grinding the sample coarsely, and then regrinding it fine. Two gm. of the fine sample were weighed and transferred to a warm mortar, 4 cc. of halowax and 1 to 2 gm. of fine sand added, and the mixture ground with a pestle for 2 minutes and passed through folded filter paper, the filtrate being caught in a test tube. The filtrate was allowed to come to room temperature, and 2 drops were placed on the lower prism of the refractometer. The sample was allowed to stand for 10 minutes with temperature constant at 30° C. The refractometer reading was then taken, and from this reading the percentage of oil was determined by use of a standard conversion table.

In determining nitrogen, samples of the ground seed as obtained for percentage of oil were weighed and nitrogen determined by the standard Kjeldahl method, then converted to protein basis by the ordinary conversion factor. All determinations were made on a moisture-free basis.

Preliminary to the oil and protein analyses, seeds were delinted with sulfuric acid, and this provided opportunity for determining the percentage of fuzz, or linters, on the seed. The effects of variety, location, and season on these three variables are summarized in the present report.

Data for each variable were treated by the analysis-of-variance method of Fisher (*3*), in order to separate total variability into its components and to test the significance of variety, location, and season, and their interactions on each of the variables.

EXPERIMENTAL RESULTS

Percentage of Oil

The varietal means and rank for percentage of oil, as determined from 4-lock-boll samples in the 1935 regional cotton variety study, are shown in table 1. Chemical analyses were not made on samples from Prattville, Ala., and Experiment, Ga., because a necessary change in location of these two tests in the succeeding years prevented comparisons between seasons on the same blocks of land. The test at Brazos Valley, Tex., was conducted only in 1937. The location means ranged from 24.21 to 20.93 percent of oil for North Carolina and Jackson, Tenn., respectively. The range in varietal means at all locations was from 23.37 to 20.04 percent. The range of 3.33 percent for oil, when considered in connection with the requirement for significance, 0.31, shows that many significant differences were established among varieties included in the study.

A comparison of the varietal rank at all locations with the rank at individual locations shows a general tendency for agreement, but certain departures indicate a differential response of varieties to locations.

From the 1936 study, the varietal means and rank for percentage of oil are summarized by locations in the second section of table 1. A comparison of the mean of all locations for 1936 with that for 1935 shows that the average percentage of oil was closely equivalent in the 2 years. The range in location means for 1936, 25.42 to 17.55, for North Carolina and Oklahoma, respectively, was considerably greater than in the preceding year. This greater range is due both to a higher maximum and to a lower minimum than in 1935. The lowest location mean in 1936 was recorded in Oklahoma, where severe drought conditions prevailed, and this indicates that severe water stress may lead to a marked reduction in oil content. Locations that were rather dry in 1936 were usually low in oil content, but the data are not entirely consistent in this respect, particularly in the case of the two Arkansas tests, which were conducted on different soil types located less than 5 miles apart. On delta land an increase was obtained for 1936 over 1935, while a decrease was found on upland soil; this indicates that quantity of rainfall alone is not the determining factor, but that certain soil characteristics, as water-holding capacity, may play an important part.

The varietal averages for all locations ranged from 23.35 to 20.02, which agrees closely with the comparable range in the preceding year. A comparison of the varietal rank at all locations for the 2 years 1935 and 1936 shows a close agreement, indicating that varietal characteristics in oil content are likely to be consistent from season to season. A comparison of the varietal rank at all locations with the corresponding rank at the individual locations indicates a general tendency for agreement, particularly in varieties outstandingly high or low in oil content.

From the 1937 study the varietal means and ranks for percentage of oil are summarized in the third section of table 1. The

TABLE 1.—*Varietal means and rank for percentage of oil, as determined*

Year and variety	Location													
	Prattville, Ala.		Marianna, Ark.				Experiment, Ga.		Baton Rouge, La.		Stoneville, Miss.		Statesville, N. C.	
			Delta		Upland									
1935	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
Acala (Roger)			23.45	11	22.36	10			23.96	7	23.50	7	24.75	4
Arkansas 17			24.02	7	22.51	6			23.57	11	23.76	5	24.85	3
Cleveland (W)			22.54	13	20.70	15			22.46	14	22.15	14	23.74	13
Cook 912			24.35	6	23.20	1			24.30	2	24.01	4	24.66	6
Delfos 4			24.66	3	22.92	3			24.16	4	23.40	8	24.35	9
Deltapine			23.59	10	22.40	9			23.65	10	22.90	11	23.96	10
Dixie Triumph 759			24.80	2	22.67	4			24.40	1	24.41	1	25.19	2
Farm Relief			21.82	15	20.87	14			22.41	15	21.79	15	23.81	12
Half and Half			24.61	5	22.49	7			23.69	9	23.26	9	24.74	5
Mexican Big Boll			23.77	9	21.90	11			24.19	3	23.54	6	23.72	14
Qualla			21.51	16	20.05	16			21.59	16	21.12	16	22.25	16
Rowden 2088			24.04	4	22.56	5			24.10	5	24.15	3	23.84	11
Startex 619			23.94	8	22.44	8			23.45	12	22.90	10	24.57	7
Stoneville 5			23.34	12	21.99	13			22.69	13	22.47	13	23.21	15
Triumph 44			25.47	1	23.15	2			24.05	6	24.16	2	25.54	1
Wilds 5			22.51	14	21.80	12			23.91	8	22.70	12	24.37	8
Average, all varieties			23.69		22.13				23.53		23.15		24.21	
Difference req., odds 99 : 1			.84		.92				.88		.98		1.01	
1936														
Acala (Roger)	20.26	6	24.39	10	20.16	10	24.60	7	23.54	7	22.60	11	25.79	7
Arkansas 17	20.49	5	25.27	3	20.54	7	23.64	13	23.92	6	23.07	8	24.87	14
Cleveland (W)	17.50	16	23.17	14	19.22	15	22.95	15	21.20	16	21.81	15	25.22	11
Cook 912	19.50	10	25.05	7	20.71	5	24.52	8	23.14	10	23.14	7	25.12	13
Delfos 4	20.61	3	25.21	5	20.71	6	25.02	4	23.95	4	24.00	3	20.00	4
Deltapine	19.95	7	23.80	12	20.34	8	24.17	11	22.94	12	22.50	13	25.16	12
Dixie Triumph 759	18.65	14	26.04	2	21.59	2	25.42	1	24.46	1	24.37	2	26.04	2
Farm Relief	19.51	12	23.11	15	19.32	14	22.96	14	22.41	14	21.95	14	25.41	9
Half and Half	19.60	9	24.66	8	20.05	12	24.27	10	23.47	8	23.60	4	26.00	3
Mexican Big Boll	19.92	8	24.49	9	21.10	3	24.51	9	24.10	3	23.55	5	25.80	6
Qualla	18.49	15	21.66	16	17.92	16	21.41	16	22.35	15	20.65	16	23.71	16
Rowden 2088	20.55	4	25.24	4	20.26	9	25.07	3	23.95	5	23.44	6	25.70	8
Startex 619	19.54	11	25.17	6	21.01	4	25.27	2	23.12	11	22.09	10	25.27	10
Stoneville 5	19.40	13	23.9[illegible]	11	20.12	11	24.04	12	22.92	13	22.51	12	24.60	15
Triumph 44	20.72	1	26.24	1	21.81	1	24.90	5	24.36	2	24.44	1	26.10	1
Wilds 5	20.71	2	23.64	13	19.70	13	24.74	6	23.40	9	23.06	9	25.92	5
Average, all varieties	19.72		24.44		20.20		24.22		23.33		22.99		25.42	
Difference required, odds 99 : 1	1.60		1.08		1.62		1.81		1.23		1.15		1.06	
1937														
Acala (Roger)	20.79	5	26.75	4	24.16	3	20.41	12	26.38	12	24.72	12	25.77	4
Arkansas 17	19.55	12	26.98	2	24.14	4	21.27	7	26.67	10	25.19	5	25.89	3
Cleveland (W)	18.99	16	24.95	15	23.19	11	21.10	9	26.09	14	23.20	15	25.35	8
Cook 912	20.19	10	26.50	9	24.97	1	22.94	1	26.79	7	25.49	2	26.49	1
Delfos 4	20.61	8	26.69	5	22.20	14	21.64	6	27.30	3	25.25	4	24.35	14
Deltapine	19.80	11	26.27	11	23.60	9	21.35	8	26.70	8	24.89	10	24.40	13
Dixie Triumph 759	20.75	6	27.71	1	24.66	2	22.94	2	27.86	2	25.06	7	25.24	10
Farm Relief	19.55	13	25.34	14	21.44	15	20.00	15	26.12	13	23.65	14	24.60	12
Half and Half	21.11	3	26.61	7	22.85	13	22.00	3	26.65	11	24.92	9	25.60	5
Mexican Big Boll	20.71	7	26.46	10	23.77	7	21.09	10	26.92	6	25.86	1	25.29	9
Qualla	19.35	15	23.94	16	21.09	16	17.47	16	25.55	15	23.12	16	22.57	16
Rowden 2088	21.02	4	26.20	12	23.67	8	21.42	5	27.06	5	24.79	11	25.67	6
Startex 619	22.36	1	26.55	8	24.01	5	20.29	13	27.22	4	25.54	3	26.37	2
Stoneville 5	19.50	14	25.54	13	23.60	10	20.04	14	24.57	16	24.02	13	23.31	15
Triumph 44	21.69	2	26.76	3	23.99	6	21.90	4	28.15	1	25.01	8	25.45	7
Wilds 5	20.59	9	26.65	6	23.14	12	20.76	11	26.69	9	25.14	6	25.00	11
Average, all varieties	20.41		26.24		23.40		21.03		26.67		24.74		25.09	
Difference required, odds 99 : 1	1.53		1.50		2.18		1.64		1.60		1.51		2.24	

from moisture-free acid-delinted cottonseed, at 12 to 15 locations, 1935-37

Location—Continued																Varietal average, all locations	
Stillwater, Okla.		Florence, S. C.		Jackson, Tenn.		Knoxville, Tenn.		College Station, Tex.		Greenville, Tex.		Lubbock, Tex.		Brazos Valley, Tex.			
Pct.	Rank	Pct.	Rank	Pct.	Rank	Pct.	Rank	Pct.	Rank	Pct.	Rank	Pct.	Rank	Pct.	Rank	Pct.	Rank
20.07	14	21.59	6	19.34	15	21.36	13	21.50	13	22.72	2	21.86	9	------	------	22.20	10
21.31	8	21.35	7	22.05	2	22.52	3	22.84	5	21.32	6	21.50	10	------	------	22.04	6
19.86	15	20.29	14	20.55	12	21.45	12	21.50	11	21.26	8	20.62	14	------	------	21.43	14
22.45	1	21.67	4	21.92	4	22.16	6	23.29	3	23.10	1	21.97	7	------	------	23.10	2
22.15	2	21.90	2	21.90	3	22.20	5	23.07	4	21.19	12	22.45	2	------	------	22.88	4
21.70	6	21.01	11	21.39	9	22.09	7	22.14	10	21.22	10	20.99	12	------	------	22.25	9
21.16	9	21.66	5	21.76	5	22.71	2	23.50	2	22.49	3	22.31	3	------	------	23.10	3
20.24	13	19.81	15	19.56	13	20.44	15	20.31	15	21.07	13	20.44	15	------	------	21.05	15
22.11	4	21.04	9	21.55	7	21.74	11	22.27	9	21.51	5	21.99	6	------	------	22.58	7
21.09	10	20.87	12	21.37	10	21.79	10	21.40	14	20.81	15	22.21	4	------	------	22.20	11
19.56	16	18.50	16	17.56	16	18.94	16	19.10	16	19.01	16	20.37	16	------	------	20.04	16
22.15	3	21.25	8	21.40	8	21.96	8	22.40	8	21.21	11	22.12	5	------	------	22.65	5
21.36	7	21.70	3	21.65	6	21.84	9	22.70	6	20.8[illegible]	14	21.92	8	------	------	22.46	8
20.45	12	20.47	13	20.87	11	21.09	14	22.50	7	21.79	4	20.75	13	------	------	21.79	13
22.02	5	22.01	1	22.45	1	23.55	1	23.04	1	21.26	9	22.81	1	------	------	23.37	1
20.65	11	21.04	10	19.45	14	22.41	4	21.55	12	21.30	7	21.05	11	------	------	21.90	12
21.15	------	21.02	------	20.93	------	21.77	------	22.14	------	21.43	------	21.59	------	------	------	22.23	------
1.03	------	1.44	------	1.06	------	.93	------	1.07	------	1.40	------	.83	------	------	------	.31	------
15.20	15	24.70	7	21.71	7	21.87	13	19.95	12	18.50	13	22.06	12	------	------	21.82	11
17.05	12	24.77	8	21.52	8	23.49	4	22.01	2	20.14	8	22.87	6	------	------	22.41	8
15.49	13	23.87	14	19.24	16	20.69	14	19.59	14	17.64	15	20.35	16	------	------	20.58	15
18.49	6	25.44	4	22.41	2	23.06	2	21.57	5	20.59	3	22.61	7	------	------	22.50	4
18.77	5	25.41	5	22.94	1	22.57	8	21.17	7	21.51	2	23.16	4	------	------	22.09	3
17.54	10	24.65	9	20.71	13	22.27	9	20.72	9	20.41	4	22.42	9	------	------	22.03	10
19.11	2	25.37	6	22.19	4	24.46	1	21.97	3	20.41	5	22.57	8	------	------	23.05	2
17.50	11	23.66	15	19.71	14	20.71	15	19.40	15	19.09	12	21.40	14	------	------	21.15	14
19.01	3	24.50	12	21.12	9	23.42	5	21.71	4	20.31	6	23.97	1	------	------	22.57	6
17.76	8	25.54	2	21.92	5	22.15	10	21.55	6	19.70	10	22.07	5	------	------	22.51	7
15.36	14	21.92	16	19.71	15	20.00	16	17.20	16	17.51	16	21.30	15	------	------	20.02	16
18.80	4	25.66	1	20.86	12	22.84	7	21.04	8	20.22	7	22.36	10	------	------	22.58	5
18.27	7	25.47	3	21.72	6	22.89	6	20.35	10	19.20	11	23.47	2	------	------	22.41	9
17.61	9	23.97	13	21.12	10	21.95	12	20.34	11	20.10	9	22.14	11	------	------	21.70	12
19.84	1	24.60	10	22.39	3	23.60	3	22.74	1	21.74	1	23.36	3	------	------	23.35	1
15.06	16	24.60	11	21.11	11	22.00	11	19.90	13	18.17	14	21.94	13	------	------	21.71	13
17.55	------	24.64	------	21.28	------	22.44	------	20.70	------	19.70	------	22.44	------	------	------	22.10	------
1.30	------	1.20	------	1.97	------	1.48	------	1.74	------	1.30	------	1.08	------	------	------	.38	------
18.00	14	23.67	6	20.50	13	22.10	8	15.11	13	16.20	15	23.59	6	18.76	11	21.80	10
19.35	5	23.95	3	21.77	5	22.41	6	16.81	7	18.41	4	23.47	7	19.81	6	22.38	6
16.21	16	20.52	16	20.96	12	21.02	14	14.15	15	16.30	14	22.12	14	17.46	14	20.77	15
20.42	3	24.20	1	22.10	4	23.01	2	16.86	6	18.37	6	22.64	12	20.81	3	22.70	3
20.61	2	24.08	2	22.41	3	22.21	7	17.51	2	19.41	2	23.04	5	19.89	5	22.52	4
18.86	11	22.62	11	20.34	14	21.96	9	16.11	9	17.71	10	22.49	13	19.10	9	21.73	11
19.10	7	23.55	8	23.51	1	23.69	1	17.36	3	19.01	3	23.36	9	20.84	2	22.98	1
18.60	12	22.41	13	21.27	10	21.44	13	14.77	14	16.96	13	23.45	8	17.96	12	21.18	13
19.24	6	23.60	7	21.21	11	22.45	5	17.00	5	18.27	7	24.22	3	19.34	8	22.34	8
18.97	10	23.30	10	21.57	8	21.70	11	15.79	11	18.16	8	24.69	1	18.80	10	22.21	9
17.61	15	20.56	15	19.46	15	19.39	16	13.87	16	15.25	16	21.07	16	15.07	16	19.69	16
19.81	4	23.80	5	22.86	2	22.64	4	16.17	8	18.40	5	23.71	4	19.92	4	22.48	5
19.00	9	23.86	4	21.77	6	22.66	3	15.84	10	17.75	9	22.82	11	19.69	7	22.38	7
19.07	8	21.15	14	19.31	16	20.84	15	17.15	4	17.57	11	22.09	15	17.92	13	21.05	14
20.66	1	23.54	9	21.50	9	21.98	10	17.72	1	19.61	1	24.42	2	21.56	1	22.93	2
18.20	13	22.46	12	21.60	7	21.52	12	15.47	12	17.50	12	22.84	10	17.42	15	21.67	12
18.99	------	22.95	------	21.39	------	21.94	------	16.11	------	17.81	------	23.16	------	19.02	------	21.03	------
1.45	------	2.20	------	2.02	------	1.54	------	1.45	------	1.44	------	1.53	------	1.41	------	.45	------

range in varietal averages at all locations for 1937 was 3.28 percent for oil, and this is remarkably consistent with the varietal ranges in preceding years, 3.33 each. Comparisons of varietal rank show only minor changes from year to year. These findings indicate that oil content of cottonseed is fundamentally a varietal characteristic and tends to be reasonably consistent from place to place in the same or different seasons.

The range in station averages for 1937 was 10.56 percent for oil, which exceeds considerably the comparable ranges in preceding years, 3.28 and 7.87 percent. The rank of stations is not consistent from year to year, indicating that modifications in percentage of oil are dependent to a greater extent on local weather conditions than on soil-type differences.

A summary of the analysis of variance by individual locations for percentage of oil in cottonseed in 1935, 1936, and 1937, is shown in table 2. Comparisons of the mean square for varieties with mean square for error in each of the 41 experiments show that highly significant contributions to variation were found for varieties at each location in each year. This consistent significance for varieties indicates that varietal differences in oil content exist and are highly significant. Consequently, these data provide conclusive evidence that oil content for varieties is primarily dependent on the genetic constitution of those varieties.

Relative differences among varieties are considerably more clear-cut at certain locations than at others. Such differences in distinction may be due to either or both of two factors: (1) The relative difference among varieties is greater at some locations than at others; and (2), residual variance or error is not equal at all places. For example, comparison shows that an unusual degree of uncontrolled variability existed at Florence, S. C., and Greenville, Tex., in 1935. At Florence, no abnormality in plant growth could be detected, but at Greenville, a rather unusual fruiting situation occurred, only a comparatively few bolls being set on well-developed plants, indicating that a nutritional unbalance may have contributed somewhat to the variability of the experiment.

Error variance was comparatively high in 1936 at Alabama, Arkansas (upland), Georgia, Jackson and Knoxville, Tenn., and College Station, Tex. It appears to be reasonably independent of the importance of other contributors to variance and not closely associated with any characteristic plant development. Error variance was generally larger in 1937 than in the preceding years and no adequate explanation for this increase is available, but it may have been caused by a greater heterogeneity among individual plots due to the unusually high yield resulting from the setting of bolls over a period longer than normal. As a consequence, wider differences in temperature probably prevailed during the developmental period of the seed in 1937 and may have been reflected in the experimental error.

The variance for series and ranges differed greatly among stations within any year, and also among years at certain stations, indicating that differences in oil content were due to varying plant response to soil differences within the experimental block or to the relation of these soil differences to the weather pattern in successive years.

TABLE 2.—*Summary of mean squares for analysis of variance on percentage of oil from 4-lock-boll samples*

Year and location	Mean squares: Total	Varieties	Series	Ranges	Error
1935					
Arkansas, Marianna:					
Delta	1.629	10.056	1.989	0.204	0.400
Upland	1.160	6.360	.477	.413	.492
Louisiana, Baton Rouge	1.230	5.432	3.681	.686	.452
Mississippi, Stoneville	1.530	6.877	4.368	1.134	.637
North Carolina, Statesville	1.225	5.128	1.625	1.340	.591
Oklahoma, Stillwater [1]	1.845	6.755	6.731		.618
South Carolina, Florence	2.158	6.580	7.608	1.308	1.191
Tennessee:					
Jackson	2.419	13.800	3.193	1.863	.647
Knoxville	1.705	8.563	5.042	.533	.501
Texas:					
College Station	2.320	12.120	4.450	2.347	.605
Greenville	1.778	5.111	4.096	.490	1.131
Lubbock	1.037	4.514	1.948	.053	.399
1936					
Alabama, Prattville	2.353	6.543	5.144	2.670	1.489
Arkansas, Marianna:					
Delta	2.018	11.292	1.853	1.123	.674
Upland	2.374	7.311	2.710	3.417	1.620
Georgia, Butler	3.036	7.177	10.206	2.949	1.806
Louisiana, Baton Rouge	1.591	5.797	1.382	1.105	.879
Mississippi, Stoneville	2.545	7.894	17.701	.007	.761
North Carolina, Statesville	1.051	3.341	1.647	1.189	.648
Oklahoma, Stillwater [1]	3.328	18.843	5.275		.982
South Carolina, Florence	1.840	7.327	4.985	.857	.839
Tennessee:					
Jackson	3.117	8.853	4.289	1.734	2.255
Knoxville	2.726	11.952	4.281	1.800	1.263
Texas:					
College Station	3.615	14.393	4.709	5.478	1.747
Greenville	2.305	12.625	.595	.518	.975
Lubbock	1.603	6.702	2.769	2.549	.672
1937					
Alabama, Prattville	2.503	6.728	9.480	2.603	1.351
Arkansas, Marianna:					
Delta	2.001	6.517	3.180	1.001	1.206
Upland	4.220	9.212	2.010	15.429	2.748
Georgia, Experiment	3.274	13.478	4.613	4.100	1.551
Louisiana, Baton Rouge	2.224	5.810	6.687	.421	1.484
Mississippi, Stoneville	2.390	5.327	12.083	1.406	1.322
North Carolina, Statesville	3.707	8.729	5.203	2.607	2.809
Oklahoma, Stillwater [1]	2.560	10.469	5.933		1.213
South Carolina, Florence	4.049	12.045	6.797	1.780	2.791
Tennessee:					
Jackson	3.738	10.010	7.083	5.445	2.352
Knoxville	2.655	7.918	10.864	1.210	1.360
Texas:					
College Station	2.556	11.348	4.388	.660	1.215
Greenville	2.354	11.160	1.446	.057	1.191
Lubbock	2.212	7.209	5.219	.464	1.357
Brazos Valley	3.517	20.639	2.587	.940	1.147
Degrees of freedom	127	15	7	7	98
Do.[1]	127	15	7		105

[1] Experiment planted in 8 randomized blocks.

Analysis of variance for combined data from 11 locations in 1935, 13 in 1936, and 14 in 1937 is shown in table 3. In each year location is, numerically, the most important contributor and variety ranks second. In this and similar tables, no asterisks are used in the mean square column to indicate significance of the several variances or contributors to variance over error, for the reason that main effects—interactions and restrictions—usually exceed odds of 99 to 1 when tested against error. When all contributors are significantly greater than error, interpretation depends on the relative size of contributors and the significance of differences between main effects or between main effects and interactions. In the columns showing significant comparisons, F tests between various contributors to variance at odds of 99 to 1 are indicated by brackets, the ends of which show the pair of contributors tested. The absence of a bracket indicates a lack of significance between contributors or lack of interpretative interest in the comparisons. In 1936 and 1937 the variance for locations significantly exceeded that for varieties, as indicated by brackets in the significant-comparisons columns, table 3. In 1935 locations numerically exceeded varieties but did not reach significance.

Both main effects, varieties and locations, were significantly greater than varieties × locations, although interaction was significantly greater than error. These data therefore indicate that modification in oil content between locations within single years may be greater than differences among varieties. Highly important varietal differences in oil content were established, and these differences significantly exceed differential response of varieties to growth conditions prevailing at the various locations.

The contributions to variance for series within locations and ranges within locations significantly exceed error and are on the average about equal to interaction. This indicates that environmental factors within the experimental blocks were sufficiently great to cause significant modifications in the oil content.

In general, the combined analyses for the 3 years are similar. The most noticeable comparative feature is that the variance for locations increased materially from 1935 to 1936, and even more from 1936 to 1937. The contribution for varieties increases in a parallel manner but to a lesser extent. Varieties × locations is low in comparison with main effects and tends to be consistent with an increase following the same pattern as varieties and locations. Total variance and other contributors likewise follow the same sequence of increase in the 3 years.

TABLE 3.—*Analysis of variance of the percentage of oil from 4-lock-boll samples*

Source of variation	1935			1936			1937		
	Degrees of freedom	Mean square	Significant comparisons[1]	Degrees of freedom	Mean square	Significant comparisons[1]	Degrees of freedom	Mean square	Significant comparisons[1]
Varieties	15	65.18		15	70.92		15	89.89	
Locations	10	165.70		12	190.84		13	1,239.04	
Varieties × locations	150	1.98		180	2.01		195	3.66	
Series within locations	77	3.53		91	4.70		98	6.97	
Ranges within locations	77	1.03		91	2.04		98	2.78	
Error	1,078	.94		1,274	1.20		1,372	1.72	
Total	1,407	2.82		1,663	5.58		1,791	11.93	

[1] In the columns showing significant comparisons, F tests between various contributors to variance at odds of 99:1 are indicated by brackets, the ends of which show the pair of contributors tested. The absence of a bracket indicates a lack of significance between contributors or lack of interest in the comparison.

The analysis for separate years indicates that growth conditions as represented by locations is the most important factor in determining the oil content of cottonseed. Despite the dominant contribution for locations, the high mean square for varieties definitely establishes characteristic and reasonably stable differences among the varieties studied. Varietal differences are reasonably consistent at all places of growth, and this may be interpreted as establishing the fact that oil content of seed is primarily and fundamentally determined by the genetic constitution of the variety. It therefore seems logical that, in the development of new varieties of cotton, attention be given to the oil content of seed in order that high oil content be added to the other desirable characteristics of varieties.

An analysis of variance for the combined data from 11 locations and 3 years for percentage of oil is shown in table 4. It is evident from this analysis that environment, as represented by locations and locations × seasons, is the most important factor in modifying oil content. Despite the dominant effect of environmental factors, these data offer clear evidence that percentage of oil is fundamentally dependent on genetic constitution. Interactions of varieties with locations, seasons, or both, are decidedly secondary in importance to general varietal differences. These findings indicate that selection for oil content in breeding should be effective and that varieties tend to maintain a consistent rank in oil percentage when grown under a wide range of conditions.

The significance of detailed comparisons between main effects, between main effects and interactions, and between first and second order interactions is indicated by the presence or absence of brackets in the column headed "Significant comparisons." The ends of the brackets indicate the contributors being compared. The presence of a bracket shows that the F value found for the ratio of that pair of mean squares exceeded that required for significance

TABLE 4.—*Analysis of variance of data from 11 locations for the percentage of oil from 4-lock-boll samples, 1935-37*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F: Found	F: Required odds 99:1	Significant comparisons [1]
Varieties	15	2,937.13	195.81	164.53	2.09	
Locations	10	13,439.91	1,343.99	1,129.31	2.34	
Seasons	2	90.00	45.00	37.81	4.62	
Varieties × locations	150	401.87	3.28	2.70	1.38	
Varieties × seasons	30	92.97	3.10	2.60	1.71	
Locations × seasons	20	6,647.94	332.40	279.30	1.60	
Varieties × locations × seasons	300	643.87	2.15	1.80	1.28	
Series within locations	77	579.10	7.52	6.32	1.44	....
Seasons × series within locations	154	489.27	3.18	2.67	1.38	....
Ranges within locations	77	205.04	2.66	2.24	1.44	....
Seasons × ranges within locations	154	230.50	1.50	1.31	1.38	....
Error	3,234	3,848.74	1.19	....	....	....
Total	4,224	29,705.41	7.03	....	....	....

[1] The ends of the brackets indicate the variances being compared. The presence of a bracket shows that the F value found for the mean squares exceeded that required for significance at odds of 99:1. Absence of a bracket for any two variances indicates that the respective mean squares are not significantly different or that the comparison is not of interpretive interest.

TABLE 5.—*Varietal means and rank for percentage of protein, as determined*

Year and variety	Location													
	Prattville, Ala.		Marianna, Ark.				Experiment, Ga.		Baton Rouge, La.		Stoneville, Miss.		Statesville, N. C.	
			Delta		Upland									
	Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
1935														
Acala (Roger)	----	----	22.64	5	24.34	11	----	----	20.05	8	21.74	12	20.19	10
Arkansas 17	----	----	20.97	14	24.09	14	----	----	21.02	7	20.62	15	19.66	15
Cleveland (W)	----	----	22.05	9	24.91	3	----	----	20.42	14	21.77	13	20.01	11
Cook 912	----	----	21.77	11	24.30	12	----	----	19.87	15	21.60	14	19.92	12
Delfos 4	----	----	21.81	10	24.66	6	----	----	20.85	9	22.14	9	22.01	2
Deltapine	----	----	22.42	6	24.75	5	----	----	21.22	5	22.24	8	21.50	3
Dixie Triumph 750	----	----	20.07	15	23.70	16	----	----	19.02	16	20.32	16	19.60	16
Farm Relief	----	----	23.09	1	24.90	4	----	----	21.31	4	22.82	3	21.15	6
Half and Half	----	----	23.01	2	25.74	1	----	----	22.55	1	24.84	1	22.04	1
Mexican Big Boll	----	----	22.90	3	25.02	2	----	----	20.65	12	22.57	4	21.25	5
Qualla	----	----	22.40	7	23.89	15	----	----	22.20	2	23.32	2	21.34	4
Rowden 2088	----	----	21.26	12	24.42	8	----	----	20.81	10	22.00	10	20.70	9
Startex 610	----	----	22.12	8	24.62	7	----	----	21.40	3	22.36	7	20.80	8
Stoneville 5	----	----	20.72	16	24.17	13	----	----	21.05	6	22.00	11	19.71	14
Triumph 44	----	----	21.25	13	24.30	9	----	----	20.07	11	22.40	5	19.72	13
Wilds 5	----	----	22.69	4	24.36	10	----	----	20.50	13	22.37	6	20.07	7
Average, all varieties	----	----	22.01	----	24.62	----	----	----	20.90	----	22.21	----	20.68	----
Difference req., odds 99 : 1	----	----	.93	----	1.16	----	----	----	1.10	----	1.21	----	1.10	----
1936														
Acala (Roger)	24.46	5	21.00	9	24.16	9	20.51	6	25.30	12	24.51	7	20.30	15
Arkansas 17	23.50	14	20.19	15	24.36	4	20.14	12	24.41	14	24.10	12	20.54	12
Cleveland (W)	23.80	12	21.75	7	24.29	6	20.35	9	26.06	5	24.42	8	20.52	13
Cook 912	23.71	13	21.52	11	24.05	2	19.77	15	24.92	13	23.92	13	20.72	10
Delfos 4	24.05	10	21.55	12	24.10	8	20.35	10	24.20	16	24.24	10	21.70	5
Deltapine	24.52	4	22.10	5	24.60	3	20.56	5	26.50	3	24.24	9	22.12	3
Dixie Triumph 750	23.31	15	20.00	16	22.82	15	19.02	16	24.20	15	23.57	14	19.61	16
Farm Relief	25.50	1	22.70	2	23.75	12	20.14	13	25.76	7	25.75	2	20.84	9
Half and Half	25.44	2	23.00	1	25.40	1	22.72	1	27.00	1	25.95	1	22.44	1
Mexican Big Boll	24.14	7	22.42	3	23.77	11	21.01	3	25.95	6	25.34	3	21.34	8
Qualla	24.54	3	22.24	4	22.47	16	21.31	2	26.80	2	24.22	11	21.75	4
Rowden 2088	24.34	6	21.66	10	24.30	5	20.66	4	25.52	9	24.90	5	21.46	6
Startex 610	24.30	8	21.85	6	24.00	10	20.36	8	26.37	4	24.81	4	21.35	7
Stoneville 5	23.00	16	21.20	13	23.47	14	19.92	14	25.40	11	22.30	16	20.57	11
Triumph 44	23.82	11	20.96	14	24.20	7	20.16	11	25.50	10	24.69	6	22.10	2
Wilds 5	24.09	9	21.62	8	23.54	13	20.41	7	25.67	8	23.56	15	20.47	14
Average, all varieties	24.15	----	21.69	----	24.03	----	20.46	----	25.61	----	24.40	----	21.12	----
Difference req., odds 99 : 1	1.44	----	1.39	----	1.74	----	1.38	----	1.11	----	1.49	----	1.21	----
1937														
Acala (Roger)	24.06	14	20.16	12	22.97	11	24.20	8	22.12	4	24.21	6	22.72	8
Arkansas 17	24.07	13	19.01	13	23.27	9	22.71	15	21.29	11	23.07	13	22.37	14
Cleveland (W)	24.91	7	20.44	10	22.90	12	23.71	10	21.69	8	23.01	10	22.04	9
Cook 912	24.52	10	19.85	14	22.64	14	22.70	14	21.39	10	22.05	16	22.54	11
Delfos 4	25.12	5	20.59	9	22.61	15	24.05	9	21.15	12	22.08	15	23.07	6
Deltapine	25.25	3	20.84	8	23.64	7	24.22	7	22.15	3	23.85	8	22.55	10
Dixie Triumph 759	23.70	15	18.49	16	22.86	13	22.06	16	20.54	16	23.47	11	21.40	16
Farm Relief	25.84	2	22.11	2	24.21	4	25.44	1	21.62	9	25.27	2	24.07	2
Half and Half	26.15	1	22.12	1	24.06	5	25.42	2	23.70	1	26.14	1	25.06	1
Mexican Big Boll	24.29	11	22.01	3	24.51	2	24.42	5	21.75	7	24.35	4	23.59	3
Qualla	23.74	16	21.52	4	21.82	16	24.95	3	22.79	2	24.40	3	23.44	5
Rowden 2088	25.06	6	21.50	5	24.75	1	23.61	13	21.97	5	23.09	7	23.02	7
Startex 610	24.10	12	21.49	6	24.40	3	24.30	6	21.00	13	23.12	12	22.40	13
Stoneville 5	24.60	8	20.30	11	23.50	8	23.65	11	20.75	15	23.02	14	22.10	15
Triumph 44	25.22	4	21.02	7	23.86	6	24.90	4	21.81	6	24.27	5	23.45	4
Wilds 5	24.57	9	19.75	15	23.17	10	23.65	12	20.86	14	23.66	9	22.45	12
Average, all varieties	24.70	----	20.76	----	23.45	----	24.00	----	21.67	----	23.86	----	22.93	----
Difference required, odds 99 : 1	1.04	----	1.44	----	2.33	----	1.28	----	1.09	----	1.51	----	1.54	----

from moisture-free acid-delinted cottonseed, 12 to 15 locations, 1935-37

Location—Continued																Varietal average, all locations	
Stillwater, Okla.		Florence, S. C.		Jackson, Tenn.		Knoxville, Tenn.		College Station, Tex.		Greenville, Tex.		Lubbock, Tex.		Brazos Valley, Tex.			
Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
24.46	11	23.02	7	23.14	3	22.66	8	23.42	6	22.74	15	24.06	12	------	------	22.78	10
24.27	13	22.34	14	22.27	13	22.17	11	21.95	15	23.30	13	23.74	1[illegible]	------	------	22.20	15
25.26	2	23.06	6	22.62	9	21.85	14	23.05	10	23.66	10	24.69	5	------	------	22.78	11
24.67	8	22.09	15	22.66	8	22.27	10	21.77	16	22.65	16	24.15	10	------	------	22.30	13
24.50	10	22.85	9	22.70	7	22.95	7	23.56	4	24.40	6	23.44	15	------	------	22.99	6
25.15	4	23.34	4	22.54	10	23.51	2	24.37	3	24.47	5	24.60	6	------	------	23.35	3
23.75	16	22.05	16	22.37	12	21.76	15	22.26	13	23.02	14	23.54	14	------	------	21.82	16
25.04	5	23.65	3	24.10	2	23.50	3	25.02	1	24.26	7	25.41	2	------	------	23.80	2
26.59	1	24.24	1	24.42	1	24.02	1	25.34	2	25.50	1	25.70	1	------	------	24.57	1
24.81	6	24.01	2	22.94	6	23.05	5	23.27	8	24.50	4	24.92	4	------	------	23.33	4
23.76	15	22.77	10	22.01	15	21.87	13	23.05	11	24.11	8	25.00	3	------	------	22.98	7
25.19	3	22.92	8	21.99	16	22.06	6	23.46	5	24.89	3	24.41	8	------	------	22.93	8
24.30	12	22.67	12	23.09	4	23.22	4	23.20	9	24.00	9	24.50	7	------	------	23.03	5
24.26	14	22.38	13	22.49	11	21.60	16	22.20	14	23.49	12	23.32	16	------	------	22.29	14
24.55	9	23.25	5	22.24	14	22.64	9	22.71	12	25.05	2	24.14	11	------	------	22.75	12
24.71	7	22.71	11	23.00	5	22.01	12	23.34	7	23.61	11	24.29	9	------	------	22.88	9
24.71	------	22.98	------	22.79	------	22.63	------	23.31	------	23.98	------	24.37	------	------	------	22.92	------
1.22	------	.97	------	1.42	------	1.00	------	1.15	------	.93	------	.87	------	------	------	32	------
23.55	14	22.48	7	24.42	8	22.62	5	21.85	13	23.66	10	24.39	11	------	------	23.13	10
24.26	11	21.30	15	23.52	15	21.67	15	21.77	14	23.34	14	24.24	12	------	------	22.67	15
25.31	7	21.86	11	24.46	7	23.05	2	23.26	4	23.66	11	24.96	6	------	------	23.41	8
25.35	9	21.01	16	24.50	6	21.54	16	22.26	10	23.52	12	24.95	7	------	------	23.05	11
24.60	10	22.71	5	24.01	10	21.77	14	23.01	6	24.14	6	24.05	15	------	------	23.18	9
25.40	3	22.60	6	25.50	3	22.10	12	23.79	2	24.12	7	25.05	5	------	------	23.81	2
25.25	8	21.52	14	23.57	14	21.81	13	21.55	15	24.21	5	23.34	16	------	------	22.43	16
25.17	9	22.37	8	24.16	9	22.74	4	22.69	7	23.97	8	25.95	2	------	------	23.68	3
27.19	1	24.29	1	25.66	2	24.35	1	24.44	1	25.64	1	26.00	1	------	------	25.01	1
24.07	13	23.01	4	25.87	1	22.61	6	22.15	11	24.46	3	25.51	3	------	------	23.68	4
22.09	16	23.15	3	22.81	16	22.85	3	21.44	16	21.35	16	25.14	4	------	------	23.01	12
25.30	5	22.35	9	23.90	12	22.17	11	22.66	9	24.30	4	24.54	10	------	------	23.42	7
25.67	2	22.05	10	24.84	5	22.50	6	23.32	3	24.50	2	24.92	8	------	------	23.03	5
24.22	12	21.81	12	23.02	11	22.56	7	21.92	12	23.45	13	24.19	13	------	------	22.72	14
25.40	4	23.30	2	25.26	4	22.27	10	23.11	5	23.82	9	24.00	9	------	------	23.55	6
23.45	15	21.79	13	23.07	13	22.46	9	22.07	8	22.89	15	24.14	14	------	------	22.89	13
24.77	------	22.35	------	24.39	------	22.44	------	22.02	------	23.82	------	24.77	------	------	------	23.33	------
1.18	------	1.00	------	1.75	------	1.62	------	1.68	------	1.40	------	1.11	------	------	------	.39	------
26.20	13	22.27	9	23.29	10	23.15	15	24.10	14	25.82	4	22.04	16	24.10	11	23.42	10
26.95	9	21.30	16	22.51	14	22.70	16	24.40	13	25.17	11	22.74	13	24.04	12	23.11	15
26.76	11	22.12	10	23.98	4	23.95	10	25.07	7	25.49	7	23.91	8	25.05	3	23.75	8
26.89	10	21.71	13	22.29	15	23.72	11	25.09	6	24.95	12	23.27	10	24.11	10	23.23	14
25.24	15	22.30	8	23.06	5	24.69	3	24.77	9	24.01	14	22.25	14	23.64	15	23.40	11
28.01	2	23.17	3	24.51	2	24.41	6	25.29	3	25.60	5	25.14	2	24.74	6	24.23	3
27.06	6	21.34	15	22.02	16	23.31	14	24.46	12	24.95	13	22.09	15	23.70	14	22.77	16
27.32	4	22.76	5	23.70	8	24.34	7	25.00	8	25.90	2	24.70	4	25.07	2	24.49	2
28.34	1	23.81	1	25.51	1	26.84	1	27.25	1	26.92	1	25.25	1	27.31	1	25.59	1
26.46	12	22.32	7	24.10	3	24.06	9	24.69	10	25.25	10	24.15	6	24.84	5	24.05	6
24.80	16	23.51	2	22.67	13	24.60	4	22.79	16	24.06	16	23.02	12	24.25	7	23.49	9
27.55	3	22.47	6	23.09	12	25.67	2	25.15	5	25.71	3	25.09	3	24.21	8	24.19	4
27.31	5	22.04	11	23.47	9	24.34	8	25.23	4	25.34	8	23.65	9	25.04	4	23.83	7
26.96	8	21.41	14	23.90	6	23.37	13	24.54	11	24.45	15	23.07	11	23.55	16	23.28	13
27.01	7	23.01	4	23.77	7	24.54	5	25.91	2	25.50	6	24.17	5	24.19	9	24.18	5
26.16	14	21.75	12	23.17	11	23.51	12	23.73	15	25.29	9	23.98	7	23.79	13	23.30	12
26.82	------	22.33	------	23.50	------	24.21	------	24.84	------	25.33	------	23.66	------	24.48	------	23.77	------
1.17	------	1.39	------	1.76	------	1.42	------	1.23	------	1.11	------	1.66	------	1.18	------	.38	------

at odds of 99 to 1. Absence of a bracket for any two contributors indicates that the respective mean squares are not significantly different, or that the comparison has no interpretive interest. *F* values, found and required, for each contributor when tested against error are shown in columns 5 and 6. These, together with the brackets in the last column, provide a convenient basis for examining each of the detailed comparisons.

Percentage of Protein

Protein analyses were made on all samples for which percentage of oil was determined, and, consequently, protein data are available to parallel all oil analyses.

The varietal means and rank for percentage of protein for all years of the regional cotton variety study are summarized by locations in table 5. The locational means for 1935 ranged from 24.71 to 20.68 for Oklahoma and North Carolina, respectively, and as a result many significant differences in percentage of protein are established among locations. A comparison of locational rank for percentage of protein with the similar rank for percentage of oil shows that in general there is a tendency for a reversal of order, due to the association of oil and protein content as influenced by environment.

The range in varietal means for protein at all locations in 1935 was from 24.57 to 21.82 percent, this range being slightly less than the corresponding difference among locations. A comparison of varietal rank at all places with the corresponding rank at individual locations shows a general tendency for agreement. A comparison of the varietal rank for percentage of protein with the comparable varietal rank for percentage of oil, as shown in table 1, reveals little tendency for association of oil and protein.

For 1936 the varietal means and rank for percentage of protein are summarized by locations in the second section of table 5. The mean of all varieties at all locations for 1936 significantly exceeded the comparable mean for the previous year, the differences being 0.41 percent. The range in location means for 1936, 25.61 to 20.46 percent, for Louisiana and Georgia, respectively, slightly exceeded the range in the previous year, and many cases of significant differences among the locational comparisons may be established. A comparison of the locational rank and means for 1936 with those for 1935 shows little agreement, and this indicates that percentage of protein is largely determined by prevailing seasonal conditions rather than geographic location or soil type. The range in varietal means for all locations in 1936 was 25.01 to 22.43 percent, and a comparison of the varietal rank in 1936 with that in 1935 shows reasonably good agreement between the 2 seasons. This agreement suggests that percentage of protein is primarily a characteristic of the variety and that the rank of the same set of varieties at different places is likely to be similar.

For 1937 the varietal means and rank for percentage of protein are summarized by locations in the third section of table 5. The average protein content was slightly higher in 1937 than in the 2 preceding years, but the range in varietal means was substantially the same as in 1935 and only slightly greater than in 1936. The range in locational means was 6.06, in contrast with 5.15 and 4.03, respectively, in the 2 previous years. The variation among stations was somewhat less for protein than for percentage of oil. The varietal rank for 1937 was reasonably consistent with that for the 2 preceding years, both as an average of all locations and for individual locations. The agreement in rank suggests that varietal differences tend to be consistent for a group of varieties when grown under a wide range of soil and weather conditions.

A summary of the analysis of variance for percentage of protein, by locations in each of the 3 years, is shown in table 6.

TABLE 6.—*Summary of mean squares for analysis of variance on percentage of protein from 4-lock-boll samples*

Year and location	Mean squares				
	Total	Varieties	Series	Ranges	Error
1935					
Arkansas, Marianna:					
Delta	1.430	4.980	7.637	0.612	0.501
Upland	1.059	1.984	2.589	1.743	.774
Louisiana, Baton Rouge	1.481	5.653	2.777	1.016	.783
Mississippi, Stoneville	2.426	8.298	12.842	1.540	.846
North Carolina, Statesville	1.927	8.319	2.967	3.349	.773
Oklahoma, Stillwater [1]	1.618	3.608	8.496		.867
South Carolina, Florence	1.152	2.456	5.055	.824	.544
Tennessee:					
Jackson	1.468	3.763	.941	1.277	1.168
Knoxville	1.103	4.231	1.382	1.484	.577
Texas:					
College Station	2.357	10.253	8.914	1.137	.767
Greenville	1.233	5.458	2.679	1.012	.499
Lubbock	.990	3.754	2.241	1.609	.433
1936					
Alabama, Prattville	1.601	3.619	.690	3.882	1.194
Arkansas, Marianna:					
Delta	1.822	6.139	3.093	.499	1.123
Upland	2.279	4.346	3.593	4.009	1.745
Georgia, Experiment	1.800	4.904	2.011	4.484	1.104
Louisiana, Baton Rouge	1.823	5.732	3.335	1.413	1.146
Mississippi, Stoneville	3.140	6.180	24.570	1.229	1.201
North Carolina, Statesville	1.415	5.021	1.018	2.043	.846
Oklahoma, Stillwater [1]	2.370	10.880	7.583		.807
South Carolina, Florence	2.062	5.572	5.405	1.799	1.305
Tennessee:					
Jackson	2.443	6.042	2.393	4.303	1.765
Knoxville	1.898	3.631	3.147	2.366	1.510
Texas:					
College Station	2.313	5.698	3.696	3.071	1.641
Greenville	1.969	6.585	1.930	1.633	1.290
Lubbock	1.296	4.639	3.169	1.719	.712
1937					
Alabama, Prattville	1.224	4.011	4.633	.297	.620
Arkansas, Marianna:					
Delta	2.430	8.231	8.263	1.301	1.207
Upland	3.802	5.355	8.601	4.913	3.136
Georgia, Experiment	1.781	7.250	2.248	1.310	.944
Louisiana, Baton Rouge	1.579	5.090	7.677	.374	.692
Mississippi, Stoneville	3.341	6.952	26.814	.471	1.317
North Carolina, Statesville	2.100	5.859	2.713	3.506	1.380
Oklahoma, Stillwater [1]	1.560	6.605	2.310		.789
South Carolina, Florence	1.679	4.651	3.291	1.677	1.110
Tennessee:					
Jackson	2.286	6.280	1.925	1.120	1.783
Knoxville	2.214	8.032	4.294	2.275	1.170
Texas:					
College Station	1.780	7.469	1.540	2.586	.869
Greenville	1.607	3.276	1.732	.649	.712
Lubbock	2.767	9.212	4.406	3.554	1.603
Brazos Valley	1.497	6.696	.525	.957	.809
Degrees of freedom	127	15	7	7	98
Do. [1]	127	15	7		105

[1] Experiment planted in 8 randomized blocks.

A comparison of the mean squares for varieties with error shows that significant differences were established among varieties at all places in each year. This finding indicates that varietal characteristics with regard to percentage of protein are distinct at the various locations and that genetic differences with respect to percentage of protein undoubtedly exist. The contribution for series and ranges reached significance at many locations, and this offers substantial evidence that ecological responses associated with position of individual blocks in the experimental field were sufficient to modify significantly the percentage of protein.

A comparison of error variance for the different station years indicates that residual variance tended to be reasonably consistent, although one or more locations in each year were considerably higher than the average, but it will be noted that the high variance locations usually were not the same in different years. In general, error variance was somewhat greater in 1936 and 1937 than in 1935, and in this respect the protein analyses coincided with the similar analyses on oil content. Apparently the factors responsible for heterogeneity in protein content were the same as or similar to those causing high residual variance in oil analyses if judged as seasonal averages, but this agreement is not apparent for individual stations in any one year. Some agronomic information of interest may be drawn from a comparison of the relative contribution for series and ranges for the 3 separate years at individual locations. Such comparisons show that series and ranges fail in many cases to exert similar effects in successive years. This indicates differential plant response for various parts of the same experimental area in succeeding years.

Analysis of variance for percentage of protein at the 11 locations in 1935, 13 locations in 1936, and 14 locations in 1937 appropriate for combination is shown in table 7. These analyses are similar to those on oil, in that locational differences are the highest contributors in each year and are significantly greater than differences among varieties. The variance for varieties was very high in comparison with error and offers indisputable evidence that varieties differ with respect to characteristic protein content. Differ-

TABLE 7.—*Analysis of variance of data from 11 locations in 1935, of 13 in 1936, and of 14 in 1937, for percentage of protein from 4-lock-boll samples*

Source of variation	1935			1936			1937		
	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]
Varieties	15	39.35		15	37.05		15	54.65	
Locations	10	207.00		12	307.27		13	206.53	
Varieties × locations	150	2.07		180	2.49		195	2.60	
Series within locations	77	4.55		91	4.51		98	5.62	
Ranges within locations	77	1.42		91	2.50		98	1.78	
Error	1,078	.70		1,274	1.20		1,372	1.24	
Total	1,407	2.97		1,663	4.19		1,791	3.50	

[1] See footnote 1, table 3.

ences among varieties greatly exceeded the differential response of varieties to different places as measured by varieties × locations. The interaction was significantly greater than error, and consequently it may be concluded that in certain cases varieties responded differentially to environmental conditions, but such response was minor in comparison with varietal differences. These data, therefore, indicate that percentage of protein is fundamentally a varietal characteristic, although one that may be modified very greatly by ecological conditions.

The contributions for series within locations and for ranges within locations offer good evidence that soil variations in the experimental block were usually sufficient to produce significant differences in the percentage of protein.

An analysis of variance for the combined data on percentage of protein from the 11 locations where studies were conducted on the same block of land for 3 years is shown in table 8. The order of major contributing factors is location, season, location × season, and variety. Among these contributors the only significant difference is that between location and variety. Considering location, season, and location × season as all components of environment, it is evident that the total environmental effect greatly exceeds varietal differences and consequently the average protein percentage in any one year is very largely dependent on the seasonal conditions prevailing.

Despite the dominant effect of environment, varietal differences are great and distinctly more important than the differential response of variety to any ecological factors. This establishes the fact that protein content is fundamentally dependent on genetic constitution.

Detailed comparisons among main effects and between these and interactions may be identified in the last column of table 8. Considering all the evidence it is clear that percentage of protein is generally dependent to a greater extent on environmental factors

TABLE 8.—*Analysis of variance of data from 11 locations for percentage of protein from 4-lock-boll samples, 1935-37*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F Found	F Required odds 99:1	Significant comparisons[1]
Varieties	15	1,620.08	108.01	96.28	2.09	
Locations	10	3,733.66	373.00	333.09	2.34	
Seasons	2	331.15	165.58	147.60	4.62	
Varieties × locations	150	526.44	3.51	3.13	1.38	
Varieties × seasons	30	99.69	3.32	2.96	1.71	
Locations × seasons	20	3,208.31	160.42	143.00	1.89	
Varieties × locations × seasons	300	596.15	1.99	1.77	1.28	
Series within locations	77	718.05	9.34	8.32	1.44	
Seasons × series within locations	154	522.31	3.39	3.02	1.38	
Ranges within locations	77	200.65	3.30	3.02	1.44	
Seasons × ranges within locations	154	174.19	1.13	1.01	1.38	
Error	3,234	3,627.96	1.12			
Total	4,224	15,419.54	3.65			

[1] See footnote 1, table 3.

TABLE 9.—*Varietal means and rank for percentage of fuzz, as determined*

Year and variety	Location													
	Prattville, Ala.		Marianna, Ark.				Experiment, Ga.		Baton Rouge, La.		Stoneville, Miss.		Statesville, N. C.	
			Delta		Upland									
1935	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
Acala (Roger)			13.04	13	11.33	14			11.79	15	9.75	14	6.67	15
Arkansas 17			14.22	8	11.05	15			13.92	10	11.89	10	6.09	14
Cleveland (W)			15.13	3	13.80	3			17.67	4	15.32	3	10.80	3
Cook 912			14.90	4	13.03	7			13.95	9	13.26	6	8.85	7
Delfos 4			14.37	7	12.15	11			15.09	8	13.60	5	8.19	9
Deltapine			13.08	12	12.01	12			15.68	6	10.63	13	7.05	11
Dixie Triumph 759			12.75	14	12.30	10			12.39	14	9.73	15	6.75	13
Farm Relief			16.63	2	17.10	1			21.61	1	19.40	1	11.46	1
Half and Half			12.46	15	13.06	6			18.00	3	11.23	12	6.91	12
Mexican Big Boll			13.64	11	13.20	5			15.18	7	14.30	4	9.62	4
Qualla			14.44	5	13.41	4			15.70	5	12.31	8	9.25	5
Rowden 2088			17.48	1	16.86	2			19.45	2	16.83	2	11.20	2
Startex 619			12.02	16	12.42	9			11.61	16	9.20	16	6.53	16
Stoneville 5			14.07	9	11.41	13			13.86	11	12.92	7	8.58	8
Triumph 44			13.90	10	12.49	8			13.45	12	12.02	9	9.09	6
Wilds 5			14.44	6	10.76	16			13.12	13	11.39	11	7.13	10
Average, all varieties			14.22		12.90				14.77		12.75		8.43	
Difference req., odds 99 : 1			2.21		2.22				1.76		2.58		2.35	
1936														
Acala (Roger)	12.06	14	8.93	15	11.77	14	16.00	4	13.29	13	12.97	14	8.56	15
Arkansas 17	10.56	16	10.60	8	11.29	16	12.84	13	13.79	10	13.44	12	9.38	11
Cleveland (W)	16.23	4	11.80	5	15.45	4	16.47	3	16.95	3	16.84	5	12.13	3
Cook 912	14.78	6	10.32	11	13.39	10	15.91	5	13.66	11	14.65	10	9.64	9
Delfos 4	14.86	5	11.49	7	13.74	8	13.94	10	14.97	6	16.86	4	9.26	12
Deltapine	13.56	8	10.53	9	13.45	9	13.96	9	14.10	8	15.61	8	11.60	4
Dixie Triumph 759	12.57	12	9.02	14	12.20	13	12.03	14	12.20	16	12.34	16	9.75	8
Farm Relief	17.87	2	16.25	1	20.76	1	20.44	2	21.75	1	21.87	1	13.28	2
Half and Half	12.73	11	9.32	12	12.62	12	11.82	15	12.27	15	13.35	13	9.52	10
Mexican Big Boll	16.73	3	12.82	4	16.34	3	14.67	6	15.74	4	17.67	3	11.64	5
Qualla	14.67	7	13.06	3	15.39	5	14.73	7	15.74	5	15.72	6	10.81	6
Rowden 2088	18.43	1	15.38	2	19.41	2	20.99	1	16.70	2	20.44	2	13.06	1
Startex 619	10.59	15	9.04	13	11.60	15	11.55	16	12.47	14	12.51	15	8.03	16
Stoneville 5	12.95	10	10.44	10	14.24	6	13.10	12	13.56	12	15.12	9	9.13	14
Triumph 44	13.01	9	11.88	6	13.32	11	14.55	8	14.77	7	15.64	7	9.20	13
Wilds 5	12.17	13	8.66	16	13.86	7	13.49	11	13.92	9	13.61	11	9.94	7
Average, all varieties	14.01		11.23		14.30		14.80		14.92		15.54		10.36	
Difference required, odds 99 : 1	3.19		2.74		2.32		3.93		1.48		1.96		3.14	
1937														
Acala (Roger)	13.64	14	10.83	15	11.38	16	14.25	14	12.29	13	12.88	15	9.95	16
Arkansas 17	14.46	11	12.05	12	12.00	13	15.52	11	12.46	12	13.85	12	12.49	11
Cleveland (W)	17.25	5	16.48	3	17.57	3	18.65	4	17.19	4	17.72	4	15.05	3
Cook 912	14.92	10	11.05	13	14.34	8	15.82	10	14.44	9	14.47	11	13.72	9
Delfos 4	18.88	3	14.96	5	13.95	10	17.64	6	14.48	7	16.33	5	13.89	8
Deltapine	16.10	7	14.85	6	14.60	7	17.76	5	14.46	8	15.97	7	14.18	6
Dixie Triumph 759	14.00	12	12.42	10	12.34	14	14.08	16	11.85	15	12.89	14	11.99	13
Farm Relief	24.39	1	21.73	1	20.21	1	23.09	1	20.99	1	24.12	1	18.57	2
Half and Half	13.28	15	11.62	14	12.70	12	14.86	13	11.64	16	13.54	13	13.33	12
Mexican Big Boll	15.19	8	15.31	4	14.75	6	17.13	7	17.86	3	16.04	6	13.92	7
Qualla	18.43	4	13.94	8	14.83	5	18.89	3	14.76	6	18.83	3	14.76	5
Rowden 2088	21.56	2	19.62	2	19.48	2	21.39	2	18.27	2	20.36	2	19.00	1
Startex 619	12.54	16	10.67	16	11.65	15	14.11	15	12.03	14	12.80	16	11.05	14
Stoneville 5	15.14	9	13.59	9	14.11	9	15.03	12	13.42	11	15.63	8	12.71	10
Triumph 44	16.86	6	14.15	7	15.32	4	15.64	9	16.17	5	15.63	9	14.91	4
Wilds 5	13.71	13	12.39	11	12.74	11	16.02	8	13.67	10	15.09	10	10.69	15
Average, all varieties	16.27		14.16		14.54		16.88		14.75		16.01		13.70	
Difference required, odds 99 : 1	2.37		2.32		2.15		2.16		2.30		2.44		1.53	

from moisture-free acid-delinted cottonseed, 12 to 15 locations, 1935-37

Location—Continued																Varietal average, all locations	
Stillwater, Okla.		Florence, S. C.		Jackson, Tenn.		Knoxville, Tenn.		College Station, Tex.		Greenville, Tex.		Lubbock, Tex.		Brazos Valley, Tex.			
Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
10.21	14	10.09	15	10.18	12	10.58	11	13.08	12	12.38	11	12.51	13	----	----	10.97	12
10.10	15	9.16	16	10.00	13	8.79	13	12.36	14	10.56	15	11.79	14	----	----	10.89	13
12.82	6	13.19	7	13.15	5	11.80	6	14.59	6	13.91	8	13.84	7	----	----	13.84	4
10.85	13	11.61	10	10.20	11	11.64	8	13.77	9	11.31	12	12.89	9	----	----	12.15	10
11.85	8	14.19	4	12.23	7	11.00	9	14.49	7	17.01	3	14.25	6	----	----	13.20	6
11.21	10	12.56	9	12.40	6	12.32	4	13.26	11	14.09	7	15.28	4	----	----	12.57	8
10.97	12	11.20	12	9.01	16	9.26	12	14.29	8	10.86	13	10.59	15	----	----	10.84	15
15.12	2	16.62	1	17.77	1	19.44	1	15.24	3	20.92	1	17.81	2	----	----	17.43	1
12.16	7	10.88	13	9.90	14	8.56	14	12.14	15	12.78	10	12.70	12	----	----	11.23	11
13.54	3	14.43	3	13.78	4	11.64	7	15.68	2	14.94	6	14.50	5	----	----	13.73	5
13.35	4	14.47	2	14.29	3	16.44	2	15.18	4	16.86	4	16.59	3	----	----	14.29	3
15.75	1	14.65	5	17.68	2	16.11	3	17.26	1	20.08	2	20.05	1	----	----	16.90	2
11.58	9	11.41	11	10.48	10	8.35	16	12.00	16	9.45	16	12.76	11	----	----	10.65	16
11.07	11	12.81	8	9.73	15	11.92	5	13.74	10	12.92	9	13.36	8	----	----	12.20	9
12.97	5	13.35	6	11.49	9	10.61	10	14.66	5	15.28	5	13.83	10	----	----	12.63	7
9.07	16	10.44	14	12.05	8	8.37	15	12.71	13	10.08	14	9.94	16	----	----	10.89	14
12.08	----	12.53	----	12.16	----	11.64	----	14.02	----	13.00	----	13.86	----	----	----	12.78	----
2.47	----	3.84	----	2.84	----	2.49	----	2.42	----	4.05	----	2.78	----	----	----	.82	----
17.70	8	13.40	13	13.05	15	12.06	16	10.94	15	14.83	9	15.80	11	----	----	12.06	13
17.11	10	12.49	10	14.09	12	12.84	12	11.72	12	13.76	13	15.54	12	----	----	12.82	14
20.72	4	17.61	3	16.87	5	10.18	3	13.88	6	16.31	4	20.00	5	----	----	10.47	3
17.11	11	15.44	5	13.06	14	14.15	10	12.53	9	15.00	8	18.08	8	----	----	14.23	8
19.66	5	14.64	7	14.08	13	15.97	6	14.14	5	15.43	6	20.29	3	----	----	14.05	6
18.50	6	14.89	6	15.39	7	15.13	7	13.87	7	14.60	10	20.20	4	----	----	14.08	7
10.60	13	12.05	15	12.42	16	12.07	15	10.89	16	12.56	16	15.20	14	----	----	12.35	15
21.87	2	20.65	1	24.47	1	24.11	1	21.20	1	19.48	2	25.76	1	----	----	20.70	1
17.01	12	13.00	11	14.95	9	14.53	9	11.01	14	13.57	14	15.36	13	----	----	13.00	12
17.77	7	16.47	4	17.87	4	16.98	5	15.00	4	15.24	7	18.70	7	----	----	16.09	5
20.80	3	13.55	12	18.70	3	17.10	4	17.14	3	18.29	3	19.11	6	----	----	10.06	4
23.02	1	18.05	2	21.84	2	19.88	2	18.54	2	19.63	1	25.42	2	----	----	19.64	2
14.15	16	14.06	10	14.14	11	12.55	14	11.28	13	14.46	11	14.79	15	----	----	12.35	10
16.20	15	14.24	8	15.30	8	14.87	8	11.82	11	14.12	12	18.15	9	----	----	13.81	10
17.22	9	14.20	9	14.63	10	13.64	11	12.23	10	16.13	5	17.90	10	----	----	14.17	9
16.29	14	13.45	14	10.01	6	12.76	13	13.56	8	13.34	15	11.45	16	----	----	13.04	11
18.24	----	15.04	----	16.11	----	15.49	----	13.73	----	15.42	----	18.28	----	----	----	14.82	----
4.02	----	3.42	----	2.35	----	2.60	----	3.36	----	2.43	----	2.77	----	----	----	.77	----
12.71	15	11.03	15	14.20	10	11.77	15	10.67	14	16.03	14	12.32	14	14.07	15	13.04	15
13.14	14	13.97	8	16.68	10	12.91	11	17.05	12	17.34	12	15.07	11	15.59	13	14.35	11
16.61	6	15.66	3	18.72	5	15.81	4	20.72	3	20.76	4	16.37	7	19.30	4	17.59	3
15.13	8	13.68	9	16.80	9	14.87	9	18.59	7	18.73	8	16.54	5	16.78	12	15.39	9
16.59	7	14.83	4	17.47	8	15.39	8	18.40	8	19.51	6	19.50	3	18.50	6	10.70	6
13.41	13	14.44	6	17.55	7	15.70	6	18.20	9	18.97	7	18.19	4	17.25	9	16.11	8
14.67	9	13.63	10	15.30	14	12.49	13	16.69	13	16.15	16	13.27	13	15.25	14	13.79	14
18.94	2	18.82	1	23.24	1	21.60	1	23.71	1	26.24	1	23.71	1	25.31	1	22.31	1
14.18	11	12.77	13	16.13	12	12.76	12	10.63	15	16.93	13	13.40	12	16.81	11	13.07	13
17.70	5	14.77	5	20.07	3	15.58	6	20.04	4	19.56	5	15.43	9	20.18	3	16.94	5
17.87	4	14.34	7	18.79	4	18.00	3	20.50	5	21.72	3	16.48	6	19.10	5	17.42	4
23.03	1	17.13	2	22.67	2	20.81	2	23.49	2	25.03	2	22.08	2	24.00	2	21.20	2
11.92	16	10.65	16	14.67	15	11.37	16	15.92	10	16.28	15	11.90	15	13.88	10	12.77	10
14.35	10	13.61	11	16.59	11	13.75	10	17.14	11	18.40	10	15.32	10	17.01	10	15.05	10
18.77	3	13.42	12	17.66	6	15.58	7	18.87	6	18.31	11	15.98	8	18.20	8	16.38	7
14.16	12	11.98	14	15.79	13	11.92	14	17.54	10	18.70	9	11.18	10	18.45	7	14.27	12
15.82	----	14.05	----	17.00	----	15.02	----	18.80	----	16.33	----	16.05	----	18.18	----	16.06	----
3.38	----	2.35	----	2.18	----	2.13	----	2.35	----	1.85	----	3.00	----	1.70	----	.59	----

than on varieties, but varietal differences are very large and tend to be consistent among locations and in different seasons at the same location. Consequently, any improvement in protein content among breeding stocks is likely to be consistent in production and of material economic value.

PERCENTAGE OF FUZZ

Percentage of fuzz was determined for all samples from which oil and protein data were obtained. In calculating this percentage, the loss in weight between the fuzzy and acid-delinted seed was divided by the weight of delinted seed and converted to a percentage basis, all weights being on an oven-dry basis.

A summary of varietal means and rank by locations for percentage of fuzz in 1935 is shown in the first section of table 9. The range in location means was rather wide, 14.77 to 8.43 percent, for Louisiana and North Carolina, respectively. No definite association of amount of fuzz with any element of weather conditions is evident. The range in varietal means, 17.43 to 10.65, indicates that large differences exist among the varieties included in the study. A comparison of varietal rank at all locations with the corresponding rank at individual locations shows a fairly close agreement, indicating that amount of fuzz is definitely a varietal characteristic.

For 1936 the varietal means and rank for percentage of fuzz are shown in the second section of table 9. The mean of all tests for 1936 was approximately 2 percent higher than in 1935. The range in locational means, 18.28 to 10.36, for Lubbock, Tex., and North Carolina, respectively, was somewhat wider than in the preceding year, and many significant comparisons may be identified among locations. A comparison of locational rank for 1936 with that for the previous year shows little agreement.

The range in varietal means for 1936 was 20.70 to 12.25 percent, and many significant differences occurred among varieties. A comparison of the varietal rank at all locations for 1936 with the comparable rank for the preceding year shows a rather close agreement, indicating that varieties responded consistently in the 2 years. A comparison of the varietal rank at all locations with individual locations shows a tendency for agreement, although some failures are evident. This indicates that percentage of fuzz is definitely a varietal characteristic, although differental response may be identified occasionally.

For 1937 a summary of the varietal means and rank by location for percentage of fuzz is shown in the third section of table 9. The mean of all locations, 16.08, was approximately 1.3 percent higher than in 1936 and 3.3 percent higher than in 1935. It is evident therefore that the amount of fuzz may vary considerably among seasons, depending on the prevailing weather conditions. The range in locational means, from 18.80 to 13.70, for College Station, Tex., and North Carolina, respectively, was somewhat less than in the 2 previous years. A comparison of the ranks of locations in the 3 years shows little consistency, and this indicates that modifications in amount of fuzz seem to depend to a greater extent on prevailing weather conditions than on soil type or place of growth.

The range in varietal means, 22.31 to 12.77, was slightly greater than those found in the 2 preceding years, but the rank of varieties at all locations was reasonably similar in the 3 seasons. These findings indicate that differences among varieties are undoubtedly genetic in nature and that these genetic differences tend to be expressed similarly under a wide range of environmental conditions. Comparisons between means of varieties for all locations and individual locations show rather good agreement and confirm the same relation found in the 2 preceding seasons.

A summary of the analysis of variance by individual locations and years for percentage of fuzz is shown in table 10. The mean

TABLE 10.—*Summary of mean squares for analysis of variance on percentage of fuzz from 4-lock-boll samples*

Year and location	Mean squares				
	Total	Varieties	Series	Ranges	Error
1935					
Arkansas, Marianna:					
Delta	5.068	15.902	13.912	4.439	2.823
Upland	6.001	26.330	4.953	7.638	2.847
Louisiana, Baton Rouge	12.207	63.365	57.043	2.502	1.797
Mississippi, Stoneville	15.882	59.783	102.304	3.554	3.864
North Carolina, Statesville	6.630	23.324	24.260	1.260	3.200
Oklahoma, Stillwater [1]	7.052	24.241	22.904	----------	3.535
South Carolina, Florence	11.934	31.255	20.056	9.361	8.511
Tennessee:					
Jackson	11.523	56.567	20.898	1.445	4.079
Knoxville	14.430	81.236	20.900	7.478	3.592
Texas:					
College Station	6.010	16.418	18.160	8.108	3.399
Greenville	21.470	89.040	57.112	9.114	9.465
Lubbock	15.499	53.800	94.878	8.334	4.478
1936					
Alabama, Prattville	10.840	44.431	6.876	12.600	5.894
Arkansas, Marianna:					
Delta	9.946	40.851	28.166	3.927	4.344
Upland	12.101	57.406	50.027	2.803	3.117
Georgia, Experiment	17.602	60.132	45.410	19.754	8.052
Louisiana, Baton Rouge	10.461	55.461	52.621	.624	1.265
Mississippi, Stoneville	13.108	59.702	75.813	2.770	2.226
North Carolina, Statesville	14.718	22.324	130.356	2.908	5.709
Oklahoma, Stillwater [1]	17.481	44.751	81.322	----------	9.320
South Carolina, Florence	11.814	40.133	28.173	5.603	6.754
Tennessee:					
Jackson	13.326	64.023	13.406	3.601	3.187
Knoxville	15.263	68.265	29.280	3.503	3.924
Texas:					
College Station	19.054	70.079	90.072	12.523	6.539
Greenville	10.817	35.357	69.636	3.017	3.417
Lubbock	20.255	111.354	44.261	22.512	4.435
1937					
Alabama, Prattville	13.507	83.096	2.034	1.181	3.248
Arkansas, Marianna:					
Delta	13.245	74.937	34.430	1.587	3.122
Upland	9.612	53.699	10.858	11.180	2.663
Georgia, Experiment	9.680	54.530	10.398	4.540	2.702
Louisiana, Baton Rouge	10.716	57.983	21.298	5.969	3.603
Mississippi, Stoneville	13.743	74.512	34.814	6.557	3.450
North Carolina, Statesville	7.564	50.110	9.175	2.248	1.356
Oklahoma, Stillwater [1]	16.028	67.652	46.654	----------	6.611
South Carolina, Florence	6.912	33.983	4.455	3.406	3.187
Tennessee:					
Jackson	9.116	52.860	10.620	3.603	2.750
Knoxville	14.829	74.124	70.712	2.424	2.648
Texas:					
College Station	8.727	45.837	14.425	1.004	3.192
Greenville	9.990	67.869	3.823	4.422	1.969
Lubbock	10.851	67.504	14.661	6.170	5.426
Brazos Valley	14.368	75.394	73.453	2.025	1.688
Degrees of freedom	127	15	7	7	98
Do. [1]	127	15	7	----------	105

[1] Experiment planted in 8 randomized blocks.

TABLE 11.—*Analysis of variance of data from 11 locations in 1935, of 13 in 1936, and of 14 in 1937, for percentage of fuzz from 4-lock-boll samples*

Source of variation	1935			1936			1937		
	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]
Varieties	15	398.53		15	652.67		15	814.44	
Locations	10	393.12		12	522.85		13	435.08	
Varieties × locations	150	11.85		180	9.82		195	6.31	
Series within locations	77	40.41		91	51.55		98	24.25	
Ranges within locations	77	5.88		91	7.37		98	3.98	
Error	1,078	4.42		1,274	4.60		1,372	2.80	
Total	1,407	14.24		1,663	17.47		1,792	14.43	

[1] See footnote 1, table 3.

square for varieties was significantly greater than error at all individual locations in each of the years. Similar comparisons of mean squares for series and ranges with error show that significant contributions occurred at many locations, and this may be interpreted as indicating that soil variation within experimental blocks was sufficient to modify significantly the amount of fuzz. In numerous instances the contribution for series was of the same order as for varieties, and this shows that the amount of fuzz may be modified greatly by soil variation within distances of not more than 800 feet in experimental blocks. This indicates that substantial differences in seed covering may be expected within the same field under average production conditions.

Error varies considerably among station years, and a comparison of the same locations in the 3 seasons indicates little consistency from year to year on the same block of land. It is therefore evident that heterogeneity in fuzz percentage is frequently due to the differential response of single plots to seasonal conditions in successive years.

Analysis of variance for combined data from 11 locations in 1935, 13 locations in 1936, and 14 locations in 1937 for percentage of fuzz is shown in table 11. These analyses show that the contributions for varieties and locations are very large in each year but not significantly differentiated in any season. Varieties × locations was significantly exceeded by both main effects (varieties and locations) and was significant when tested against error.

An analysis of variance for combined data on percentage of fuzz for 11 locations and the 3 years is shown in table 12. The numerical rank of mean squares for major contributors to variance was season, variety, location, and location × season. No significant differences exist among the three main effects or between locations and locations × seasons. All other main-effect and interaction comparisons are highly significant, as is indicated by the brackets in the last column. The high variance for the three contributors representing ecological factors establishes the fact that percentage of fuzz may be modified greatly by prevailing weather conditions and perhaps by differences in soil type represented by locations.

TABLE 12.—*Analysis of variance of data from 11 locations for percentage of fuzz from 4-lock-boll samples, 1935-37*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F		Significant comparisons[1]
				Found	Required odds 99:1	
Varieties	15	23,406.78	1,560.45	407.41	2.09	
Locations	10	8,979.01	897.90	234.43	2.34	
Seasons	2	6,323.38	3,101.69	825.46	4.03	
Varieties × locations	150	2,046.07	13.04	3.56	1.38	
Varieties × seasons	30	397.70	13.26	3.46	1.71	
Locations × seasons	20	6,125.53	306.28	79.96	1.89	
Varieties × locations × seasons	300	2,144.74	7.15	1.87	1.28	
Series within locations	77	2,244.65	29.15	7.61	1.44	
Seasons × series within locations	154	6,796.58	44.13	11.52	1.38	
Ranges within locations	77	474.68	6.16	1.61	1.44	
Seasons × ranges within locations	154	762.60	4.95	1.29	1.38	
Error	3,234	12,386.02	3.83			
Total	4,224	72,088.60	17.07			

[1] See footnote 1, table 3.

The mean square for varieties exceeds by more than a hundredfold mean squares for all interactions with varieties, and it is therefore clearly evident that, although each interaction is significant when tested against error, the predominant tendency is for varieties to retain their relative rank when grown under widely varying conditions. It follows that new varieties with characteristic fuzz percentage and types of covering may be developed through breeding and may be expected to retain their relative amounts of fuzz in production.

The variances for series within locations and seasons × series within locations are highly significant over the entire study and indicate that differential plant response to soil differences within an experimental block of approximately 4 acres is usually sufficient to cause significant differences in fuzz percentage. By analogy, soil variations within a large-increase block or farmer's field may be expected to produce significant variations in amount of fuzz on the seed.

RELATION OF OIL TO PROTEIN CONTENT

Previous publications have called attention to a negative relationship of oil and protein content of cottonseed, and the studies reported here provide information on the fundamental relation involved. In most of the previous studies the effects of varieties and locations of growth could not be, or were not, examined separately.

In the present study the same 16 varieties were grown for 3 consecutive years at a large number of locations and, because of the resulting symmetry of the data, the effects of genetical and ecological factors may be examined separately. Station averages showed a lack of consistency in successive years at individual locations, and for this reason the various tests may be treated as

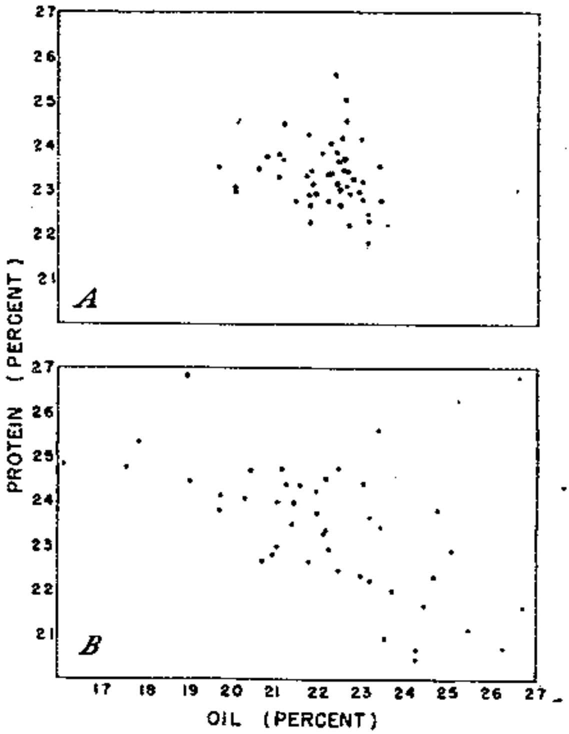

FIGURE 1.—Percentage of oil and protein in averages for (*A*) varieties for each season and (*B*) stations for each season.

"location years" and considered as a group instead of being separated into locations, years, and interaction.

A scatter diagram for varietal averages in each season shows clearly that no definite relation exists between percentages of oil and protein among the varieties included in this study (fig. 1, *A*).

A scatter diagram for locational averages in each season indicates a definite negative association of percentages of oil and protein in cottonseed (fig. 1, *B*).

These findings indicate that percentages of oil and protein, calculated on the basis of acid-delinted oven-dry seed weight, are substantially independent when considered on a varietal or genetic basis but are negatively associated when ecological factors are responsible for the differences being studied.

One practical implication of these findings is that selection for high oil and high protein content in a breeding program is likely to be successful in isolating lines high for both factors. The general study indicates that such lines may be expected to maintain their relative oil and protein levels under production, and consequently it seems logical that oil and protein should be added to the factors now used as a basis for selection in breeding work.

The negative association of percentages of oil and protein for location-year averages indicates that growth conditions favorable for a high oil content are conducive to a low protein percentage and vice versa. Little practical advantage is likely to result from these findings in the main Cotton Belt, where weather conditions are fortuitous. These findings do suggest, however, that studies of the effect of irrigation on oil and protein content may identify an irrigation schedule which will give a profitable increase of one of these constituents in cottonseed.

No correlation values are reported in this summary of results for the reason that oil and protein are associated also with lint index, seed index, and other variables.

LABORATORY STUDIES OF FIBER PROPERTIES[5]

Laboratory determinations of upper quartile length, mean length, and coefficient of length variability calculated on a weight-frequency basis from length arrays and tensile strength of fiber by the Chandler bundle method were made on both 4- and 5-lock-boll samples from 2 locations as a pilot study prior to scheduling the general fiber testing. The interactions, kinds of sample × varieties and kinds of sample × varieties × locations, did not differ from error, and consequently the general program of fiber testing was scheduled on 100 4-lock-boll samples only. Laboratory testing was largely completed on the 1935 samples but was interrupted before data were obtained on samples from the last 2 years of the regional cotton variety study.

UPPER QUARTILE LENGTH

The varietal means and rank for upper quartile length in 1935 are summarized by locations in the top section of table 13. Footnotes indicate locations where data were obtained from series 1 and 8 only and the one location where data were completed on series 1 to 5 and 8.

The locational averages for upper quartile length ranged from 1.16 to 1.00 inches, for Greenville, Tex., and Oklahoma, respectively, and the range among locations permits many significant differences to be established. Consequently, these data establish the fact that environmental conditions may modify upper quartile length to a marked degree.

An examination of the means and rank of varieties at all locations with the means and rank at individual locations indicates that in general there is a rather good agreement. Certain discrepancies may be identified, particularly in a proportionally greater shortening of long-staple varieties under such conditions of marked moisture deficiency as occurred at Stillwater, Okla., in 1935.

MEAN LENGTH

Varietal averages and rank for mean length are summarized by locations in the second section of table 13. The range in locational means was from 1.00 to 0.85 inches, for Mississippi and Oklahoma, respectively. A comparison of the locational rank for mean length with the similar rank for upper quartile length shows a general tendency for agreement, but several cases of failure were caused by unequal uniformity of the total fiber-length distribution.

[5] Fiber laboratory data were obtained through cooperative arrangements with the Cotton and Fiber Branch, Office of Marketing Services, War Food Administration, following the standard methods of procedure described in A.S.T.M. Standards on Textile Materials, prepared by Committee D-13. 1935.

TABLE 13.—*Varietal means and rank of fiber-length—upper quartile length,*

UPPER QUARTILE LENGTH

Variety	Prattville, Ala.[1]		Marianna, Ark. Delta[2]		Marianna, Ark. Upland[1]		Experiment, Ga.[1]		Baton Rouge, La.		Stoneville, Miss.		Statesville, N. C.	
	Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
Acala (Roger)	1.16	4	1.16	4	1.19	4	1.19	4	1.24	4	1.25	3	1.19	2
Arkansas 17	1.19	2	1.18	2	1.20	2	1.21	3	1.25	3	1.28	2	1.18	3
Cleveland (W)	.99	14	1.01	13	1.01	13	1.02	13	1.06	15	1.06	14	1.04	10
Cook 912	1.01	13	.98	15	1.00	14	1.01	15	1.09	11	1.06	15	1.03	13
Delfos 4	1.18	3	1.17	3	1.20	3	1.25	2	1.26	2	1.23	4	1.17	4
Deltapine	1.11	7	1.12	6	1.13	6	1.18	5	1.21	5	1.19	6	1.11	6
Dixie Triumph 759	.99	15	1.01	14	1.00	15	1.03	12	1.07	13	1.08	12	1.04	11
Farm Relief	1.11	6	1.14	5	1.15	5	1.15	6	1.20	6	1.20	5	1.15	5
Half and Half	.81	16	.90	16	.87	16	.85	16	.90	16	.89	16	.84	16
Mexican Big Boll	1.12	5	1.09	7	1.11	7	1.13	7	1.17	7	1.17	7	1.11	7
Qualla	1.09	8	1.09	8	1.09	8	1.08	9	1.13	9	1.14	8	1.06	9
Rowden 2088	1.07	10	1.06	9	1.08	10	1.07	10	1.12	10	1.10	10	1.04	12
Startex 619	1.02	12	1.04	12	1.03	12	1.02	14	1.07	14	1.09	11	1.00	15
Stoneville 5	1.08	9	1.06	10	1.09	9	1.09	8	1.15	8	1.14	9	1.07	8
Triumph 44	1.04	11	1.05	11	1.05	11	1.04	11	1.08	12	1.07	13	1.01	14
Wilds 5	1.36	1	1.32	1	1.37	1	1.40	1	1.43	1	1.44	1	1.32	1
Average, all varieties	1.09		1.09		1.10		1.11		1.15		1.15		1.09	
Difference req., odds 99 : 1	.02		.06		.04		.03		.03		.03		.04	
MEAN LENGTH, WEIGHT-FREQUENCY BASIS														
Acala (Roger)	0.99	4	1.02	4	1.05	2	1.05	3	1.06	4	1.09	3	1.04	2
Arkansas 17	1.02	2	1.05	2	1.02	3	1.05	4	1.09	2	1.10	2	1.04	3
Cleveland (W)	.85	15	.90	14	.86	15	.88	15	.91	15	.92	15	.92	11
Cook 912	.87	13	.88	15	.87	14	.89	14	.94	11	.93	13	.91	13
Delfos 4	1.00	3	1.01	3	1.01	4	1.09	2	1.08	3	1.05	4	1.03	4
Deltapine	.95	7	.90	6	.97	5	1.01	5	1.04	5	1.02	6	.97	7
Dixie Triumph 759	.86	14	.91	11	.89	12	.91	11	.93	13	.95	12	.92	12
Farm Relief	.96	6	1.01	5	.97	6	1.00	6	1.02	6	1.03	5	1.00	5
Half and Half	.70	16	.76	16	.74	16	.75	16	.78	16	.77	16	.73	16
Mexican Big Boll	.98	5	.96	8	.90	8	1.00	7	1.02	7	1.02	7	.99	6
Qualla	.94	8	.93	16	.97	7	.94	10	.97	10	1.00	8	.93	9
Rowden 2088	.94	9	.94	9	.93	10	.95	8	.98	9	.96	11	.93	10
Startex 619	.89	12	.90	13	.89	13	.90	12	.93	14	.97	10	.88	14
Stoneville 5	.93	10	.98	7	.95	9	.95	9	.99	8	.99	9	.95	8
Triumph 44	.89	11	.91	12	.92	11	.90	13	.94	12	.93	14	.88	15
Wilds 5	1.17	1	1.12	1	1.18	1	1.20	1	1.23	1	1.25	1	1.16	1
Average, all varieties	.93		.96		.95		.97		.99		1.00		.96	
Difference req., odds 99 : 1	.06		.04		.06		.05		.03		.03		.03	
COEFFICIENT OF VARIABILITY FOR LENGTH														
Acala (Roger)	26.05	3	26.10	2	22.70	14	22.80	8	26.46	1	23.21	5	22.59	2
Arkansas 17	24.60	9	24.30	7	23.80	8	21.85	11	24.30	8	22.09	7	21.60	8
Cleveland (W)	25.75	5	23.50	13	23.90	6	22.95	5	24.14	10	22.55	9	20.85	11
Cook 912	23.75	11	24.30	8	22.85	10	20.85	14	23.31	11	21.84	12	20.00	13
Delfos 4	25.85	4	24.90	5	25.80	2	22.95	6	25.26	5	25.10	1	21.20	9
Deltapine	25.60	6	24.25	9	24.75	4	23.70	4	25.40	4	24.87	2	22.21	3
Dixie Triumph 759	22.85	13	21.45	16	21.40	16	21.00	13	22.36	14	21.74	13	19.65	16
Farm Relief	26.20	2	25.30	4	26.30	1	25.40	1	26.05	2	24.80	3	22.76	1
Half and Half	26.30	1	23.55	12	25.10	3	22.50	9	24.75	7	22.76	8	22.00	4
Mexican Big Boll	22.00	15	22.00	15	22.75	13	20.45	16	21.99	16	20.45	16	19.96	14
Qualla	24.55	10	24.35	6	23.60	9	24.30	3	25.54	3	22.44	10	21.97	6
Rowden 2088	21.60	16	24.15	10	22.80	12	20.55	15	22.26	15	21.45	14	19.69	15
Startex 619	22.70	14	23.05	14	22.25	15	21.25	12	22.69	13	21.12	15	20.32	12
Stoneville 5	25.05	8	25.35	3	23.90	7	22.85	7	24.26	9	23.14	6	21.00	10
Triumph 44	22.90	12	23.95	11	22.85	11	22.00	10	23.26	12	22.31	11	21.87	7
Wilds 5	25.40	7	28.20	1	24.15	5	24.70	2	25.12	6	23.26	4	22.17	5
Average, all varieties	24.45		24.33		23.62		22.51		24.20		22.75		21.26	
Difference req., odds 99 : 1	5.00		1.91		3.44		2.10		1.47		1.60		1.52	

[1] Data from series 1 and 8 only.
[2] Data from 6 series for upper quartile length and from series 1 and 8 for mean length and for coefficient of length variability.

mean length, and coefficient of variability length of 14 locations in 1935

Stillwater, Okla.		Florence, S. C.		Jackson, Tenn.		Knoxville, Tenn.		College Station, Tex.[1]		Greenville, Tex.		Lubbock, Tex.		Average, all locations	
Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
UPPER QUARTILE LENGTH—Continued															
1.07	3	1.19	3	1.15	4	1.23	3	1.21	4	1.29	2	1.17	4	1.20	2
1.07	4	1.19	4	1.17	3	1.19	4	1.22	2	1.25	3	1.17	3	1.20	3
.89	15	1.00	14	.96	14	1.02	15	.99	15	1.10	12	1.00	13	1.01	15
.92	13	.98	15	.96	15	1.05	11	1.05	11	1.11	10	.98	15	1.02	13
1.09	2	1.20	2	1.19	2	1.24	2	1.22	3	1.24	5	1.17	2	1.20	4
1.05	6	1.12	7	1.09	7	1.15	6	1.19	5	1.19	6	1.09	7	1.14	6
.92	14	1.01	13	.97	13	1.03	14	1.03	13	1.06	14	1.01	12	1.02	14
1.06	5	1.13	5	1.10	5	1.16	5	1.11	7	1.2[illegible]	4	1.15	5	1.15	5
.81	10	.83	16	.84	16	.88	16	.84	16	.90	16	.84	16	.88	16
1.00	7	1.13	6	1.10	6	1.12	7	1.13	6	1.15	8	1.11	6	1.12	7
.99	9	1.09	8	1.06	9	1.11	8	1.00	10	1.12	9	1.08	9	1.09	8
1.00	8	1.08	9	1.06	10	1.08	10	1.09	9	1.11	11	1.06	10	1.07	10
.95	11	1.03	12	1.09	12	1.04	12	1.05	12	1.07	13	.98	14	1.03	11
.90	10	1.06	10	1.08	8	1.11	9	1.11	8	1.17	7	1.08	8	1.09	9
.95	12	1.03	11	1.01	11	1.03	13	1.03	14	1.05	15	1.02	11	1.03	12
1.22	1	1.36	1	1.34	1	1.38	1	1.43	1	1.43	1	1.33	1	1.36	1
1.00	......	1.06	......	1.07	......	1.11	......	1.11	......	1.16	......	1.08	......	1.10	......
.05	......	.03	......	.04	......	.03	......	.03	......	.04	......	.04	......	......	......
MEAN LENGTH, WEIGHT-FREQUENCY BASIS—Continued															
0.91	2	1.01	4	0.99	4	1.02	3	1.06	3	1.11	2	0.99	4	1.02	3
.90	4	1.02	3	1.01	2	1.01	4	1.07	2	1.07	3	.99	3	1.03	2
.76	15	.86	14	.83	14	.87	15	.87	15	.94	12	.86	13	.87	15
.80	13	.85	15	.83	15	.90	12	.92	11	.96	10	.84	15	.89	12
.91	3	1.02	2	1.01	3	1.02	2	1.05	4	1.04	5	.99	2	1.02	4
.89	6	.95	7	.94	7	.90	6	1.03	5	1.02	6	.92	9	.97	6
.80	14	.87	13	.85	13	.88	13	.90	13	.93	13	.88	12	.89	13
.90	5	.97	6	.95	6	.95	7	.96	8	1.05	4	.98	5	.98	5
.69	16	.72	16	.72	16	.75	16	.75	16	.78	16	.72	16	.74	16
.85	8	.98	5	.96	5	.97	5	1.00	6	.99	8	.96	6	.97	7
.85	9	.94	9	.91	10	.92	10	.95	9	.97	9	.93	7	.94	8
.86	7	.94	8	.93	8	.94	9	.95	1[illegible]	.95	11	.92	10	.94	9
.82	11	.89	11	.88	11	.90	11	.91	12	.92	14	.86	14	.90	11
.83	10	.92	10	.92	9	.94	8	.98	7	1.00	7	.92	8	.94	10
.82	12	.88	12	.86	12	.88	14	.90	14	.90	15	.88	11	.89	14
1.04	1	1.17	1	1.15	1	1.15	1	1.25	1	1.22	1	1.14	1	1.17	1
.85	......	.94	......	.92	......	.94	......	.97	......	.99	......	.92	......	.95	......
.04	......	.03	......	.04	......	.03	......	.07	......	.04	......	.04	......	......	......
COEFFICIENT OF VARIABILITY FOR LENGTH—Continued															
27.17	4	26.56	1	24.99	2	30.20	3	22.50	7	24.77	9	26.70	2	25.04	3
27.67	1	24.15	12	23.64	11	25.97	11	23.85	4	25.70	7	20.24	4	24.56	8
27.27	3	24.51	8	23.81	10	26.70	9	22.00	9	25.35	8	24.46	12	24.31	9
23.92	15	24.54	7	22.52	12	23.52	12	20.00	13	23.60	14	24.81	9	23.25	12
26.95	6	25.86	3	24.50	6	29.77	4	23.80	2	27.96	1	26.72	3	25.77	2
26.10	7	26.17	2	24.67	4	29.41	6	22.65	6	26.25	4	27.20	1	25.61	4
24.02	14	23.69	13	22.34	13	24.66	13	20.20	16	22.86	16	23.04	16	22.54	16
27.06	5	25.81	4	24.61	5	31.30	1	25.25	1	26.40	3	26.22	5	26.07	1
25.12	11	24.21	9	24.47	7	26.94	8	20.30	15	24.60	11	24.34	13	24.28	10
25.59	9	22.80	15	21.46	16	24.10	16	20.85	14	23.50	15	24.60	10	22.60	14
24.67	12	24.21	10	23.82	9	30.34	2	21.45	12	25.07	5	24.52	11	24.69	7
24.49	13	21.82	16	21.82	15	24.15	15	22.10	8	24.27	12	24.02	14	.59	15
23.86	16	23.02	14	22.31	14	24.27	14	21.80	11	23.67	13	23.56	15	22.69	13
27.34	2	24.16	11	25.91	1	27.17	7	21.95	10	25.82	6	25.25	6	24.76	6
25.15	10	24.92	6	24.36	8	26.30	10	22.75	5	24.75	10	25.16	8	24.07	11
26.07	8	25.00	5	24.06	3	29.66	5	22.00	3	27.29	2	25.24	7	25.38	5
25.78	......	24.47	......	23.76	......	27.28	......	22.14	......	25.19	......	25.14	......	24.30	......
2.16	......	2.59	......	1.95	......	1.94	......	4.95	......	1.94	......	2.20	......	......	......

A substantial shortening in fiber length occurred under the moderate drought conditions and relatively high temperatures that prevailed in Oklahoma. Locations having an abundance of summer rainfall tend in general to produce longer lint than those having a limited rainfall. Length cannot be predicted, however, with satisfactory accuracy from precipitation and temperature, either alone or together. An intensive study of the relations of length with precipitation and maximum and minimum temperatures, on both a cumulative and a period basis, failed to disclose any close relation between fiber length and the weather measurements available in this study.

The varietal rank for mean length agreed with rank for upper quartile length in comparisons where the actual differences in length were considerable. For comparisons among varieties having closely similar length, the ranks for the two variables frequently differed, owing to varying degrees of uniformity in the total fiber-length distribution.

COEFFICIENT OF VARIABILITY FOR LENGTH

The varietal means and rank for coefficient of variability for length are reported by locations in the third part of table 13. The range in locational means was from 27.28 to 21.26 percent, for Knoxville, Tenn., and North Carolina, respectively. The rank of locations for coefficient of variability for length is not closely associated with the rank for either upper quartile length or mean length. Such failure in agreement is expected, since the coefficient of variability reflects in part the differential between upper quartile and mean length.

The range in varietal averages at all locations is from 26.07 to 22.54 percent. The varietal rank at individual locations usually agrees rather well with the varietal rank for all locational averages. This agreement holds fairly well for the high and low varieties or for any pair separated by 1 percent or more in mean values. Certain failures in agreement for pairs of varieties having closely equivalent means are evident, but these are without material significance.

ANALYSIS OF VARIANCE

A summary of analysis of variance by individual locations for upper quartile length is shown in the upper section of table 14. At each location the contribution for varieties greatly exceeded the requirement for significance, indicating that varietal distinctions were clear-cut at all places. The relative contribution for varieties in relation to error varied rather widely between tests, owing largely to differing levels of heterogeneity within tests. At locations where length arrays were made on each of the eight series, the precision was usually considerably greater than for locations where only partial data were available.

An unusual degree of variability occurred at 2 locations, Arkansas (delta) and Oklahoma. No clear reason is apparent for the wide variability in the Arkansas (delta) test, but fiber determinations were made on series 1 and 8 first and some months later on series 2, 3, 4, and 5. It is possible that differences in condition-

Table 14.—*Analysis of variance for individual locations for fiber-length variables—upper quartile length, mean length, and coefficient of variability for length*

Location	Mean squares				
	Total	Varieties	Series	Ranges	Error
UPPER QUARTILE LENGTH, WEIGHT-FREQUENCY BASIS					
Alabama, Prattville [2]	0.0138	0.0281	0.0009		0.0003
Arkansas, Marianna:					
Delta [2]	.0108	.0573	.0070		.0018
Upland	.0131	.1049	.0008	0.0010	.0008
Georgia, Experiment [1]	.0156	.0317	.0003		.0004
Louisiana, Baton Rouge	.0139	.1121	.0020	.0013	.0006
Mississippi, Stoneville	.0146	.1171	.0056	.0013	.0005
North Carolina, Statesville	.0118	.0930	.0015	.0022	.0008
Oklahoma, Stillwater	.0107	.0742	.0159		.0013
South Carolina, Florence	.0137	.1109	.0044	.0008	.0005
Tennessee:					
Jackson	.0136	.1085	.0021	.0004	.0009
Knoxville	.0128	.1032	.0005	.0012	.0006
Texas:					
College Station [1]	.0165	.0338	.0011		.0004
Greenville	.0151	.1156	.0063	.0018	.0009
Lubbock	.0126	.0998	.0021	.0010	.0009
MEAN LENGTH, WEIGHT-FREQUENCY BASIS					
Alabama, Prattville [1]	0.0099	0.0109	0.0015		0.0004
Arkansas, Marianna:					
Delta [1]	.0072	.0146	.0003		.0002
Upland [1]	.0092	.0185	.0015		.0004
Georgia, Experiment [1]	.0106	.0217	.0000		.0003
Louisiana, Baton Rouge	.0098	.0774	.0025	0.0012	.0005
Mississippi, Stoneville	.0105	.0837	.0051	.0007	.0004
North Carolina, Statesville	.0090	.0701	.0020	.0017	.0006
Oklahoma, Stillwater	.0074	.0489	.0125		.0011
South Carolina, Florence	.0098	.0770	.0035	.0006	.0006
Tennessee:					
Jackson	.0100	.0769	.0029	.0004	.0010
Knoxville	.0077	.0611	.0010	.0007	.0005
Texas:					
College Station [1]	.0120	.0242	.0002		.0005
Greenville	.0101	.0772	.0075	.0009	.0007
Lubbock	.0089	.0678	.0024	.0012	.0009
COEFFICIENT OF VARIABILITY FOR LENGTH					
Alabama, Prattville [2]	4.162	4.913	10.238		2.882
Arkansas, Marianna:					
Delta [2]	2.542	4.643	2.880		.419
Upland [2]	2.984	3.918	14.851		1.360
Georgia, Experiment [2]	2.952	4.501	6.281		.509
Louisiana, Baton Rouge	3.191	16.029	4.591	1.520	1.245
Mississippi, Stoneville	3.151	14.257	5.131	.657	1.488
North Carolina, Statesville	2.322	9.064	3.177	.986	1.331
Oklahoma, Stillwater	4.250	14.588	5.555		2.686
South Carolina, Florence	5.146	12.979	3.325	7.986	3.874
Tennessee:					
Jackson	3.736	13.472	6.410	1.674	2.263
Knoxville	8.033	49.594	6.134	2.807	2.181
Texas:					
College Station [1]	2.746	2.703	2.258		2.821
Greenville	4.457	16.105	12.501	3.250	2.171
Lubbock	3.923	11.669	4.651	2.365	2.810
Degrees of freedom	127	15	7	7	98
Do. [1]	31	15	1		15
Do. [2]	95	15	5		75

[1] For series 1 and 8.
[2] For series 1 to 5 and 8.

ing or handling may have contributed to the large error variance. Soil uniformity at this location was apparently among the best of the 14 locations. In the test at Stillwater, Okla., a moderate drought occurred during the fruiting season and this may have contributed materially to the heterogeneity, particularly since this test was planted on terraced land, where the water-holding capacity of the soil varied materially within the blocks. These data therefore show definitely that varietal differences in upper half mean length were identified at all locations, but that the precision of distinctions varied considerably from place to place.

In the second section of table 14 is shown a summary of the analysis of variance by individual locations for mean length, which was in general similar to and fairly consistent with the comparable analysis for upper quartile length. Many significant varietal distinctions may be made at every location, but there are rather wide differences in the variance for varieties at single locations. This is partially due to incomplete data for certain locations and also to inherent locational differences in variability.

A summary of the analysis of variance at individual locations for coefficient of variability for length is shown in the third section of table 14. In this analysis the contribution for varieties differs widely at the different locations. It follows that the precision with which differences between varieties may be identified varies accordingly at the several locations.

Significant differences among varieties were established at all locations except Prattville, Ala., and College Station, Tex., where the contribution for varieties was not significantly different from error. Considering the analyses at all locations, the varietal distinction in coefficient of variability is materially less than in upper quartile length or mean length and consequently it may be concluded that the coefficient of variability for length is a less efficient measure of varietal distinction than either of the computed length measures.

An analysis of variance for combined data on upper quartile length from the nine locations having complete data is shown in the first section of table 15. The contribution of varieties to variance clearly dominates the analysis and significantly exceeds locations. Varieties × locations is significantly larger than error, al-

TABLE 15.—*Analysis of variance of fiber length for all data*

Source of variation	Upper quartile length, weight-frequency basis			Mean length, weight-frequency basis			Coefficient of variability for length		
	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]
Varieties	15	0.9503		15	0.5773		15	106.46	
Locations	8	.1460		7	.1340		7	405.30	
Varieties × locations	120	.0022		105	.0020		105	5.26	
Series within locations	63	.0028		56	.0034		56	5.74	
Ranges within locations	63	.0012		56	.0010		56	2.61	
Error	882	.0007		784	.0006		784	2.16	
Total	1,151	.0141		1,023	.0103		1,023	7.01	

[1] See footnote 1, table 3.

though significantly exceeded and dominated by both main effects. From these data it may be concluded that genetic constitution is the most important factor in determining length. Growth conditions are identified as being highly important in modifying the length of all varieties. The significant locations/interaction comparison indicates that the predominant tendency in environmental effects is for varieties to be modified in the same directions and generally to a similar extent. The significant interaction/error comparison, however, indicates that a differential modification in length may occur. An examination of the means indicates that this differential usually is the result of a disproportionately greater shortening of the longer varieties under conditions of deficient moisture.

An analysis of variance for combined data on mean length from eight locations is shown in the second section of table 15. The variance for varieties dominates the analysis and offers supporting evidence that genetic constitution is the most important controllable factor determining fiber length. Location contributed approximately one-fourth as much as variety, and consequently it is evident that seasonal conditions under which cotton is grown may materially affect fiber length. The interaction varieties × locations is greatly exceeded by both main effects, although significant when tested against error. This finding indicates that the differential response of varieties to places may be identified, although such response is definitely secondary in importance to main effects.

The analysis of variance for combined data from eight locations having complete data for coefficient of variability for length is given in the third section of table 15. Variance for locations is about three times more than for varieties, and both main effects are significantly greater than interaction, which in turn significantly exceeds error. These data indicate that the coefficient of variability is affected more by weather conditions than by variety, although important varietal distinctions were identified. The interaction varieties × locations, while of interest since it indicates the differential response of varietal variability under various growth conditions, is clearly dominated by both main effects and is therefore relatively unimportant in total variability.

A comparison of the combined analysis for coefficient of variability with those for upper quartile and mean lengths offers substantial evidence that the coefficient is a less efficient measure for varietal distinction than either of the length measures.

CHANDLER STRENGTH

Strength determinations, using the Chandler bundle method for determining tensile strength of lint, were made on both the 4- and 5-lock-boll samples from two locations in 1935 as a guide for general strength testing. After this preliminary work, complete data were obtained on the 4-lock-boll samples from eight locations and partial data were obtained from the remaining locations.

A summary of the varietal means and rank by locations for Chandler strength of the 4-lock-boll samples for 1935 is shown in the top section of table 16. The range in location means is from

TABLE 16.—*Varietal means and rank of fiber strength and fineness—Chandler locations*

CHANDLER STRENGTH, THOUSAND POUNDS PER SQUARE INCH

Variety	Prattville, Ala.[1]		Marianna, Ark. Delta[1]		Marianna, Ark. Upland[2]		Experiment, Ga.[3]		Baton Rouge, La.		Stoneville, Miss.		Statesville, N. C.	
	Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
Acala (Roger)	91.3	1	95.9	1	93.8	1	84.7	1	83.8	1	91.8	1	79.5	1
Arkansas 17	86.6	6	88.7	5	88.1	5	78.5	5	80.2	5	87.1	3	73.1	6
Cleveland (W)	79.8	13	82.9	14	82.0	13	72.3	12	71.6	12	73.7	15	65.1	15
Cook 912	87.5	5	86.2	7	88.1	6	78.8	4	82.3	3	85.7	7	75.0	5
Delfos 4	80.0	12	84.9	9	83.0	11	71.1	14	71.2	14	77.8	13	66.7	14
Deltapine	78.0	15	83.3	13	81.4	14	72.2	13	73.5	10	78.7	11	67.1	13
Dixie Triumph 759	81.9	8	83.5	12	83.6	9	72.6	10	74.0	9	78.9	10	68.7	10
Farm Relief	80.5	9	86.4	6	84.9	7	77.3	7	77.6	8	82.6	8	71.1	8
Half and Half	79.3	14	77.1	16	75.9	16	72.7	9	70.9	15	78.1	12	69.4	11
Mexican Big Boll	89.0	3	91.5	3	93.1	2	80.7	3	78.9	6	86.9	5	75.1	4
Qualla	72.1	16	79.4	15	79.6	15	65.3	16	66.5	16	73.6	16	64.5	16
Rowden 2088	87.9	4	89.7	4	88.5	4	77.9	6	80.7	4	87.0	4	75.2	3
Startex 619	80.5	10	83.7	11	83.3	10	70.0	15	71.4	13	77.2	14	69.6	9
Stoneville 5	83.6	7	84.2	10	84.9	8	77.3	8	78.3	7	80.4	6	72.1	7
Triumph 44	80.4	11	85.5	8	82.2	12	72.4	11	72.8	11	79.8	9	68.4	12
Wilds 5	90.9	2	94.2	2	91.6	3	82.6	2	83.1	2	88.2	2	77.9	2
Average, all varieties	83.0		86.1		85.3		75.4		76.1		82.1		71.1	
Difference req., odds 99:1	6.3		4.0		3.7		4.3		2.6		3.0		2.7	
WEIGHT PER INCH, 10^{-5} MILLIGRAMS														
Acala (Roger)	4.03	14	4.27	15	4.49	15	4.00	15	4.02	15	4.10	15	4.34	15
Arkansas 17	4.35	13	4.64	12	4.90	12	4.55	13	4.48	12	4.49	13	4.92	14
Cleveland (W)	4.79	7	5.56	5	5.76	4	5.42	3	5.32	3	5.52	3	5.65	5
Cook 912	4.65	10	5.48	7	5.36	9	5.29	5	4.89	9	5.12	5	5.22	11
Delfos 4	4.02	15	4.50	14	4.65	14	4.44	14	4.33	13	4.39	14	4.95	13
Deltapine	4.76	8	5.18	11	5.10	10	4.72	12	4.74	11	4.83	11	5.37	10
Dixie Triumph 759	4.89	6	5.45	8	5.47	5	4.95	9	5.03	8	5.07	8	5.46	8
Farm Relief	5.09	3	5.56	4	5.39	7	5.11	6	5.11	6	5.31	4	5.49	7
Half and Half	5.76	1	6.23	1	6.30	1	5.99	1	5.79	1	6.03	1	6.30	1
Mexican Big Boll	4.57	11	5.24	10	5.03	11	5.04	8	4.87	10	4.84	10	5.45	9
Qualla	4.94	5	5.59	3	5.42	6	4.86	10	5.15	5	5.10	7	5.57	6
Rowden 2088	5.20	2	5.91	2	5.96	2	5.62	2	5.51	2	5.59	2	6.02	2
Startex 619	5.03	4	5.55	6	5.83	3	5.40	4	5.11	7	5.04	9	5.74	3
Stoneville 5	4.48	12	4.62	13	4.75	13	4.82	11	4.33	14	4.62	12	5.20	12
Triumph 44	4.71	9	5.43	9	5.30	8	5.09	7	5.17	4	5.12	6	5.74	4
Wilds 5	3.20	16	3.91	16	3.81	16	3.67	16	3.57	16	3.67	16	4.22	16
Average, all varieties	4.67		5.20		5.23		4.94		4.84		4.93		5.36	
Difference req., odds 99:1	.61		.42		.53		.55		.24		.20		.28	
COEFFICIENT OF VARIABILITY FOR FINENESS														
Acala (Roger)	8.70	10	8.68	9	9.80	9	9.14	13	9.10	11	10.37	9	11.05	6
Arkansas 17	8.66	11	6.49	16	9.13	13	9.89	10	10.51	7	10.91	10	11.11	5
Cleveland (W)	10.04	7	12.65	3	12.67	2	10.59	8	11.26	5	12.27	1	13.64	1
Cook 912	11.35	3	14.36	1	8.62	15	12.81	1	12.00	2	11.79	4	10.95	7
Delfos 4	12.20	1	7.53	12	10.28	7	8.73	15	8.41	15	9.05	16	8.97	15
Deltapine	7.38	16	7.48	13	8.18	16	8.42	16	7.81	16	9.06	14	9.66	14
Dixie Triumph 759	10.49	5	9.86	6	11.43	4	10.72	7	11.81	3	11.35	7	11.17	4
Farm Relief	8.28	13	9.24	8	10.57	5	8.98	14	8.02	12	9.92	11	10.70	10
Half and Half	9.59	8	7.46	14	10.22	8	10.97	4	8.80	13	11.64	6	10.12	13
Mexican Big Boll	10.58	4	11.72	4	12.21	3	10.85	6	12.32	1	11.75	5	12.32	2
Qualla	11.52	2	6.66	15	12.93	1	12.19	2	9.21	10	9.06	15	10.57	11
Rowden 2088	10.33	6	12.08	2	9.67	11	9.35	11	11.75	4	12.05	2	11.30	3
Startex 619	8.62	12	9.91	5	9.19	12	9.21	12	9.35	9	11.07	8	10.72	9
Stoneville 5	7.52	15	7.99	11	8.76	14	10.51	9	8.54	14	9.11	13	8.15	16
Triumph 44	9.20	9	9.80	7	9.67	10	11.60	3	10.97	6	12.01	3	10.41	12
Wilds 5	8.15	14	8.04	10	10.50	6	10.90	5	9.95	8	9.24	12	10.37	8
Average, all varieties	9.56		9.43		10.24		10.31		10.04		10.67		10.66	
Difference req., odd 99:1	6.83		2.93		5.95		4.86		2.44		2.19		2.35	

[1] Series 1 and 3 only, all three variables.
[2] Series 1 and 3 only, for Chandler strength; all series for other variables.
[3] Series 1 and 2 only, for weight per inch and for coefficient of variability.

strength, weight per inch, and coefficient of variability for fineness—at 14 in 1935

CHANDLER STRENGTH, THOUSAND POUNDS PER SQUARE INCH—Continued

Stillwater, Okla. [3]		Florence, S. C.		Jackson, Tenn.		Knoxville, Tenn.		College Station, Tex. [4]		Greenville, Tex.		Lubbock, Tex. [5]		Average, all locations	
Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
99.4	2	91.7	1	100.3	1	85.9	1	102.2	1	94.0	2	90.3	1	91.0	1
95.1	5	85.3	4	92.7	7	79.9	6	91.7	6	91.7	4	82.5	7	85.2	6
93.6	7	76.5	14	85.8	13	73.5	12	81.1	14	78.3	15	77.0	15	77.1	14
98.2	3	87.7	2	94.4	4	83.7	3	92.7	5	87.3	9	83.9	5	85.8	5
91.2	10	77.6	13	86.2	12	72.4	15	80.3	15	87.6	8	77.4	14	78.7	12
86.4	14	79.5	11	84.9	14	73.3	13	82.8	12	82.7	14	77.6	13	78.3	13
92.8	9	82.1	9	88.6	9	75.8	9	85.0	11	85.4	11	81.6	8	80.5	9
93.0	8	82.5	8	90.0	8	77.7	8	85.1	10	85.9	10	78.7	12	82.0	8
84.8	15	79.7	10	79.7	16	75.0	10	82.5	13	83.8	13	79.1	11	77.1	15
100.5	1	88.6	3	96.5	3	80.1	4	95.3	2	96.7	1	86.0	2	87.5	3
83.7	16	71.7	16	84.4	15	69.0	16	78.6	16	77.6	16	65.0	16	73.3	16
95.0	6	83.9	6	94.1	5	80.0	5	93.9	3	93.7	3	85.9	3	86.1	4
88.6	13	75.8	15	88.6	10	72.9	14	87.1	8	84.0	12	81.2	9	79.0	11
90.9	11	83.1	7	93.4	6	79.0	7	90.9	7	88.4	7	85.5	4	83.7	7
89.3	12	78.9	12	87.1	11	74.9	11	86.7	9	90.4	6	79.9	10	80.2	10
96.4	4	85.3	5	97.8	2	84.5	2	93.7	4	91.2	5	83.3	6	88.0	2
92.4	......	81.8	......	90.3	......	77.3	......	88.1	......	87.4	......	80.9	......	82.1	......
1.3	......	2.7	......	4.2	......	2.7	......	7.0	......	4.5	......	4.4	......		......

WEIGHT PER INCH, 10^{-4} MILLIGRAMS—Continued

Stillwater, Okla.		Florence, S. C.		Jackson, Tenn.		Knoxville, Tenn.		College Station, Tex.		Greenville, Tex.		Lubbock, Tex.		Average, all locations	
4.53	15	4.27	15	4.32	15	3.67	15	4.40	15	4.31	15	4.42	15	4.25	15
4.78	13	4.72	13	4.64	13	4.78	11	4.92	13	4.62	13	4.56	14	4.67	13
5.72	3	5.51	2	5.60	3	5.48	4	5.94	2	5.60	3	5.89	2	5.50	3
5.40	7	5.22	6	5.33	5	4.58	13	5.34	7	5.25	9	5.39	6	5.20	9
4.69	14	4.58	14	4.47	14	4.40	14	4.51	14	4.51	14	4.61	13	4.54	14
5.19	11	4.99	10	4.99	11	4.85	9	5.02	12	5.07	10	5.07	12	5.01	11
5.33	8	5.13	8	5.30	7	5.36	5	5.54	4	5.37	5	5.19	10	5.25	8
5.67	4	5.15	7	5.31	6	4.79	10	5.08	10	5.37	6	5.18	11	5.31	5
6.32	1	5.88	1	5.76	1	5.61	3	6.34	1	6.14	1	6.37	1	6.06	1
5.26	9	4.93	11	5.17	10	5.06	7	5.31	8	5.05	11	5.35	7	5.08	10
5.52	5	5.31	4	5.21	9	4.91	8	5.17	9	5.31	8	5.54	4	5.20	7
5.78	2	5.38	3	5.67	2	5.63	2	5.67	3	5.61	2	5.61	3	5.65	2
5.48	6	5.26	5	5.36	4	5.23	6	5.30	6	5.40	4	5.21	8	5.36	4
4.87	12	4.84	12	4.75	12	4.74	12	5.07	11	4.87	12	5.18	9	4.79	12
5.26	10	5.13	9	5.30	8	5.78	1	5.53	5	5.33	7	5.44	5	5.30	6
4.06	16	3.72	16	3.81	16	3.51	16	3.51	16	3.72	16	3.78	16	3.80	16
5.24	......	5.00	......	5.06	......	4.90	......	5.17	......	5.10	......	5.18	......	5.07	......
.20	......	.31	......	.29	......	.80	......	.61	......	.24	......	.45	......	.09	......

COEFFICIENT OF VARIABILITY FOR FINENESS—Continued

Stillwater, Okla.		Florence, S. C.		Jackson, Tenn.		Knoxville, Tenn.		College Station, Tex.		Greenville, Tex.		Lubbock, Tex.		Average, all locations	
10.36	2	8.55	11	9.57	8	8.30	14	9.19	12	9.97	11	8.06	15	9.63	10
9.15	10	8.32	12	8.85	11	9.69	9	11.03	8	10.10	9	8.59	13	9.70	9
12.45	1	13.10	1	10.47	2	10.22	7	13.17	2	14.11	1	12.30	1	12.25	1
9.15	11	9.55	6	10.04	4	10.80	3	11.27	7	12.96	2	10.56	5	11.01	4
8.34	13	7.74	14	7.67	14	6.72	16	7.82	14	7.09	16	9.09	9	8.33	14
8.39	12	6.61	16	7.47	15	7.48	15	10.69	9	9.24	14	9.91	6	8.29	15
10.16	4	10.52	2	11.44	1	10.47	6	11.66	4	11.09	5	11.35	3	11.03	2
9.21	9	8.74	9	7.91	13	8.37	13	7.46	16	10.40	6	9.78	7	9.31	11
9.96	6	8.87	8	9.41	10	12.06	1	11.54	5	11.38	4	9.07	10	10.05	7
10.19	3	9.60	4	9.72	6	10.01	8	14.78	1	10.26	7	10.96	4	11.02	3
7.40	14	7.80	13	9.56	9	8.63	12	7.65	15	9.36	12	8.76	12	8.15	13
10.00	5	8.91	7	9.67	7	9.55	10	12.88	3	11.64	3	12.04	2	10.80	5
9.54	7	9.60	5	9.81	5	10.96	2	10.17	10	9.20	15	9.21	8	9.84	8
6.79	16	7.70	15	7.34	16	10.58	5	7.83	13	9.35	13	7.34	16	8.24	16
9.35	8	10.00	3	10.36	3	10.76	4	9.51	11	10.19	8	8.88	11	10.37	6
6.96	15	8.56	10	8.57	12	8.85	11	11.43	6	10.15	10	8.56	14	9.25	12
9.21	......	9.02	......	9.24	......	9.50	......	10.51	......	10.41	......	9.66	......	9.59	......
2.37	......	2.11	......	3.01	......	4.29	......	5.02	......	2.56	......	4.07	......	.80	......

92.4 to 71.1 thousand pounds per square inch, for Oklahoma and North Carolina, respectively. The wide differences in strength among locations indicate that ecological conditions have a very important influence on fiber strength.

Varietal means at all locations ranged from 91.0 to 73.3 thousand pounds per square inch, and this shows clearly that wide differences in strength exist among varieties. The generally good agreement in rank between the all-location averages and single-location means indicates that fiber strength is fundamentally dependent on genetic constitution.

WEIGHT PER INCH

Fiber fineness, expressed as weight per inch, 10^{-3} mg. (µg.), was determined for certain samples from the 1935 regional cotton variety study. Complete data on weight-per-unit length were obtained on samples from Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Jackson, Tenn., and Greenville, Tex., and data for series 1 and 8 were obtained for the other seven locations. Subsequent computations provided estimates of the coefficient of variability for fineness, as determined from the various length fractions.

The varietal means and rank for weight per inch, 10^{-3} mg., are summarized by locations in the second section of table 16. The range in locational means, 5.36 to 4.67, for North Carolina and Alabama, respectively, was wide in comparison with the requirement for significance, and many significant differences existed among locations. This shows that environmental conditions during the time the fiber is developing may greatly modify weight-per-unit length of fibers. Varietal means, as an average of all locations, ranged from 6.06 to 3.80, and these offer clear-cut evidence that weight-per-unit length is definitely a varietal characteristic. Comparisons of the rank of varietal means at all locations with the rank at individual locations indicate a farly good consistency. These findings offer substantial evidence that fiber-weight-per-unit length is controlled primarily by genetic factors, but that it may be modified greatly by environmental conditions under which the fiber is produced. The fairly good consistency in varietal rank at individual locations indicates that there is a tendency for the fibers of all varieties to be modified in the same direction and to somewhat the same extent by growth conditions.

COEFFICIENT OF VARIABILITY FOR FINENESS

A summary of varietal means and rank by locations for coefficient of variability for fineness as determined on the various length groups within arrays is shown in the third section of table 16. The range in locational means was from 10.67 to 9.02 for Mississippi and South Carolina, respectively, a difference rather small in comparison with other measures of fiber properties. A rather poor agreement was found in a comparison of varietal rank at all locations with varietal rank at individual locations, and this indicates that the coefficient of variability is not a stable varietal character or a critical measure of varietal distinction.

ANALYSIS OF VARIANCE

A summary of the analysis of variance at individual locations for tensile strength in 1935 is shown in the top section of table 17. Footnotes indicate locations having data on series 1 and 8 only. A comparison of mean square for varieties with mean square for error shows that significant varietal differences were identified at all locations, but that the relative distinction among varieties differed widely at the various locations. Differences in the precision of comparing varietal means at the individual locations are associated in certain cases with incompleteness of data, and at locations having comparable data by variations in the heterogeneity of strength within tests.

Analysis of variance by individual locations for weight per inch, 10^{-4} mg., is summarized in the second section of table 17. A comparison of the mean square for varieties with error shows that significant varietal distinctions were found at each location. Rather wide differences in the precision of such comparisons will also be noted, partly owing to incompleteness of data and partly to differences in the inherent variability in weight-per-unit length present at the various places.

A summary of the analysis of variance by individual locations for coefficient of variability for fineness is shown in the third section of table 17. A comparison of mean square for varieties with mean square for error shows that at eight locations significant distinctions were made among varieties, while at six locations no significance was found. The relatively lower efficiency for the coefficient of variability as compared with Chandler strength and weight per inch indicates that the coefficient provides a less effective basis for varietal differentiation than other measurements of fiber properties.

An analysis of variance for combined data from the 10 locations having complete Chandler-strength determinations in 1935 is shown in the first section of table 18. Location was numerically the greatest contributor although not significantly larger than variety. Both main effects significantly exceed interaction, which in turn is significant when tested against error. In this study tensile strength was dependent to a greater extent on growth conditions or subsequent weathering than on any other factor, although varieties differed widely in intrinsic tensile strength. The significantly greater variance for varieties to varieties × locations establishes the genetic basis for fiber strength and shows clearly that relative differences among varieties tend to be consistent over a wide range of growth conditions.

A differential response of varieties to locations was identified, and this may be due to differences in relative earliness as judged by the time of boll set or to differential weathering after the bolls opened. Although significant when tested against error, interaction is distinctly secondary in importance, being exceeded 58-fold by varieties and 134-fold by locations.

An analysis of variance for combined data from six locations on weight per inch, 10^{-4} mg., is shown in the second section of table 18. The variance for varieties numerically exceeded locations and both main effects were significantly greater than interaction,

TABLE 17.—*Analysis of variance by individual locations for fiber length and fineness—Chandler strength, weight per inch, and coefficient of variability for fineness*

Location	Mean squares: Total	Mean squares: Varieties	Mean squares: Series	Mean squares: Ranges	Mean squares: Error
CHANDLER STRENGTH					
Alabama, Prattville [1]	31.23	59.47	8.20	—	4.53
Arkansas, Marianna:					
Delta	38.79	199.53	136.60	10.53	9.37
Upland	40.27	195.99	180.72	0.40	7.97
Georgia, Experiment [1]	27.90	52.63	44.18	—	2.08
Louisiana, Baton Rouge	30.63	217.29	29.89	7.26	4.04
Mississippi, Stoneville	38.01	247.56	82.94	4.12	5.14
North Carolina, Statesville	23.91	163.16	15.59	11.18	4.11
Oklahoma, Stillwater [1]	34.26	50.32	28.50	—	18.57
South Carolina, Florence	30.06	207.66	39.08	3.46	4.14
Tennessee:					
Jackson	45.80	251.15	147.45	4.05	10.09
Knoxville	26.21	185.61	15.18	4.06	4.18
Texas:					
College Station [1]	50.66	85.16	208.08	—	5.67
Greenville	45.47	236.48	122.87	30.02	11.81
Lubbock	47.83	255.25	111.63	54.04	11.08
WEIGHT PER INCH, 10^{-4} MILLIGRAMS					
Alabama, Prattville [1]	0.36	0.64	0.76	—	0.04
Arkansas, Marianna:					
Delta [1]	.39	.78	.05	—	.02
Upland [1]	.42	.80	.04	—	.08
Georgia, Experiment [1]	.36	.69	.31	—	.03
Louisiana, Baton Rouge	.35	2.60	.24	0.04	.03
Mississippi, Stoneville	.35	2.74	.14	.05	.02
North Carolina, Statesville	.34	2.50	.06	.05	.05
Oklahoma, Stillwater	.34	2.45	.24	—	.05
South Carolina, Florence	.30	2.09	.17	.06	.00
Tennessee:					
Jackson	.33	2.27	.45	.04	.05
Knoxville [1]	.45	.84	.28	—	.07
Texas:					
College Station [1]	.44	.86	.01	—	.04
Greenville	.35	2.65	.14	.08	.03
Lubbock [1]	.37	.75	.03	—	.02
COEFFICIENT OF VARIABILITY FOR FINENESS					
Alabama, Prattville [1]	4.67	4.26	0.14	—	5.37
Arkansas, Marianna:					
Delta [1]	6.08	11.33	4.73	—	.92
Upland [1]	3.97	4.11	.08	—	4.08
Georgia, Experiment [1]	2.97	3.25	2.42	—	2.72
Louisiana, Baton Rouge	5.31	17.29	7.71	3.42	3.44
Mississippi, Stoneville	4.19	12.39	6.90	3.57	2.77
North Carolina, Statesville	4.24	11.54	5.18	2.17	3.21
Oklahoma, Stillwater	4.02	10.34	5.31	—	3.26
South Carolina, Florence	4.36	17.41	1.88	3.83	2.58
Tennessee:					
Jackson	5.92	11.09	2.77	7.53	5.24
Knoxville [1]	4.32	4.06	7.24	—	2.12
Texas:					
College Station [1]	6.26	9.29	.17	—	3.63
Greenville	6.18	21.11	9.07	4.75	3.78
Lubbock [1]	3.23	4.15	.18	—	2.51
Degrees of freedom	127	15	7	7	98
Do. [1]	31	15	1	—	15

[1] For series 1 and 8.

TABLE 18.—*Analysis of variance of fiber strength and fineness for all locations*

Source of variation	Chandler strength, 1,000 pounds per square inch			Weight per inch, 10^{-3} milligrams			Coefficient of variability for fineness		
	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]
Varieties	15	1,871.94		15	14.4436		15	68.05	
Locations	9	4,295.55		5	4.1040		5	66.29	
Varieties × locations	135	31.80		75	.0830		75	4.50	
Series within locations	70	89.10		42	.1998		42	5.58	
Ranges within locations	70	13.92		42	.0521		42	4.26	
Error	980	7.19		583	.0398		588	3.50	
Total	1,279	60.09		767	.3618		767	5.43	

[1] See footnote 1, table 3.

which in turn was greater than error. These data offer substantial evidence that varietal differences in weight per inch may be identified and that fineness of fiber is basically genetic. Locations exerted a large effect on weight per inch, and these effects tended to be consistent for all varieties, although in certain instances a minor but specific differential response was identified.

The analysis of variance for combined data from six locations for coefficient of variability for fineness is shown in the third section of table 18. The variance for varieties and locations was of approximately the same size and significantly exceeded interaction. It is therefore evident that varieties differ in regard to the variability for fineness and that conditions of growth likewise modify the same characteristic. A comparison of the combined analyses indicates clearly that the coefficient is a less efficient measure than fiber strength or weight-per-unit length for either varietal or locational differentiation.

FIBER MATURITY

Fiber-maturity data of two kinds—percentage of immature fibers and coefficient of variability for maturity as determined from the various length groups in the arrays—were obtained from certain samples in the 1935 regional cotton variety study. Complete data were obtained from South Carolina, Jackson, Tenn., and Greenville, Tex. Maturity data were obtained also from series 1 and 8 at the other 11 locations.

PERCENTAGE OF IMMATURE FIBERS

The varietal means and rank for percentage of immature fibers are summarized by locations in the top section of table 19. The locational means ranged from 33.80 to 18.30 for Knoxville and Jackson, Tenn., respectively, which indicates that immaturity as determined by the method employed varies widely among locations included in this study. The differences required for significance at the individual locations are unusually high, considering the size of the means. Some consistency between varietal means at the various locations was evident in varieties near the opposite ends of the rank, but in general the varietal behavior was not consistent.

TABLE 19.—*Varietal means and rank of fiber maturity—percentage of locations*

PERCENTAGE OF IMMATURE FIBERS

Variety	Prattville, Ala.[1]		Marianna, Ark. Delta[1]		Marianna, Ark. Upland[1]		Experiment, Ga.[1]		Baton Rouge, La.[1]		Stoneville, Miss.[1]		Statesville, N. C.[1]	
	Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
Acala (Roger)	31.77	8	21.64	11	24.26	10	36.93	2	36.81	4	27.45	6	21.22	8
Arkansas 17	30.92	11	27.33	5	23.18	12	28.82	9	32.66	8	22.98	14	22.09	6
Cleveland (W)	34.49	5	23.46	14	21.12	15	24.09	13	33.36	7	29.08	4	17.03	15
Cook 912	31.39	10	20.83	16	21.09	13	22.63	16	30.30	0	23.65	12	18.98	11
Delfos 4	45.44	1	34.38	2	33.98	2	36.39	3	42.77	1	29.11	3	22.59	4
Deltapine	28.80	14	22.03	15	21.06	14	27.44	12	27.30	14	25.61	9	15.94	16
Dixie Triumph 759	34.82	4	26.65	6	24.87	8	29.52	8	35.05	6	21.44	15	19.84	9
Farm Relief	31.62	0	29.24	3	28.40	5	39.30	1	36.19	5	24.23	11	27.65	1
Half and Half	29.22	13	21.69	10	26.49	7	27.72	11	27.85	13	23.00	13	21.58	7
Mexican Big Boll	26.65	15	25.70	8	1.27	0	23.02	14	25.53	16	18.50	16	17.06	14
Qualla	32.74	7	26.17	7	28.89	4	30.58	7	28.53	12	26.09	8	22.71	3
Rowden 2088	25.97	16	23.38	13	23.52	11	22.87	15	27.31	15	24.91	10	19.07	10
Startex 619	29.28	12	25.39	9	20.03	16	28.54	10	28.98	11	20.86	7	18.58	13
Stoneville 5	37.21	3	30.28	1	37.05	1	34.21	5	41.46	2	30.11	2	25.80	2
Triumph 44	33.55	0	23.91	12	27.24	6	32.73	6	20.02	10	27.78	5	18.77	12
Wilds 5	42.43	2	28.55	4	32.12	3	35.35	4	40.20	3	37.90	1	22.59	5
Average, all varieties	32.89		26.45		26.21		30.01		32.78		26.18		20.76	
Difference required, odds 99 : 1	10.54		11.75		9.61		10.38		11.20		11.99		12.16	

COEFFICIENT OF VARIABILITY FOR MATURITY

Variety	Prattville, Ala.[1]		Marianna, Ark. Delta[1]		Marianna, Ark. Upland[1]		Experiment, Ga.[1]		Baton Rouge, La.[1]		Stoneville, Miss.[1]		Statesville, N. C.[1]	
	Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
Acala (Roger)	32.55	1	31.12	1	29.42	1	24.24	5	24.39	0	25.26	8	25.86	3
Arkansas 17	21.72	3	30.13	2	27.50	2	17.30	16	17.58	15	34.78	2	22.12	10
Cleveland (W)	18.88	8	28.29	4	20.89	11	26.17	3	25.39	6	21.25	11	23.26	7
Cook 912	18.44	9	27.03	5	23.34	7	22.82	9	20.28	4	19.52	13	23.72	6
Delfos 4	17.39	12	25.74	7	22.39	8	23.59	7	21.00	11	37.35	1	22.05	8
Deltapine	24.60	2	28.56	3	26.42	3	23.07	8	21.61	9	29.62	3	21.29	12
Dixie Triumph 759	17.06	13	16.23	16	20.81	12	21.32	10	22.73	8	24.16	10	18.77	14
Farm Relief	21.69	4	20.69	13	20.40	13	19.45	15	19.38	14	25.98	6	18.92	13
Half and Half	18.44	10	22.23	10	24.08	6	20.67	12	16.11	16	18.17	15	20.34	16
Mexican Big Boll	15.25	15	18.24	15	21.30	9	19.85	14	27.06	3	28.40	4	21.52	11
Qualla	17.66	11	20.94	12	19.09	15	26.30	2	31.11	1	20.11	5	24.20	4
Rowden 2088	14.72	16	19.36	14	24.20	5	25.13	4	20.04	12	25.21	9	18.46	15
Startex 619	20.48	0	21.10	9	25.64	4	23.65	6	23.30	7	25.63	7	23.98	5
Stoneville 5	15.67	14	21.48	11	16.62	16	21.25	11	19.40	13	20.47	12	27.44	2
Triumph 44	19.04	7	25.22	8	21.20	10	19.94	13	27.62	2	17.82	16	22.70	9
Wilds 5	20.53	5	26.20	6	20.01	14	32.85	1	21.44	10	18.99	14	37.80	1
Average, all varieties	19.73		24.12		22.72		23.01		22.78		24.02		22.65	
Difference required, odds 99 : 1	15.55		23.53		11.81		10.34		16.26		21.95		22.65	

[1] Data from series 1 and 8 only.

COEFFICIENT OF VARIABILITY FOR MATURITY

A summary of the varietal means and rank by locations for coefficient of variability for maturity, is shown in the second section of table 19. The locational means range from 31.26 to 19.73 percent, for Jackson, Tenn., and Alabama, respectively. The difference required for significance indicates that the coefficient of variability is an extremely variable measure. In several cases the difference required for significance is of about the same order, and in one case exceeds the mean. A comparison of the varietal means and rank for the different locations shows little tendency for agreement.

immature fibers and coefficient of variability for maturity—for 14 in 1935

PERCENTAGE OF IMMATURE FIBERS—Continued

Stillwater, Okla.[1]		Florence, S. C.		Jackson, Tenn.		Knoxville, Tenn.[1]		College Station, Tex.[1]		Greenville, Tex.		Lubbock, Tex.[1]		Average, all locations	
Pct.	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*	*Pct.*	*Rank*
22.28	12	31.09	7	16.75	11	41.85	3	29.02	9	24.77	12	26.26	7	26.75	6
30.27	4	27.45	11	17.50	9	30.33	11	23.00	14	26.95	7	27.79	6	25.54	10
21.70	14	28.07	10	13.27	16	28.24	12	28.71	10	21.35	14	18.49	10	23.07	13
21.88	13	24.56	16	13.37	15	35.83	7	18.03	16	19.50	16	20.36	14	21.55	16
32.44	3	30.60	2	23.43	2	42.74	2	43.96	2	36.75	1	41.43	2	34.45	1
25.17	9	26.76	14	15.65	12	27.05	14	26.55	12	20.14	15	21.38	12	22.59	15
28.31	6	31.30	8	16.96	10	30.83	9	30.33	6	22.87	13	24.79	9	25.70	9
24.84	10	35.06	4	20.85	5	41.47	4	32.52	4	29.80	3	41.50	1	30.43	4
23.63	11	31.89	6	20.69	6	34.50	9	29.89	7	27.36	6	19.78	15	26.44	7
26.45	7	27.35	12	14.08	14	30.76	10	21.75	15	25.51	11	21.93	11	23.05	14
21.40	15	26.74	15	21.30	4	37.17	6	33.82	3	26.41	8	21.07	13	26.39	8
25.99	8	27.24	13	14.25	13	29.12	13	29.08	8	26.17	9	24.00	10	23.71	12
21.08	16	29.45	9	18.02	8	25.93	15	26.64	11	25.52	10	28.77	5	24.87	11
33.08	2	35.67	3	23.84	1	37.58	5	31.34	5	29.72	4	31.26	4	31.84	3
29.46	5	32.99	5	20.42	7	24.19	16	25.76	13	27.06	5	25.59	8	27.15	5
35.80	1	38.57	1	22.36	3	44.38	1	47.08	1	30.67	2	34.88	3	33.39	2
26.49	......	30.71	......	18.30	......	33.80	......	29.85	......	26.34	......	26.83	......	26.68	......
17.07	......	5.49	......	5.13	......	16.57	......	20.73	......	4.57	......	8.92	......	2.22	......
COEFFICIENT OF VARIABILITY FOR MATURITY—Continued															
35.81	1	29.16	1	35.99	4	26.97	3	28.40	3	32.96	1	29.19	2	30.69	1
18.61	11	19.74	10	34.54	5	26.10	5	22.84	4	27.92	4	21.85	12	25.62	5
19.12	9	25.44	2	28.58	11	24.94	7	19.93	7	28.42	3	25.55	8	25.36	6
27.94	2	22.49	4	31.76	7	14.77	16	28.69	2	26.41	7	26.75	4	25.30	7
18.68	10	16.59	13	29.34	8	24.57	9	14.04	16	20.77	15	14.74	16	22.15	12
15.57	14	20.60	7	37.64	3	27.56	2	19.05	9	27.80	5	23.43	10	26.32	4
18.11	13	16.26	14	28.60	10	18.05	14	16.60	13	23.54	11	22.72	11	21.35	14
19.56	7	19.75	9	27.34	12	23.13	10	22.61	5	24.76	10	20.56	13	22.60	11
15.37	15	15.27	15	27.22	13	16.27	15	21.29	6	23.29	12	27.35	3	20.54	16
19.54	8	21.24	3	38.76	2	20.46	1	30.03	1	25.10	9	30.75	1	26.69	3
23.09	4	21.02	6	26.72	14	22.19	11	18.14	10	26.50	6	26.58	5	24.04	8
19.79	6	20.15	8	33.10	6	20.87	13	17.00	12	19.62	16	25.22	9	22.68	10
23.85	3	15.19	16	28.61	9	24.67	8	17.59	11	25.34	8	18.38	15	22.95	9
18.36	12	18.26	12	25.35	15	21.46	12	14.85	14	22.71	13	26.09	6	21.23	15
15.27	16	19.69	11	24.44	16	25.32	6	19.10	8	21.00	14	19.34	14	21.48	13
20.03	5	21.00	5	42.11	1	26.18	4	14.73	15	30.55	2	25.86	7	27.82	2
20.55	......	20.31	......	31.26	......	23.34	......	20.31	......	25.42	......	24.02	......	24.17	......
21.16	......	7.29	......	10.84	......	12.42	......	18.39	......	6.99	......	16.79	......	3.44	......

ANALYSIS OF VARIANCE

A summary of analysis of variance by individual locations for percentage of immature fibers is shown in the top section of table 20. A comparison of the mean square for varieties with error shows significance at only 8 of the 14 locations. This finding in conjunction with the variability in mean square leads to the conclusion that percentage of immature fibers is not a highly stable character or one sufficiently sensitive to provide precise distinctions among varieties.

A summary of the analysis of variance at individual locations for coefficient of variability for maturity, is shown in the second

TABLE 20.—*Analysis of variance by locations for percentage of immature fibers and coefficient of variability for maturity*

PERCENTAGE OF IMMATURE FIBERS

Location	Mean squares				
	Total	Varieties	Series	Ranges	Error
Alabama, Prattville [1]	43.09	55.00	318.09		12.80
Arkansas, Marianna:					
Delta [1]	24.73	33.83	20.75		15.80
Upland [1]	31.25	46.91	5.60		10.64
Georgia, Experiment [1]	34.28	51.21	108.09		12.41
Louisiana, Baton Rouge [1]	30.67	59.65	22.83		14.60
Mississippi, Stoneville [1]	28.22	38.52	48.68		16.65
North Carolina, Statesville [1]	17.04	19.78	3.07		17.03
Oklahoma, Stillwater [1]	38.83	43.15	53.25		33.36
South Carolina, Florence	39.36	138.60	138.22	16.88	17.43
Tennessee:					
Jackson	28.04	103.95	62.52	10.48	15.22
Knoxville [1]	58.41	84.75	65.09		31.63
Texas:					
College Station [1]	77.22	108.50	23.10		40.48
Greenville	30.69	149.67	61.68	5.29	12.08
Lubbock [1]	56.71	103.91	62.02		9.16

COEFFICIENT OF VARIABILITY FOR MATURITY

Location	Total	Varieties	Series	Ranges	Error
Alabama, Prattville [1]	32.13	37.36	17.86		27.85
Arkansas, Marianna:					
Delta [1]	52.91	39.16	98.64		63.75
Upland [1]	30.81	22.46	227.43		16.07
Georgia, Experiment [1]	20.20	27.21	35.17		12.31
Louisiana, Baton Rouge [1]	30.31	32.15	.88		30.43
Mississippi, Stoneville [1]	69.51	64.42	350.18		55.60
North Carolina, Statesville [1]	60.04	66.08	12.33		59.07
Oklahoma, Stillwater [1]	51.23	54.31	.18		51.55
South Carolina, Florence	46.65	113.65	125.69	46.44	30.77
Tennessee:					
Jackson	96.52	218.79	264.50	65.73	68.00
Knoxville [1]	25.29	32.99	22.40		17.77
Texas:					
College Station [1]	45.38	51.20	53.00		38.93
Greenville	41.33	105.06	78.95		23.24
Lubbock [1]	33.16	35.61	6.84		32.47
Degrees of freedom	127	16	7	7	98
Do. [1]	31	15	1		15

[1] For series 1 and 8.

section of table 20. A comparison of mean square for varieties with the corresponding mean square error shows that in the 3 cases where complete data were available significant contributions were identified for varieties. At the 11 locations for which data on series 1 and 8 only were obtained, no significant contributions for varieties were identified. These data indicate that the coefficient of variability for maturity is not a sensitive or effective variable for making distinctions among varieties.

An analysis of variance for combined data from the three locations having complete data on percentage of immature fibers is shown in the first section of table 21. The contribution for locations dominates the analysis and significantly exceeds both varieties and interaction. Variety is significantly greater than varieties × locations, and interaction is significant when tested against error. From these data it is evident that percentage of immature fibers is determined largely by growth conditions, although varietal differences were identified.

An analysis of variance for combined data from the three locations having complete data on the coefficient of variability for

TABLE 21.—*Analysis of variance of fiber immaturity for 3 locations*

Source of variation	Percentage of immature fibers			Coefficient of variability for maturity		
	Degrees of freedom	Mean square	Significant comparisons [1]	Degrees of freedom	Mean square	Significant comparisons [1]
Varieties	15	337.13		15	253.71	
Locations	2	5,072.95		2	3,510.19	
Varieties × locations	30	27.50		30	91.8[illegible]	
Series within locations	21	87.47		21	156.40	
Ranges within locations	21	10.80		21	54.22	
Error	294	14.91		294	42.34	
Total	383	68.00		383	79.51	

[1] See footnote 1, table 3.

maturity is shown in the second section of table 21. The variance for locations definitely dominated the analysis and significantly exceeded that for varieties, which in turn was significantly greater than interaction. From these data it is clear that the coefficient of variability for maturity is largely determined by growth conditions, although general varietal differences and a differential response of varieties to places were identified. The coefficient of variability for maturity is a less efficient measure, both of locational effects and of varietal differences, than percentage of immature fibers.

LITERATURE CITED

(1) BROWN, H. B., and ANDERS, C. B.
1920. COTTON EXPERIMENTS. 1919 AND 1920. Miss. Agr. Expt. Sta. Bul. 187, 31 pp., illus.

(2) CRESWELL, C. F., and BIDWELL, G. L.
1921. COMPOSITION OF COTTON SEED. U. S. Dept. Agr. Dept. Bul. 948, 221 pp., illus.

(3) FISHER, R. A.
1938. STATISTICAL METHODS FOR RESEARCH WORKERS. Ed. 7, 356 pp., illus. Edinburgh and London.

(4) GARNER, W. W., ALLARD, H. A., and FOUBERT, C. L.
1914. OIL CONTENT OF SEEDS AS AFFECTED BY THE NUTRITION OF THE PLANT. Jour. Agr. Res. 3: 227-249.

(5) HANCOCK, N. I.
1942. FACTORS IN THE BREEDING OF COTTON FOR INCREASED OIL AND NITROGEN CONTENT. Tenn. Agr. Expt. Sta. Cir. 79, 7 pp.

(6) MELOY, G. S.
1943. OIL AND PROTEIN CONTENT OF COTTONSEED AFFECTED BY DEFOLIATION, DROUGHT, FROST. The Cotton and Cotton Oil Press 44 (23): 14-16.

(7) RAST, L. E.
1918. OIL CONTENT OF COTTON SEED AS INFLUENCED BY VARIETY AND SELECTION. Ga. Agr. Col. Cir. 70, 4 pp., illus.

(8) THARP, W. H., JR.
1943. HOW TO INCREASE COTTONSEED OIL PRODUCTION. U. S. Dept. Agr. AWI-46, 11 pp., illus.

(9) WARE, J. O.
1931. SELECTION OF COTTON PLANTS FOR PROTEIN AND OIL CONTENT. Ark. Agr. Expt. Sta. Bul. 268, pp. 34-35.

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