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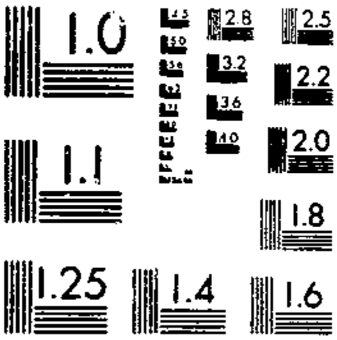

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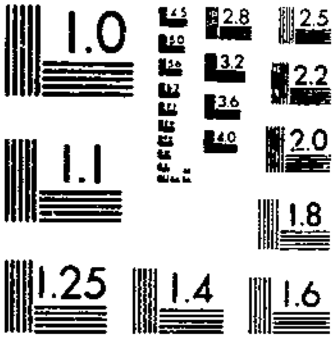

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NATIONAL BUREAU OF STANDARDS-1963-A

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Fiber and Spinning Properties of Cotton: A Correlation Study of the Effect of Variety and Environment[1]

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CONTENTS

During the past several years, extensive data have been accumulated on fiber and spinning properties representing upland, sea-island, and American-Egyptian cotton produced under a wide

[1] Submitted for publication May 26, 1948. Acknowledgment is made to the many agencies and workers who have contributed to these studies. The Cotton Branch, Production and Marketing Administration, U. S. Department of Agriculture, conducted the spinning tests and provided the skein strength data, the yarn-appearance data, and some of the fiber data. Various State and Federal agricultural experiment stations cooperated in growing and providing the samples. Private and institutional cotton breeders provided pure seed lots of the many varieties and strains of cotton tested. The University of Tennessee fiber research laboratory, under the direction of Dr. K. L. Hertel, and the State-Federal fiber laboratory, at Knoxville, under the direction of Mr. D. M. Simpson, furnished all of the fiber-length, surface-area, and fiber-strength data used in this bulletin, except as specifically noted that the fiber data were furnished by the Cotton Branch, PMA. The X-ray angle determinations were made in the Beltsville (Md.) fiber laboratory under the direction of Dr. E. E. Berkley. Dr. J. O. Ware handled the many details involved in arranging the cooperative plantings, ginning, sample taking, and other studies. The statistical computations were made by Mrs. Josephyne B. Griffin, Miss Martha A. Peck, and Mrs. Mary F. Holmead.

[2] Died September 28, 1948.

range of environmental conditions. Annual cooperative studies have been made by the agricultural experiment stations of the cotton-growing States and the United States Department of Agriculture. The detailed reports of the fiber and spinning results have been published annually. From time to time, certain summary reports have been made. These, for the most part, have been limited in scope or have not separately treated environmental and varietal influences. The present report is concerned primarily with the fiber and spinning data accumulated since the advent of the more rapid techniques for fiber testing and is concerned principally with relating environmental and varietal influences on fiber properties to spinning performance as measured by skein strength and yarn-appearance grade of single, carded, and combed yarns. It is summarized below.

SUMMARY

The fiber and spinning data relating to environmental and varietal influences on fiber properties were obtained from three groups of samples.

Group A consists of 447 samples from the 1945 and 1946 crops, spun into carded yarns by the long-draft roving and spinning process. The fiber measurements used in the study, with the exception of the X-ray determinations, were made in the University of Tennessee fiber research laboratory and are limited to fiber measurements that may be made with considerable rapidity on the Fibrograph, Arealometer, and Pressley breaker.

Group B consists of 408 samples spun by the regular-draft process from the 1941–44 crops; 227 of these went into carded counts of 22s, 36s, and 50s, and 181 into carded counts of 22s, 36s, and 60s. Fibrograph, Arealometer, and Pressley indexes were made in the two fiber laboratories at Knoxville, Tenn. Analyses for this group included also the more laborious fiber measurements for weight per inch and percentage of thick-walled fibers furnished by the laboratories of the Cotton Branch, Production and Marketing Administration.

Group C consists of 190 samples from the 1941–45 crops, spun into combed yarns. The fiber data included array measurements for upper quartile length and mean length, Pressley index, weight per inch, and percentage of thick-walled (mature) fibers furnished by the laboratories of the Cotton Branch, Production and Marketing Administration.

For the above three major groups of samples, simple and multiple correlation coefficients and regression equations are given for relating fiber properties to skein strength. For two of the groups, the analyses include yarn-appearance grades.

The importance of distinguishing between varietal, i.e., genetic, differences and environmental influences is clearly demonstrated by the marked differences in the regression equations. The results confirm previous observations that environmentally induced differences in fiber properties tend to be compensatory in nature. Growth conditions that result in fiber length exceeding normal for the variety tend to produce weaker and coarser fiber, and vice

versa. This tendency results, as would be expected, in lower simple and multiple correlation coefficients than those obtained for varietal differences.

Individual fiber properties that characterize different varieties vary in relative importance in contributing to the skein strength or yarn appearance, depending on the yarn count, or size, and upon whether any one property is approaching the optimum or the minimum requirement for good spinnability. For example, fiber strength is generally the most important single contributor to skein strength, usually accounting for as much as length and fineness combined. The relative importance of fiber strength decreases, and, conversely, the importance of length and fineness increases as smaller yarns are spun from a given sample and as fiber length approaches the minimum requirement for good spinnability. Differences in varieties for upper-half mean length are more closely associated with differences in skein strength than those for mean length. In fact, for varietal differences in skein strength, approximately equal weighting for upper-half mean and Pressley index provides nearly as good prediction as may be obtained by including other properties, such as mean length and surface area measurements, especially for the coarser yarn counts. This apparently is due to the fact that fineness for different varieties is rather closely associated with upper-half mean length.

Differences in upper-half mean length and in fineness contribute about equally to varietal differences in yarn-appearance grade.

In determining environmentally induced differences in fiber properties and skein strength, mean length is more important than upper-half mean, superseding Pressley index as the principal contributor to skein strength. Fineness is also of greater relative importance than in the case of varietal differences.

For environmental differences in yarn-appearance grade, fineness becomes the principal contributor, about equaling the combined contribution of mean length and Pressley index. Apparently Pressley index, which is of little or no contribution to yarn-appearance grade differences for varieties, becomes important as an index of weather exposure or deterioration caused by biological and physical agencies.

Several tables in the Appendix show the fiber properties and their relationship to spinning performance in several groups of samples other than those discussed in detail in the text. Some of these groups are too small to be of particular interest or the methods used in obtaining the data are no longer those of current interest. Also included in the appendix tables are subgroupings of some of the data treated in the text. Some of these tables may be of especial interest to those concerned with particular length groups. It is apparent from these studies that where accuracy of prediction is desired for a group of varieties having a narrow range in length, a specific regression equation should be used. A few such equations are shown. The writer will be glad to furnish those especially interested in varieties or growths having a narrow range of fiber properties additional formulas for special application.

SOURCE OF DATA AND STATISTICAL PROCEDURE

The data treated here were derived from the more recent of the annual series of cooperative plantings begun in 1935. From 1935 through 1937, a regional variety study was made in which 16 varieties were grown from the same seed lots for 3 years at 8 locations in the main Cotton Belt. Various agronomic, fiber, and spinning studies were made. Parts of the data are still unpublished. The results of the fiber and spinning tests were published in several reports issued by the Cotton Branch, Production and Marketing Administration. Based on these results, Webb and Richardson (*14*)[3] analyzed the relationships between fiber properties and carded yarn strength, but did not separate varietal and environmental influences. Pope and Ware (*9*) and Pearson (*7*) summarized the fiber properties characterizing the 16 varieties and as modified by season and place of growth.

Following the regional variety study, a plan was worked out for cooperative annual varietal and environmental studies on fiber and spinning properties. In this plan an attempt was made to serve more adequately the needs of the cotton breeders in various regions by including varieties and strains of local interest. As a consequence much of the symmetry with respect to varieties and locations necessarily was sacrificed but was compensated for by broadening the scope of study on both varietal differences and environmental effects.

By 1941 new and more rapid methods of fiber testing had been developed that permitted measuring a much larger number of samples between harvest and planting time. Hertel (*6*) had developed the Fibrograph for determining fiber length; Sullivan and Hertel (*12*) had developed the Arealometer for estimating the fineness, i. e., the surface area, of the fibers; and Pressley (*10*) developed an instrument that bears his name, the Pressley breaker, which replaced the more laborious Chandler bundle method for determining fiber strength. Keeping pace with these fiber-testing developments, the cooperatively run spinning laboratories at Clemson, S. C., and College Station, Tex., had developed procedures for handling a greater volume of spinning tests.

The present study on fiber and spinning data was set up to determine the usefulness to the cotton breeder and to the cotton improvement program of these more rapid methods for measuring fiber properties, using fiber and spinning data from the cooperative annual varietal and environmental studies conducted from 1941 through 1946. These studies include data on all of the principal varieties and strains of cotton that have been grown in this country during this period. The environmental conditions sampled each year are those that obtain in all of the States in which cotton growing, either under irrigation or rainfall conditions, is an important industry. About 30 State and Federal experiment stations and substations annually cooperate in providing the samples.

The fiber tests here reported were made on subsamples taken at ginning time from the spinning samples. For the crop years

[3] Italic numbers in parentheses refer to Literature Cited, p. 35.

1945–46, the fiber tests were made at the University of Tennessee fiber research laboratory at Knoxville, Tenn., except for the X-ray angle determinations, which have been made at the Beltsville, Md., laboratory since 1941. For the crop years 1941–44, inclusive, the surface area or the Arealometer determinations were made in the University of Tennessee fiber laboratory; and the upper-half mean length and the mean-length measurements of the Fibrograph were made in the State-Federal laboratory at Knoxville, as were the Pressley indexes, except for the combed yarn tests for 1941–45, in which all of the fiber data were furnished by the Cotton Branch, Production and Marketing Administration. Data on weight per inch and percentage of thick-walled fibers were furnished by the Cotton Branch, PMA, as were all of the yarn data on skein strength and yarn-appearance grades.

The spinning data for 1941–44 represent the regular-draft process; those for 1945–46 represent the long-draft roving and spinning process.

The detailed fiber and spinning data have been published in processed reports issued annually by the Cotton Branch, PMA, or by the Bureau of Plant Industry, Soils, and Agricultural Engineering.

The procedure used in analyzing the data is the conventional method outlined by Snedecor (*11*) and Wallace and Snedecor (*13*). The 1941–44 data were put on punch cards and handled in the usual manner. Data on the combed-yarn group and the 1945–46 carded-yarn group were calculated directly from the data sheets. Data prior to 1941 were not included in these studies, inasmuch as the methods of making fiber measurements were not strictly comparable.

Simple correlation coefficients were calculated for total, among-stations, among-varieties, within-stations, and within-varieties groups. Those for total effect, of course, represent the over-all or combined influences of heredity and environment, no clue being available as to the part attributable to either. Those for among-station and among-variety main effects represent primarily station and varietal influences, respectively. Since each station grew different varieties and each variety was grown at one or more but not at all stations, neither the among-station nor among-variety coefficients are free from bias. The within-station coefficients, however, do represent differences that safely can be attributed to varietal effects. Likewise, the within-variety coefficients represent soil, locational, climatic, seasonal, or other environmental effects from which varietal influences have been removed.

Since the primary purpose of these studies was to isolate and study differences that could be attributed to either varietal or environmental influences, the variances for total and main effects for stations and varieties were of little interest. The coefficients for within stations (varietal effects) and for within varieties (environmental effects) were, however, of especial interest and were used to obtain multiple correlation coefficients and regression equations. Inasmuch as it is awkward to refer continuously to within station as indicating varietal effects, and to within variety as indicating environmental effects, the adjectives varietal and environmental will be used to denote within-station and within-variety effects, respectively.

Further details of the statistical methods used may be found in the processed report by Barker (*1*), which treats of fiber and spinning property relationships of the 1945 crop.

SKEIN STRENGTH IN RELATION TO FIBER PROPERTIES

Instead of attempting to present and discuss all of the data that were studied and analyzed for skein strength and fiber-property relationships, it seemed preferable to relegate some of the smaller groups to the Appendix and to confine the main discussion to three major groups of samples.

CARDED YARNS

LONG-DRAFT SPINNING

Samples from the 1945 and 1946 cooperative studies were spun into carded and combed yarns on long-draft roving and spinning equipment. The 1945 samples had two counts common to the singles carded yarns. All were spun into 22s and 36s; the third count was variable, depending upon the upper-half mean length of the sample. For 71 of the samples, the third count was 50s except for 9 samples that were spun into 44s. These 9 samples represented varieties that were usually spun into 50s. They were, therefore, included even though this limited the analysis to the 2 counts, 22s and 36s, common to the 71 samples. This group was separately analyzed, and the results are presented in appendix tables 18 to 20. The group in which the third count was spun into 60s represented 157 samples. The results of the analysis of this group are shown in appendix tables 24 to 26. The rest of the group that was spun into 44s was so small that it was not analyzed.

For the 1946 crop, no 60s or 44s were spun. This resulted in a large group, 228 samples, in which three counts—22s, 36s, and 50s—were common. The results of the analyses of this group are shown in appendix tables 21 to 23. Another small group of 45 samples, representing the combed yarns spun into 60s, 80s, and 100s on the long-draft roving and spinning equipment during 1945–46, is shown in appendix tables 27 to 29.

In order to obtain a larger and more representative sample upon which to base relationships for fiber properties and carded yarns spun on long-draft equipment, it seemed logical to combine the 228 samples from the 1946 crop in which the 3 yarn counts of 22s, 36s, and 50s were common with the comparable samples from the 1945 crop. This necessitated converting the 60s of the 157 samples from the 1945 crop to 50s, which was done by using regressions established by the Cotton Branch, PMA. For the purposes of this study, it was felt that little violence to the data would result. This combination resulted in 447 samples representing 53 among-station-year observations, leaving 394 within-station-year observations for estimating varietal influences—a sufficiently diverse and sizable number of observations to inspire considerable confidence in interpreting varietal effects.

The number of among-variety observations was 149, leaving 298 within-variety observations for studying environmental influences. Actually, the almost 300 within-variety observations could have been increased conservatively, since it was known that for several of the varieties the seed stocks were the same for 1945 and 1946; but since in some instances it was unknown whether the seed stocks were identical, the safer procedure seemed to be to take only the sum of the within-variety observations for each year. For convenience, this composite group of 447 samples will be referred to as group A.

SIMPLE CORRELATIONS

The simple correlation coefficients (r) are of interest per se as well as in computing the standard regression coefficients referred to as betas (β). The simple correlation coefficients for group A are given in table 1.

TABLE 1.—*Simple correlation coefficients for the varietal (within-station) and environmental (within-variety) comparisons for group A*

Variates [1]	Coefficients		Variates [1]	Coefficients	
	Varietal differences	Environmental differences		Varietal differences	Environmental differences
22s with UHM	0.64*	0.32*	UHM with ML	0.69*	0.91*
22s with ML	.45*	.35*	UHM with SA	.32*	−.08
22s with SA	.35*	.20*	UHM with PI	.41*	−.34*
22s with PI	.81*	.38*	UHM with XR	−.22*	.55*
22s with XR	−.63*	−.07			
			ML with SA	−.10	−.24*
36s with UHM	.64*	.33*	ML with PI	.26*	−.29*
36s with ML	.44*	.36*	ML with XR	−.12	.43*
36s with SA	.37*	.22*			
36s with PI	.81*	.37*	PI with SA	.21*	.06
36s with XR	−.62*	−.09	PI with XR	−.79	−.69*
50s with UHM	.65*	.42*	SA with XR	−.12	.05
50s with ML	.44*	.43*			
50s with SA	.41*	.27*			
50s with PI	.78*	.33*			
50s with XR	−.60*	.00			

[1] The identity of the symbols used for the variates is as follows: 22s, 36s, and 50s = skein strength of 22s, 36s, and 50s carded yarns, respectively; UHM = Fibrograph upper-half mean length; ML = Fibrograph mean length; SA = surface area, or Arealometer measurement; PI = Pressley index; and XR = X-ray angle.

* = Correlation coefficient significant at odds of 99:1.

From table 1 it is evident that for varietal effects all five fiber properties shown are highly correlated with skein strength. Pressley index leads for all counts but is slightly lower for 50s. X-ray angle is consistently lower than Pressley index at all counts, but is negative in sign. Upper-half mean length has a correlation coefficient of 0.64 or greater for all counts. Mean length is consistently lower for each count. The coefficient for fineness increases slowly but steadily as the yarns become smaller.

Upper-half mean length is significantly associated with each of the other four fiber measurements, especially with mean length. Mean length is significantly and positively associated with Pressley strength. Correlations of mean length with surface area and X-ray are negative but not significant. Pressley index, as expected, shows a high negative relation to X-ray angle; and the positive association with surface area reaches significance at odds of 99:1.

For environmental effects, a very different relationship is evident. Individual fiber properties are not very closely correlated with skein strength, although all of them except X-ray angle reach significance. Pressley index, mean length, and upper-half mean length appear to be of approximately equal importance in relation to skein strength of 22s and 36s. For 50s, Pressley index recedes in importance and is almost equaled by surface area which gains somewhat as yarn size decreases. Upper-half mean with mean length attains a positive coefficient exceeding 0.90. Both upper-half mean and mean length have a significant negative coefficient with Pressley index, but positive with X-ray angle—a sharp contrast to the relationship for varietal properties. Surface area was found to have a negative relationship with both upper-half mean and mean length, the latter reaching significance. Pressley index and X-ray-angle relationship remains highly negative but is somewhat less than for varietal effects.

MULTIPLE CORRELATIONS

Regression equations are not presented for all of the combinations of fiber properties that are shown. For those who may feel that some equations not reported would better serve their needs, the pertinent variances for group A are given in table 2.

TABLE 2.—*Mean measurements for fiber and yarn properties for 447 observations, and variances for varietal and environmental comparisons for group A*

Variate	Means	Variance	
		Varietal comparisons	Environmental comparisons
Skein strength of 22s	114.79 pounds	38,810.1909	20,467.6096
Skein strength of 36s	61.96 pounds	13,847.8023	7,341.9074
Skein strength of 50s	41.14 pounds	7,588.0316	4,035.8715
Upper-half mean length	1.069 inches	.8980	.9886
Mean length	.819 inch	1.0114	1.6172
Surface area	2.883 cm.² mg.	14.9450	13.4767
Pressley index	6.679	104.8145	58.0300
X-ray angle	35.6°	3,072.3282	1,448.6855

The relation of fiber properties to skein strength of singles carded yarns spun on long-draft roving and spinning equipment, as determined from multiple correlation studies on group A, is shown in table 3. Some of the very interesting facts brought out there may be dealt with briefly; others merit careful study.

For all yarn counts for both varietal and environmental effects, the addition of X-ray-angle determinations is without appreciable effect. Previously (*4*), it has been shown that where Pressley index determinations were questionable, owing to biological deterioration of the fiber, X-ray-angle determinations may be substituted for fiber-strength measurements. It also has been indicated (*8*) that the inclusion of both Pressley index and X-ray-angle determinations is of value for determining strength of plied yarns. For estimating skein strength of singles carded yarns, however, it appears that unless the Pressley indexes are questionable, X-ray-angle determinations add little to the multiple correlation coefficients.

As was true for the simple correlation coefficients, the multiples are much lower for environmental than for varietal effects. The R^2 values in table 3 indicate that whereas about 80 percent of the varietal differences in skein strength may be accounted for by four rapidly measured fiber properties obtained from the Fibrograph, Pressley breaker, and the Arealometer, the maximum noted for environmental differences was 55 percent for 50s.

One very important fact that stands out in table 3 is that from the standpoint of the practical breeder whose main interest is in genetic differences, R^2 is nearly as high for two properties, upper-half mean length and Pressley index, as it is when all four or five fiber measurements are evaluated. Omitting both mean length and surface area, the percentage of skein strength accounted for drops off only 2 percent for 22s, 3 percent for 36s, and 4 percent for 50s.

That good predictions for varietal differences in skein strength could be made by considering only differences in upper-half mean length and Pressley index was, so far as the writers are aware, first noted by Pope (unpublished data) and by Barker and Berkley (*2*). That Arealometer measurements can usually be dispensed with in estimating varietal differences in spinning performance is apparently due to the fact that genetic differences in fiber length are rather closely associated with differences in surface area, as was previously noted in the discussion of simple correlation coefficients (p. 8). A word of caution is in order for those who may use only length and strength in estimating varietal differences in skein strength; occasional difficulty will be encountered when a variety is unusually coarse or fine for its length. The writers found that predictions made in this manner were invariably too high for varieties Station C, Station 21, and Rowden, but too low for a few varieties that had finer-than-average fiber for their length group.

For environmentally induced differences in fiber and spinning properties, however, a very different condition exists. In the first place, mean length supersedes upper-half mean length as the important length measurement, and surface area measurements become of greater importance. Secondly, surface area measurements cannot be omitted without causing appreciable reduction in

TABLE 3.—*Contribution of fiber properties to skein strength of 22s, 36s, and 50s singles carded yarns, long-draft process, as determined from multiple correlation studies of varietal and environmental effect in group A*

Fiber properties, R, and R^2	Correlation results with carded yarns: Varietal comparisons								
	22s			36s			50s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*	
Upper-half mean	0.23*	20		0.22*	18		0.23*	19	
Mean length	.14*	12		.15*	12		.16*	13	
Surface area	.15*	13		.18*	15		.24*	19	
Pressley index	.59*	49		.60*	50		.51*	41	
X-ray angle	−.08	6		−.06	5		−.10	8	
R			0.89			0.89			0.88
R^2			.79			.80			.77
Upper-half mean	.23*	19		.21*	18		.22*	18	
Mean length	.14*	12		.14*	12		.15*	13	
Surface area	.15*	13		.18*	15		.23*	19	
Pressley index	.65*	56		.66*	55		.59*	49	
R			.89			.89			.88
R^2			.79			.80			.77
Upper-half mean	.33*	32		.34*	33		.39*	39	
Mean length	.04	4		.03	3		.01	1	
Pressley index	.66*	64		.67*	64		.61*	60	
R			.88			.88			.86
R^2			.77			.77			.73
Upper-half mean	.36*	35		.36*	35		.40*	39	
Pressley index	.66*	65		.66*	65		.61*	61	
R			.88			.88			.86
R^2			.77			.77			.73
Mean length									
Pressley index									
R									
R^2									

Fiber properties, R, and R^2	Correlation results with carded yarns: Environmental comparisons								
	22s			36s			50s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*	
Upper-half mean	−0.04	2		0.00	0		0.06	3	
Mean length	.58*	37		.59*	40		.59*	36	
Surface area	.30*	19		.33*	23		.38*	23	
Pressley index	.57*	36		.53*	36		.55*	33	
X-ray angle	.08	5		.01	1		.08	5	
R			0.68			0.70			0.75
R^2			.46			.49			.56
Upper-half mean	.01	1		.01	1		.11	7	
Mean length	.56*	40		.59*	40		.57*	36	
Surface area	.30*	22		.33*	23		.38*	24	
Pressley index	.52*	37		.53*	36		.51*	32	
R			.68			.70			.74
R^2			.46			.49			.55
Upper-half mean	.26*	24		.28*	25		.41*	35	
Mean length	.27*	25		.27*	25		.21	18	
Pressley index	.54*	51		.55*	50		.53*	46	
R			.62			.63			.66
R^2			.38			.40			.43
Upper-half mean									
Pressley index									
R									
R^2									
Mean length	.50*	49		.52*	50		.57*	54	
Pressley index	.52*	51		.52*	50		.49*	46	
R			.61			.62			.64
R^2			.37			.38			.40

* = Beta values significant at odds of 99 : 1.

the R^2 values.

In table 3 the columns headed "Relative effect" are of especial interest. The figures given indicate the relative contribution of the several fiber properties to skein strength. In this large group that represents most of the varieties spun in 1945 and 1946, about 55 percent of the variation between varieties is accounted for in 22s and 36s by differences in fiber strength expressed as Pressley index and X-ray angle, or as Pressley index alone when X-ray angle is omitted. For 50s, surface area becomes of increasing importance, largely at the expense of Pressley index, which is credited with only 49 percent of the skein strength.

For environmentally induced differences, mean length leads for relative effect but is closely followed by Pressley index. Differences in surface area assume importance, accounting for nearly one-fourth of the differences in skein strength.

A study of the relative effects in the appendix tables for the different groups shows some very interesting trends for these percentage figures in comparing variety and environment, coarser and finer counts, and longer and shorter length groups. While several pages of discussion might be used for these trends and their implications, it seems preferable to provide the detailed information in tables in the Appendix for the use of those readers who are interested in special applications.

From tables 2 and 3, regression equations were derived for making generalized skein strength predictions for singles carded yarns spun on long-draft roving and spinning equipment. It is evident from tables 1 and 3 that different regression equations are required to predict varietal effects at a given location and environmentally induced differences within a given variety. Probably most breeders are interested in varieties and strains that have a considerable range in fiber length and other properties. For them the following formulas should be useful. For those who may have especial interest in shorter or longer varieties or growths, specialized equations may be calculated from the data given in the appendix tables 12 to 14 and 21 to 29.

From group A the following regression equations are recommended for estimating skein strength differences:

1. Among varieties at one location where—
   - (a) Arealometer, Fibrograph, and Pressley breaker data are available:
     22s = 46.90 UHM + 26.72 ML + 7.68 SA + 12.58 PI − 65.54
     36s = 26.03 UHM + 16.35 ML + 5.57 SA + 7.49 PI − 46.99
     50s = 20.48 UHM + 13.31 ML + 5.28 SA + 5.06 PI − 39.81.
   - (b) Fibrograph and Pressley breaker data only are available:
     22s = 75.76 UHM + 12.78 PI − 53.68
     36s = 45.05 UHM + 7.64 PI − 38.49
     50s = 36.53 UHM + 5.20 PI − 31.88.
2. Among samples representing different growth conditions for a given variety where—
   - (a) Arealometer, Fibrograph, and Pressley breaker data are available:
     22s = 2.13 UHM + 62.96 ML + 11.86 SA + 9.86 PI − 40.28
     36s = 1.12 UHM + 39.51 ML + 7.81 SA + 5.91 PI − 34.31
     50s = 6.[illegible]3 UHM + 28.46 ML + 6.60 SA + 4.21 PI − 35.48.
   - (b) Fibrograph and Pressley breaker data only are available:
     22s = 36.81 UHM + 30.70 ML + 10.22 PI − 19.31
     36s = 23.90 UHM + 18.29 ML + 6.15 PI − 20.44
     50s = 25.98 UHM + 10.56 ML + 4.42 PI − 23.78.

In the above equations the constants differ slightly from those that would have been obtained by using the mean values for skein strengths and fiber properties shown in table 2. The constants were derived from the mean values given in appendix tables 21 to 23 for the 1946 crop. There appeared to be two valid reasons for using the means from the 1946 crop only: (1) Some of the values for skein strength of 50s in the 1945 crop represented 60s converted to 50s, as previously noted; and (2) Pressley indexes for the 1945 crop were low, being adjusted to two standard samples that differ from the set that is at present being widely used. For comparative purposes it is of course of no importance to what standard sample the daily Pressley breaks are adjusted, so long as the correction is constant for a given set of data. The 1946 level for Pressley indexes, however, was preferred in the above equations because many fiber laboratories are now using the same set of standard samples, and the Bureau of Plant Industry, Soils, and Agricultural Engineering has a sufficient quantity to supply interested laboratories for several seasons.

Experience gained from these studies has indicated the need for adjusting the constant to different station levels when spinning results become available for some but not all of the samples in which the breeder is interested. For example, suppose that at station Z lack of funds permitted spinning 10 samples only, and the breeder is very much interested in comparing the spinning results obtained from the 10 samples with estimated performance for the 40 other strains. It is obvious that for this purpose, predictions for the 40 unspun strains should be based on the average performance at that particular station for the season in question instead of on the mean for all stations in the entire Cotton Belt. Such modification may readily be made as follows: Consider that at station Z the 10 strains that were spun gave mean skein strengths and fiber properties as shown in table 2. Then the equation for predicting the 40 unspun samples would become:

$$22s = 46.90\,(UHM - 1.069) + 26.72\,(ML - 0.819) + 7.68\,(SA - 2.883) + 12.58\,(PI - 6.679) + 114.79$$

which reduces to

$$22s = 46.90\ UHM + 26.72\ ML + 7.68\ SA + 12.58\ PI - 63.44.$$

In this example the mean values, for obvious reasons, differ little from those that were used for obtaining the generalized equation; consequently, the constant is changed by only 2.1 pounds, but it serves to illustrate how simple the procedure is. This is important and has been demonstrated to be practical from the standpoint of the breeder, and may be of considerable value in the one-variety community development. For instance, were one interested in spinning many lots representing numerous localities and conditions of growth of cotton from a given variety, it might be desired to spot check occasional samples for fiber properties and perhaps have a few spinning tests made. Such data would provide the means of modifying the constant in the equations for estimating for the variety in question what performance could be expected for the lots from different localities.

REGULAR-DRAFT SPINNING

Some readers, no doubt, will be interested in what is here designated as group B for studying the relationship of fiber and spinning properties where the regular-draft spinning process is used. Group B is divided, largely on the basis of fiber length, into two subgroups, designated B_1 and B_2. An additional group is included in appendix table 13.

Subgroup B_1 represents the varieties and growths from the 1941–44 crops that were spun by the regular-draft process into carded yarns of 22s, 36s, and 50s. The lot comprises 227 samples obtained from 111 varieties and strains representing 36 station years, thus giving 191 and 116 observations for evaluating varietal and environmental differences, respectively.

The subgroup B_2 represents samples that were processed in the same manner as B_1, with the exception that the top count was 60s instead of 50s. There is some overlapping of varieties in the two subgroups. For example, a variety that under most environmental conditions produced fiber that was too short to be spun into 60s would, under exceptional conditions, produce fiber sufficiently long to be spun into 60s. Conversely, some varieties that usually were spun into top counts of 60s would occasionally produce staple that was judged to be too short for 60s. The subgroups therefore represent both varietal and environmentally induced differences in fiber properties.

SIMPLE CORRELATIONS

Simple correlation coefficients obtained for subgroups B_1 and B_2 are given in table 4. It is very interesting to note that within B_2 there is a very close association of heritable fiber and spinning properties. Several measurements for fiber length, strength, and fineness correlated with skein strength have coefficients ranging from about 0.60 to 0.80 for subgroup B_2 but rarely exceeding 0.40 for subgroup B_1. The rather close relationship between fineness, expressed as either surface area or weight per inch, and skein strength increases markedly as yarn size decreases in B_1. Pressley index and skein strengths for all three yarn counts give very high coefficients within subgroup B_2.

TABLE 4.—*Simple correlation coefficients for varietal (within-station) and environmental (within-variety) comparisons for group B*

Variates [1]	Subgroup B_1		Subgroup B_2	
	Varietal	Environmental	Varietal	Environmental
22s with UHM	0.41*	0.05	0.63*	0.18
22s with ML	.42*	.05	.60*	.22
22s with SA	.33*	.19	.16	.06
22s with PI	.44*	.38*	.82*	.32*
22s with XR	−.10	−.21	−.63*	−.25*
22s with WI	−.45*	−.23	−.57*	−.22
22s with TW	−.10	−.16	.15	−.02

TABLE 4.—*Simple correlation coefficients for varietal (within-station) and environmental (within-variety) comparisons for group B*—Continued

Variates [1]	Subgroup B_1		Subgroup B_2	
	Varietal	Environmental	Varietal	Environmental
36s with UHM	.46*	.09	.65*	.24
36s with ML	.40*	.06	.61*	.29*
36s with SA	.41*	.25*	.20	.21
36s with PI	.43*	.38*	.81*	.32*
36s with XR	−.13	−.22	−.63*	−.22
36s with WI	−.54*	−.30*	−.60*	−.33*
36s with TW	−.13	−.22	.14	−.07
50s with UHM	.55*	.00	....	....
50s with ML	.45*	−.01	....	....
50s with SA	.55*	.34*	....	....
50s with PI	.30*	.32*	....	....
50s with XR	−.06	−.12	....	....
50s with WI	−.68*	−.42*	....	....
50s with TW	−.24*	−.34*	....	....
60s with UHM	....	....	.67*	.19
60s with ML	....	....	.60*	.25*
60s with SA	....	....	.25*	.31*
60s with PI	....	....	.79*	.24
60s with XR	....	....	−.60*	−.14
60s with WI	....	....	−.63*	−.38*
60s with TW	....	....	.11	−.07
UHM with ML	.75*	.86*	.73*	.74*
UHM with SA	.46*	−.12	.29*	.05
UHM with PI	−.07	−.39*	.29*	−.26*
UHM with XR	.13	.40*	−.21*	.14
UHM with WI	−.53*	.10	−.49*	−.25*
UHM with TW	−.23*	.11	.10	−.34*
ML with SA	.13	−.34*	−.02	−.05
ML with PI	−.05	−.34*	.30*	−.23
ML with XR	.18*	.35*	−.20	−.07
ML with WI	−.24*	.29*	−.32*	−.22
ML with TW	.01	.28*	.22*	−.17
SA with PI	−.04	−.05	.20	−.15
SA with XR	.07	.05	−.11	.42*
SA with WI	−.77*	−.79*	−.61*	−.70*
SA with TW	−.60*	−.74*	−.51*	−.50*
PI with XR	−.68*	−.76*	−.86*	−.71*
PI with WI	−.01	−.13	−.54*	.06
PI with TW	.00	.06	−.02	.31*
XR with WI	−.14	−.04	.40*	−.32*
XR with TW	.11	−.05	.16	−.39*
WI with TW	.58*	.80*	.36*	.63*

[1] The identity of the symbols used for the variates is as follows: 22s, 36s, 50s, and 60s = skein strength of 22s, 36s, 50s, and 60s carded yarns, respectively; UHM = Fibrograph upper-half mean length; ML = Fibrograph mean length; SA = surface area or Arealometer measurement; PI = Pressley index; XR = X-ray angle; WI = weight per inch; and TW = percentage of thick-walled fibers.
* = Significant at odds of 99 : 1.

For environmentally induced differences in skein strength in 22s, one coefficient only, Pressley index with skein strength, reaches significance at odds of 99:1 for both subgroups. For 36s and 50s (or 60s), weight per inch also attains significance in both subgroups, and mean length becomes significant in subgroup B_2. In general, for environmental differences the two subgroups differ from each other much less than they do for association of varietal differences. The negative relation for percentage of thick-walled fibers attains significance for 50s in B_1 but is very low for 60s in B_2.

In considering the interrelationships of the fiber properties, it is interesting to note that upper-half mean length and surface area are significantly associated for varietal but not for environmental differences. In B_2 a significant positive association for upper-half mean length and Pressley index was found for varietal influences, but a significant negative relation for environmental effects. The invariably high coefficients for interrelation of surface area, weight per inch, and percentage of thick-walled fibers are of interest. It may be remarked, however, that they do not appear to be sufficiently high that one could with confidence consider establishing regressions for expressing one measurement in terms of the other, as has been suggested by Pfeiffenberger (*8*) and others.

MULTIPLE CORRELATIONS

For those who may be interested in solving equations other than those shown here, the mean measurements for skein strength and fiber properties of group B and the variances are given in table 5. Skein strength for subgroup B_1 is 9 pounds lower for 22s and 6 pounds lower for 36s than those of subgroup B_2. With respect to fiber properties subgroup B_1 averages 0.12 (or 1/8) inch shorter than B_2 for upper-half mean length and almost as much for mean length. B_1 is considerably coarser as judged by surface area measurements. Pressley index is approximately the same for the two subgroups, although B_1 averages nearly 2° smaller X-ray angle.

The relation of fiber properties to skein strength obtained by regular-draft process is shown in table 6. From 86 to 88 percent of varietal differences in skein strength is accounted for in B_2, whereas in B_1 the same properties account for less than 70 percent. For environmentally induced differences, however, the two subgroups do not differ appreciably, both having a maximum of 35 percent of the skein strength accounted for by fiber-property measurements. In fact, R^2 values are slightly higher for environmental comparisons in B_1 except for 36s.

Varietal comparisons in B_1 show that only three beta values reach significance for 22s: (1) Mean length, which is indicated as accounting for 20 percent of skein strength; (2) Pressley index, accounting for 31 percent; and (3) weight per inch, credited with 20 percent. For 36s a fourth property, percentage of thick-walled fibers, reaches significance, and for 50s a fifth property, surface area, becomes significant. From the standpoint of yarn size, mean fiber length and Pressley index make progressively smaller

TABLE 5.—*Mean measurements for yarn and fiber properties for group B, and variances for varietal and environmental comparisons*

Variate	Means		Variance			
			Subgroup B_1		Subgroup B_2	
	Subgroup B_1	Subgroup B_2	Varietal	Environmental	Varietal	Environmental
Skein strength of 22s	97.07	106.40	7,341.4164	2,929.0870	14,825.1902	4,148.3878
Skein strength of 36s	50.36	56.55	2,997.1320	1,204.4815	5,532.4344	1,789.3692
Skein strength of 50s	31.61	......	1,993.3060	971.7766	......	......
Skein strength of 60s		27.96	......		1,944.8461	840.2294
Upper-half mean length	1.012	1.131	.3089	.2586	.3748	.1159
Mean length	.827	.914	.2536	.3033	.3186	.1779
Surface area	2.943	3.126	11.8086	8.8273	4.8039	4.3902
Pressley index	7.501	7.450	29.6280	22.3304	47.2258	19.1429
X-ray angle	32.970	34.750	1,427.7432	837.6767	1,458.4406	548.2177

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TABLE 6.—*Contribution of fiber properties to skein strength of singles carded yarns, regular-draft process, as determined from multiple correlation studies for group B*

SUBGROUP B_1

Fiber properties, R, and R^2	Correlation results with carded yarns: Varietal comparisons								
	22s			36s			50s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*	
Upper-half mean length	−0.06	3		0.00	0		−0.01	0	
Mean length	.36*	20		.28*	17		.31*	19	
Pressley index	.56*	31		.46*	28		.30*	18	
X-ray angle	.16	9		.03	2		−.02	1	
Surface area	.13	7		.16	10		.23*	14	
Weight per inch	−.36*	20		−.48*	29		−.56*	34	
Thick-walled fibers	.16	9		.24*	14		.22*	14	
R			0.75			0.78			0.83
R^2			.56			.60			.68
Upper-half mean length	.04	3		.11	9		.13	11	
Mean length	.38*	32		.30	24		.31*	25	
Pressley index	.48*	41		.46*	38		.34*	28	
Surface area	.28*	24		.34*	28		.46*	37	
R			.69			.71			.76
R^2			.48			.51			.57
Upper-half mean length	.25*	25		.38*	39		.51*	54	
Mean length	.26*	27		.13	14		.09	10	
Pressley index	.47*	48		.46*	47		.34*	36	
R			.65			.65			.65
R^2			.42			.42			.42
Upper-half mean length	.44*	48		.49*	51		.58*	63	
Pressley index	.47*	52		.46*	48		.34*	37	
R			.62			.65			.65
R^2			.39			.42			.42

Mean length	.44*	49		.42*	49		.47*	59	
Pressley index	.46*	51		.44*	51		.32*	41	
R			.62			.60			.56
R^2			.39			.36			.31

SUBGROUP B_2

Upper-half mean length	0.33*	21		0.31*	20		0.35*	23	
Mean length	.11	7		.13*	8		.09	6	
Pressley index	.75*	48		.70*	47		.70*	46	
X-ray angle	.12	8		.09	6		.13	8	
Surface area	−.10	6		−.05	3		−.02	1	
Weight per inch	−.10	7		−.13	8		−.15*	10	
Thick-walled fibers	.08	5		.10	7		.10	6	
R			0.93			0.94			0.93
R^2			.86			.88			.86
Upper-half mean length	.36*	28		.35*	29		.40*	34	
Mean length	.13*	10		.15*	12		.12	10	
Pressley index	.69*	55		.67*	56		.64*	55	
Surface area	−.08	6		−.04	3		.01	1	
R			.92			.93			.92
R^2			.85			.86			.84
Upper-half mean length	.31*	27		.33*	28		.40*	35	
Mean length	.17*	15		.17*	15		.11	10	
Pressley index	.67*	58		.67*	57		.64*	55	
R			.92			.93			.92
R^2			.85			.86			.84
Upper-half mean length	.42*	38		.45*	40		.48*	42	
Pressley index	.69*	62		.68*	60		.65*	58	
R			.91			.92			.92
R^2			.83			.85			.84
Mean length	.39*	36		.40*	37		.39*	37	
Pressley index	.70*	64		.69*	63		.67*	63	
R			.90			.90			.88
R^2			.80			.81			.77

* = Beta values significant at odds of 99 : 1.

TABLE 6.—*Contribution of fiber properties to skein strength of singles carded yarns, regular-draft process, as determined from multiple correlation studies for group B*—Continued

SUBGROUP B_1

Fiber properties, R, and R^2	Correlation results with carded yarns: Environmental comparisons								
	22s			36s			50s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*	
Upper-half mean length	0.02	1		0.08	4		0.15	8	
Mean length	.33	17		.32	19		.43	22	
Pressley index	.68*	36		.64*	37		.60*	31	
X-ray angle	.17	9		.10	6		.22	11	
Surface area	.32	17		.33	19		.30	16	
Weight per inch	.18	10		.08	5		−.01	0	
Thick-walled fibers	−.19	10		−.17	10		−.24	12	
R			0.54			0.59			0.59
R^2			.30			.35			.35
Upper-half mean length	.01	1		.08	6		−.12	8	
Mean length	.33	28		.32	24		.41	28	
Pressley index	.52*	44		.55*	41		.44*	30	
Surface area	.33*	27		.39*	29		.49*	34	
R			.53			.58			.55
R^2			.28			.34			.31
Upper-half mean length	.21	29		.32	37		.18	30	
Mean length	.04	6		−.04	4		−.03	5	
Pressley index	.48*	66		.50*	58		.38*	65	
R			.44			.47			.35
R^2			.20			.22			.12
Upper-half mean length	.24*	34		.29*	36		.16	29	
Pressley index	.48*	66		.50*	64		.38*	71	
R			.44			.47			.35
R^2			.20			.22			.12

Mean length	.21*	32		.22*	33		.12*	25	
Pressley index	.46*	68		.46*	67		.36*	75	
R			.43			.44			.34
R^2			.19			.19			.12

SUBGROUP B_2

Upper-half mean length	0.12	12		0.14	10		0.09	6	
Mean length	.16	17		.24	18		.23	16	
Pressley index	.33	34		.37	27		.25	17	
X-ray angle	−.07	8		−.07	5		−.09	6	
Surface area	.01	1		.20	14		.32	22	
Weight per inch	−.22	23		−.23	17		−.25	18	
Thick-walled fibers	.06	6		.12	9		.20	14	
R			0.48			0.59			0.57
R^2			.23			.35			.33
Upper-half mean length	.10	11		.10	8		.02	1	
Mean length	.25	28		.33	28		.34	31	
Pressley index	.42*	47		.47*	39		.38*	34	
Surface area	.13	14		.29*	24		.38*	34	
R			.46			.57			.55
R^2			.21			.33			.30
Upper-half mean length	.12	16		.14	17		.08	12	
Mean length	.22	30		.27	32		.26	40	
Pressley index	.40*	54		.42*	50		.32*	48	
R			.44			.50			.40
R^2			.20			.25			.16
Upper-half mean length	.28*	42		.35*	46		.27*	47	
Pressley index	.39*	58		.41*	54		.31*	53	
R			.42			.46			.36
R^2			.18			.22			.13
Mean length	.31*	44		.38*	48		.32*	51	
Pressley index	.39*	56		.41*	52		.31*	49	
R			.44			.49			.39
R^2			.19			.24			.16

* = Beta values significant at odds of 99 : 1.

contributions, whereas surface area, weight per inch, and percentage of thick-walled fibers make progressively greater contributions as yarn size decreases. The four properties that are rapidly measured by the Fibrograph, Pressley breaker, and Arealometer result in R^2 values that are appreciably lower than those derived from all seven properties shown. A still further reduction in R^2 values results where only Fibrograph and Pressley index measurements are included. Such, it will be recalled, is not the case for group A, or, as will be seen, for subgroup B_2.

For environmental comparisons in B_1, only the beta value for Pressley index reaches significance where seven measurements are included in the multiple correlation. Where only the four rapidly measured fiber properties are included, both Pressley index and surface area become significant; Fibrograph mean length barely fails to reach significance; and upper-half mean length contributes almost nothing and even has a negative beta for 50s. It is interesting to note that where fineness measurements are omitted and only Fibrograph and Pressley breaker measurements are included, upper-half mean length becomes more important than mean length. For environmental as well as for varietal comparisons, surface area measurements in B_1 become of increasing importance as yarn size is reduced.

In B_2, surprisingly high R^2 values were obtained for varietal comparisons. For 36s only two measurements, Pressley index and upper-half mean length, account for 85 percent of the skein strength. Arealometer and other types of fineness measurements seem to be of little value. Where all seven fiber-property measurements are included, only 3 percent increase is obtained for R^2. The unusually high R^2 values in this group are attributed to adequate fiber length for good processing and to most of the varieties having rather fine lint, and thus to differences in skein strength being largely controlled by differences in fiber strength. Where the four rapidly measured fiber properties are used alone, upper-half mean length has a greater relative effect than mean length. Where only one Fibrograph measurement is used with Pressley breaker measurements, upper-half mean length is superior to mean length.

For environmental comparisons in subgroup B_2, the R^2 values are not high. In only one instance is more than a third of the observed differences in skein strength accounted for. This is not surprising in view of the compensating effects that environmental influences exerted on fiber properties as indicated by the simple correlation coefficients shown in table 4 (p. 14). Increased fiber length was significantly associated with decreased fiber strength. A higher percentage of thick-walled fiber was associated with a shorter upper-half mean length but a longer mean length. Other compensatory trends are indicated, although they fail to reach significance. Pressley index is the only property that makes a significant contribution to skein strength for all three counts. Surface area becomes an important contributor as yarn size becomes smaller. For environmental differences, mean length appears to be superior to upper-half mean length, in contrast to the condition for varietal effects.

Using the four rapidly measured fiber properties, the regression equations recommended for estimating skein strength of carded yarns spun on regular-draft equipment are:

Among samples averaging about an inch or less for upper-half mean length and from which the finest practicable yarn count is 50s –

1. Among varieties at a given location where Arealometer, Fibrograph, and Pressley breaker data are available:

$$22s = 5.78\ UHM + 64.07\ ML + 7.03\ SA + 7.59\ PI - 39.38$$
$$36s = 10.74\ UHM + 32.16\ ML + 5.46\ SA + 4.65\ PI - 38.06$$
$$50s = 10.66\ UHM + 27.37\ ML + 6.05\ SA + 2.82\ PI - 40.74.$$

2. Among samples representing different growth conditions for a given variety where Arealometer, Fibrograph, and Pressley breaker data are available:

$$22s = 1.26\ UHM + 32.69\ ML + 5.93\ SA + 5.96\ PI + 6.61$$
$$36s = 5.49\ UHM + 19.91\ ML + 4.59\ SA + 4.00\ PI - 15.21$$
$$50s = -7.09\ UHM + 23.24\ ML + 5.14\ SA + 2.91\ PI - 17.41.$$

Among samples averaging more than 1 inch for upper-half mean length and from which a yarn count of 60s is practicable –

1. Among varieties at a given location where –
   (*a*) Arealometer, Fibrograph, and Pressley breaker data are available:

$$22s = 71.16\ UHM + 28.50\ ML - 4.39\ SA + 12.16\ PI - 76.99$$
$$36s = 42.60\ UHM + 20.02\ ML - 1.26\ SA + 7.29\ PI - 60.26$$
$$60s = 28.63\ UHM + 9.04\ ML + 0.21\ SA + 4.10\ PI - 43.85.$$

   (*b*) Fibrograph and Pressley breaker data only are available:

$$22s = 85.48\ UHM + 12.22\ PI - 81.28$$
$$36s = 54.32\ UHM + 7.40\ PI - 60.00$$
$$60s = 34.65\ UHM + 4.18\ PI - 42.34.$$

2. Among samples representing different growth conditions for a given variety where
   (*a*) Arealometer, Fibrograph, and Pressley breaker data are available:

$$22s = 19.00\ UHM + 37.61\ ML + 3.95\ SA + 6.16\ PI - 7.68$$
$$36s = 12.26\ UHM + 33.32\ ML + 5.82\ SA + 4.52\ PI - 39.62$$
$$60s = 1.31\ UHM + 23.63\ ML + 5.32\ SA + 2.51\ PI - 30.47.$$

   (*b*) Fibrograph and Pressley breaker data only are available:

$$22s = 22.88\ UHM + 33.62\ ML + 5.87\ PI + 6.10$$
$$36s = 18.08\ UHM + 27.39\ ML + 4.09\ PI - 19.38$$
$$60s = 6.61\ UHM + 18.20\ ML + 2.12\ PI - 11.96.$$

Before leaving group B, attention might be called to the differences in the equations for corresponding yarn counts, either varietal or environmental comparisons, of subgroups B_1 and B_2. Appendix tables show similar subgroups, distinguished chiefly by grouping of varieties differing in fiber length and associated fiber characters. These and other data shown here or available in the bureau files emphasize that while for general purposes equations sufficiently comprehensive to include the majority of the common upland varieties are very much needed, individuals or organizations that are interested in a limited group of varieties—for example, very short, moderately short, moderately long, or long-staple varieties—might well be justified in establishing special equations based on variations within the group of especial interest instead of relying upon more generalized equations. It is obvious that the relative weightings for fiber length and fiber strength, for example, would change for groups in which either property was limiting. In a group where fiber length was at or near the minimum for the yarn in question, skein-strength differences would not be closely related to fiber-strength differences. If, by contrast, a group was composed of varieties in which fiber length was such that slippage of fibers rarely occurred when the yarn ruptured, fiber-strength differences would be of especial importance.

The relative importance of different fiber properties varies when varieties are grouped according to fiber length or the highest count that is considered practicable for the variety, as shown in figure 1.

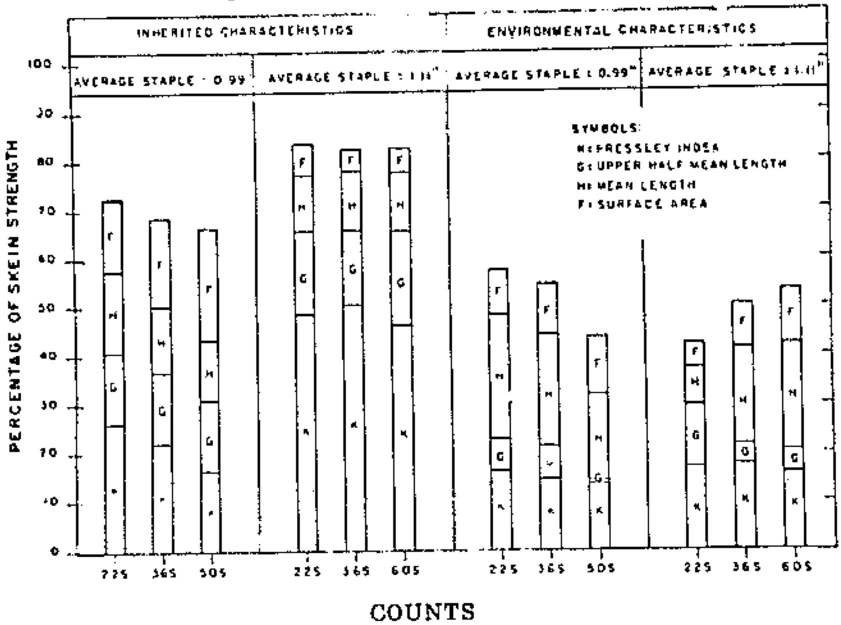

FIGURE 1.—The relation of fiber properties to skein strength in samples that differ in fiber length, based on the finest count of carded yarns considered practicable.

This graph shows that the differences in skein strength accounted for by differences in fiber properties are based chiefly on subgroups B_1 and B_2. To some extent the graph is modified by taking into consideration some of the smaller groups that are included in the Appendix.

This figure shows that where one is especially interested in a group of varieties that differ little in fiber length, more precise predictions may be obtained by using specially adapted formulas, as, for example, those derived from B_1 for short-staple varieties or growths or those from B_2 for longer staple varieties and growths, instead of the more generalized formulas that cover a wide range of varieties, as those given for group A.

COMBED YARNS

The combed-yarn samples here dealt with represented crops in the years 1941 to 1946, inclusive. Samples from crops for 1941 to 1944 were processed on regular-draft spinning equipment, by using a self-weighted middle spinning roll. The 1945–46 samples were processed on long-draft spinning equipment.

Standard-draft roving equipment was used in the processing of the 1941–44 samples, four processes being included as follows:

Slubber, intermediate, fine, and jack. With the 1945–46 samples, however, only two processes of roving were used. One of these is the slubber, which is now long draft, and the other is the jack, which still is standard draft. Combed yarn data have been accumulated more slowly than carded yarn data. The fiber and spinning results that have so far been analyzed from lots processed into combed yarns are, with the exception of those shown in appendix tables 27 to 29, limited to those listed under group C. The fiber data are not comparable to those that are emphasized for groups A and B in that the fiber measurements, with the exception of the Pressley index, are not those that can be made rapidly. It is expected that within the near future the number of samples on which Fibrograph and Arealometer measurements are available will be increased to such an extent that regression equations similar in reliability to those presented for groups A and B may be established. Meanwhile, it may be of interest to examine the somewhat meager data that have been accumulated.

Group C includes sea-island, American-Egyptian, and long-staple upland varieties that were spun from 1941 to 1945, inclusive. The 190 samples represent 44 station years and 146 within-station observations for judging varietal effects, and 68 varieties and 122 within-variety observations for estimating environmental influences. The skein-strength measurements and the fiber-property measurements were made in the laboratories of the Cotton Branch, Production and Marketing Administration. Some of the samples have one or more of the X-ray angle, Fibrograph, or Arealometer measurements, but the data seem too fragmentary to justify making several subgroupings, especially in view of the fact that Fibrograph, Arealometer, and X-ray data are currently being systematically obtained on samples going into combed yarns. The estimated round bundle or Chandler bundle strength was used as reported, whereas the unconverted Pressley indexes were used for all of the other groups analyzed in this report.

In view of the fact that the sea-island samples and many of the long-staple upland samples were grown in the Coastal Plain of the Southeast, attention is called to the possibility that group C as a whole may have suffered from biological deterioration to a somewhat greater extent than groups A and B, although the fiber samples were usually harvested as promptly as weather would permit.

SIMPLE CORRELATIONS

The simple correlation coefficients for group C are shown in table 7. All of the fiber properties, with the exception of percentage of thick-walled fibers, were found to be highly correlated with skein strength for all three yarn counts for varietal comparisons. For environmental differences, however, only weight per inch gave a significant coefficient with skein strength for all three counts. For 100s the mean length coefficient reached significance and for 60s and 80s closely approached significance. Upper quartile length gave a significant coefficient with each of the other fiber properties for varietal comparisons. For environmental comparisons the coefficient for upper quartile and mean length was the highest coefficient obtained in group C. Upper quartile length and estimated Chandler bundle strength association changed from a significant positive to a significant negative relation in comparing varietal and environmentally induced differences. The same trend is apparent for mean length and fiber strength. The significant negative relations for weight per inch and mean length and for weight per inch and fiber strength for varietal comparisons almost disappear for environmental differences. There are two significant coefficients involving percentage of thick-walled fibers—a very high positive value for relation to weight per inch in both varietal and environmental comparisons and a significant negative value for relation to upper quartile length as affected by varietal influences.

TABLE 7.—*Simple correlation coefficients for varietal (within-station) and environmental (within-variety) comparisons for group C*

Variates[1]	Coefficients		Variates[1]	Coefficients	
	Varietal	Environmental		Varietal	Environmental
60s with UQL	0.61*	0.08	UQL with M	0.82*	0.85*
60s with M	.64*	.22	UQL with CBS	.31*	−.23*
60s with CBS	.65*	.14	UQL with WI	−.66*	−.12
60s with WI	−.58*	−.42*	UQL with TW	−.26*	−.08
60s with TW	−.05	.15			
			M with CBS	.20	−.26*
80s with UQL	.68*	.10	M with WI	−.44*	−.07
80s with M	.71*	.22	M with TW	.08	.18
80s with CBS	.66*	.14			
80s with WI	−.65*	−.46*	CBS with WI	−.30*	−.09
80s with TW	−.09	.12	CBS with TW	−.12	.08
100s with UQL	.66*	.11	WI with TW	.60*	.56*
100s with M	.67*	.26*			
100s with CBS	.59*	.11			
100s with WI	−.65*	−.47*			
100s with TW	−.08	.12			

[1] The identity of the symbols used for the variates is as follows: 60s, 80s, and 100s = skein strength of 60s, 80s, and 100s combed yarns, respectively; UQL = upper quartile length; M = mean length; CBS = Chandler bundle strength converted from Pressley index; WI = weight per inch; and TW = percentage of thick-walled fibers.

* = Correlation coefficient significant at odds of 99 : 1.

MULTIPLE CORRELATIONS

For those who may wish to solve additional regression equations for group C, the mean values for the various properties and the variances are given in table 8.

The contribution of fiber properties to the skein strength of combed yarns as determined by multiple correlation studies for group C is shown in table 9.

TABLE 8.—*Mean values for skein strengths and fiber properties of the 190 samples in group C, and the variances for varietal (within-station) and environmental (within-variety) effects*

Variate	Means	Variance	
		Varietal comparisons	Environmental comparisons
Skein strength of 60s	47.15 pounds	2,854.1758	1,824.3668
Skein strength of 80s	31.91 pounds	1,443.3927	1,047.1995
Skein strength of 100s	23.32 pounds	953.5044	564.5051
Upper quartile length	1.535 inches	.9339	.3613
Mean length	1.222 inches	.6402	.3909
Estimated tensile strength	85.76 1,000 lb. per sq. in.	5,810.0081	4,139.4266
Weight per inch	3.048 micrograms	12.4399	5.4731
Thick-walled fibers	72.95 percent	2,994.4771	2,176.6382

For varietal comparisons, 80s gave the highest R^2 values — slightly more than 85 percent of skein strength being accounted for by four fiber properties—mean length, fiber strength, weight per inch, and upper quartile length—which are credited with 36, 26, 21, and 16 percent, respectively. Fiber tensile strength becomes of decreasing importance, whereas fiber weight per unit length becomes of increasing importance as yarn size decreases. It is interesting to note that upper quartile length is indicated as an unimportant fiber measurement for evaluating spinning performance. Actually it has a negative beta that attains significance for 60s and 80s, but if it is omitted from the equation R^2 is little affected.

Particular attention is directed to the comparatively high R^2 values obtained by the use of only two fiber properties — mean fiber length and fiber strength characterizing different varieties. These values are very similar to the results shown in table 6 for subgroup B_2, except that in the latter instance upper-half mean length of the Fibrograph was used. Apparently for estimating approximate varietal differences in skein strength, the mean length fiber sorter method from the array or the more rapidly obtained upper-half mean length of the Fibrograph may be used in conjunction with the Pressley index. Adding a third fiber property, fineness as measured by weight per inch, increases R^2 by 4, 6, and 8 percent for 60s, 80s, and 100s, respectively. While this increase is not large, it does indicate that among long-staple strains, varieties, and species, fiber length and weight-per-unit length are by no means perfectly correlated. It will be recalled that in table 7 the coefficients for mean and upper quartile length with weight per inch were –0.44 and –0.66, respectively.

For environmental comparisons, group C differs greatly from groups A and B. Environmentally induced differences in fiber strength and fiber length have little or no association with differences in skein strength. Of the five properties included, only two, weight per inch and percentage of thick-walled fibers, make sig-

TABLE 9.—*Contributions of fiber properties to skein strength of combed yarns as determined by multiple correlation studies, group C*

Fiber properties, R, and R^2	Correlation results with carded yarns: Varietal comparisons								
	60s			80s			100s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*	
Upper quartile length	−0.23	12		−0.20*	11		−0.17	9	
Mean length	.51*	26		.54*	28		.46*	25	
Chandler bundle strength	.51*	26		.48*	25		.40*	22	
Weight per inch	−.47*	25		−.52*	27		−.58*	31	
Thick-walled fibers	.20*	10		.18*	10		.24*	13	
R			0.88			0.94			0.89
R^2			.78			.88			.80
Upper quartile length	−.32*	18		−.29*	16		−.28*	16	
Mean length	.65*	35		.67*	36		.64*	36	
Chandler bundle strength	.52*	28		.49*	26		.42*	24	
Weight per inch	−.35*	19		−.40*	21		−.43*	24	
R			.87			.93			.88
R^2			.76			.86			.77
Mean length	.44*	38		.48*	38		.45*	38	
Chandler bundle strength	.50*	42		.47*	38		.40*	34	
Weight per inch	−.23*	20		−.30*	24		−.33*	28	
R			.86			.92			.87
R^2			.74			.84			.75
Upper quartile length	.45*	46		.53*	63		.42*	45	
Chandler bundle strength	.51*	54		.31*	37		.52*	55	
R			.78			.75			.77
R^2			.60			.56			.59
Mean length	.53*	49		.60*	53		.58*	55	
Chandler bundle strength	.55*	51		.54*	47		.47*	45	
R			.84			.88			.82
R^2			.70			.78			.67

Fiber properties, R, and R^2	Correlation results with carded yarns: Environmental comparisons								
	60s			80s			100s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*	
Upper quartile length	−0.16	10		−0.06	4		−0.20	12	
Mean length	.24	15		.15	10		.32	18	
Chandler bundle strength	.07	4		.06	4		.05	3	
Weight per inch	−.67*	42		−.72*	49		−.71*	42	
Thick-walled fibers	.47*	29		.48*	33		.44*	26	
R			0.64			0.65			0.67
R^2			.41			.42			.45
Upper quartile length	−.50*	29		−.42*	26		−.52*	28	
Mean length	.67*	38		.59*	36		.71*	39	
Chandler bundle strength	.16	9		.15	9		.13	7	
Weight per inch	−.42*	24		−.45*	28		−.47*	26	
R			.55			.56			.61
R^2			.31			.32			.37
Mean length	.24*	30		.23*	28		.27*	32	
Chandler bundle strength	.18	21		.16	20		.14	16	
Weight per inch	−.39*	49		−.43*	52		−.44*	52	
R			.49			.52			.54
R^2			.24			.27			.29
Upper quartile length	.12	41		.14	45		.14	50	
Chandler bundle strength	.17	59		.17	55		.14	50	
R			.18			.20			.18
R^2			.03			.04			.03
Mean length	.28*	56		.28*	57		.31*	62	
Chandler bundle strength	.21	43		.21	43		.19	38	
R			.30			.30			.32
R^2			.09			.09			.10

* = Beta values significant at odds of 99:1.

nificant contributions to skein strength, as shown graphically in figure 2.

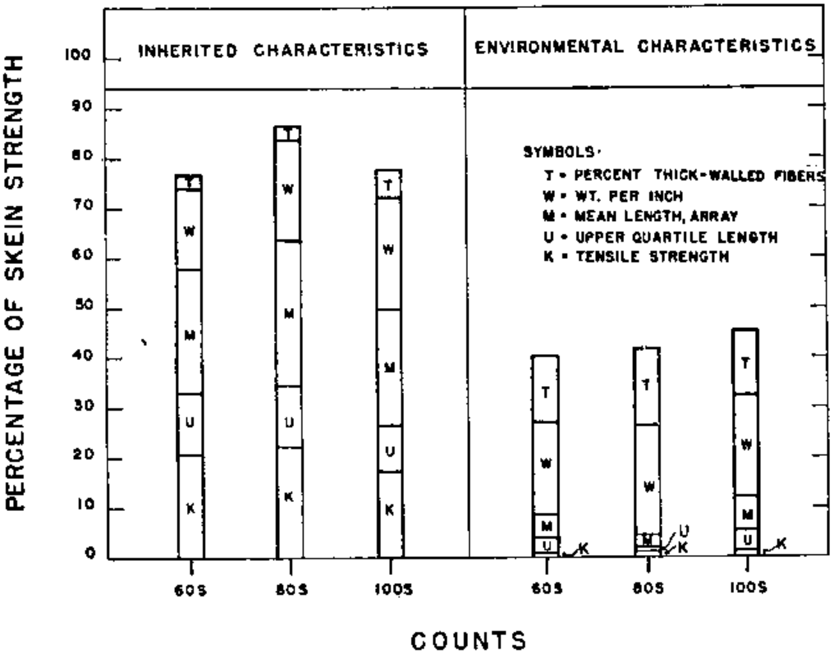

FIGURE 2.—Percentage of skein strength for combed yarns accounted for by the various fiber properties for long-staple upland, sea-island, and American-Egyptian varieties. Compare with figure 1 for relative effects of fiber fineness, length, and strength.

The futility of attempting to understand the relationships of fiber and yarn properties without separating varietal and environmental influences is even more clearly evident from table 9 than it is from tables 3 and 6. Correlation studies based on over-all effects, a blend of varietal and environmental influences, in group C would lead to the erroneous conclusion that fiber fineness is the all-important fiber property in determining the skein strength of combed yarns and that fiber length and strength are relatively unimportant. This may be readily visualized from figure 2. If the lot being studied represented largely environmental differences, varietal relationships would be even further obscured. By separating the two, the relationships take on real meaning—the breeder of long-stapled cottons may be informed that the most important properties with which he need be concerned are fiber length and strength and that if he is unable to obtain weight-per-inch determinations his progress in breeding should not be too much affected.

The spinner interested in different growths of a particular variety, however, might find it advantageous to spot check his samples for weight per inch and percentage of thick-walled fibers, or, from the standpoint of speed and economy, to obtain Arealometer determinations. It is rather surprising, in view of the fact that many of these samples came from the Coastal Plain where weather damage prior to harvest sometimes occurs, that environmental differences in fiber strength was an unimportant—actually a negative—contributor to skein strength. In commercial lots where it is impractical to harvest the cotton as promptly as was done for these studies, fiber deterioration might assume greater importance than the studies indicated.

If Fibrograph and Arealometer data are unavailable, the following regression equations may be of interest for estimating skein strength of combed yarns.

1. Among varieties at a given location—
   (a) Array, estimated Chandler strength, weight per inch, and percentage of maturity data are available:
   60s = −12.73 UQL + 33.85 M + 0.36 CBS − 7.14 WI + 0.19 TW + 2.65
   80s = −8.01 UQL + 25.41 M + .24 CBS − 5.57 WI + .13 TW + .21
   100s = −5.35 UQL + 17.64 M + .16 CBS − 5.06 WI + .13 TW + 1.56.
   (b) Array and estimated Chandler strength only are available:
   60s = 35.68 M + 0.38 CBS − 29.38
   80s = 28.52 M + .27 CBS − 25.94
   100s = 21.68 M + .19 CBS − 19.67.
2. Among samples representing different locations or places of growths for a given variety—
   (a) Array, estimated Chandler strength, weight per inch, and percentage of maturity data are available:
   60s = −11.16 UQL + 16.73 M + 0.05 CBS − 12.30 WI + 0.43 TW + 46.18
   80s = −3.21 UQL + 7.94 M + .03 CBS − 9.89 WI + .33 TW + 30.38
   100s = −7.83 UQL + 12.00 M + .02 CBS − 7.25 WI + .22 TW + 25.03.
   (b) Array and estimated Chandler strength only (regression equations for the (b) set were not computed for the reason that the R^2 values were too low to be of predictive interest).

In appendix tables 27 to 29, an indication is given as to the relation of Fibrograph, Arealometer, and Pressley breaker measurements to combed yarn skein strength, although the group studied is too small to give a satisfactory regression equation. Additional data for enlarging the group are now being obtained from the 1947 crop. By the time this bulletin appears in print, the reader interested in combed yarns may be able to obtain from the writer a more reliable regression equation based on rapidly measured fiber properties.

YARN-APPEARANCE GRADE FOR CARDED AND COMBED YARNS

The writers have devoted less attention to yarn-appearance grade than to skein strength. Enough has been done, however, to establish the fact that varietal differences in fiber length and fineness are significantly associated with differences in yarn-appearance grade. Differences in fiber properties induced by environmental factors also exert an influence on yarn-appearance grade. In general, however, the multiple correlation coefficients that have been obtained in these studies tend to be low. This is attributed to several possibilities, chief of which are (1) the determination of yarn-appearance grade by visual comparisons with check standards, which affords more opportunity for operator bias or error in grading than does reading from a mechanical instrument, and (2) the influence of seed-coat fragments and other foreign matter on nep formation, as shown by Pearson (*7*). Harrison (*5*) also showed that seed-fuzz fragments, very immature fibers, tapering fibers, and other fiber irregularities that are difficult to evaluate except by detailed microscopic studies are involved in nep formation. Neither the kind nor the quantity of impurities were taken into consideration in the present study, which is primarily concerned with the role of heredity and environment in determining or modifying the readily measured fiber properties.

Yarn-appearance studies discussed here were made on group A as representing carded yarns and group C for combed yarns. The reader may find it helpful to refer back to the descriptions of these groups (p. 7 and p. 25) and the fiber-property relationships (p. 8 and p. 26) in attempting to evaluate the relation of fiber properties and yarn-appearance grade.

SIMPLE CORRELATIONS

The simple correlation coefficients for yarn-appearance grade and fiber properties are shown in table 10.

For group A (carded yarns), it will be noted that varietal differences in surface area, in upper-half mean length, and in Pressley index are directly and significantly associated with varietal differences in yarn-appearance grade. The direct association with mean length failed to reach significance. For environmental differences, however, there is a significant reversal in relationship of yarn-appearance grade to Pressley index and both mean length and upper-half mean length. Surface area remains positive and is about equally high for both varietal and environmental effects.

In group C, combed yarns, four out of five of the fiber measurements shown are indicated in table 10 as having a significant association at odds of 99 : 1, with varietal differences in yarn-appearance grade. Both weight per inch and percentage of thick-walled fibers show a very high negative association, while upper quartile length shows an almost equally high direct relation to yarn-appearance grade. The positive coefficient for mean length is considerably lower but easily reaches significance. For environmental effects, fiber-length differences are not associated with yarn-appearance grade. The coefficients for weight per inch and percentage of thick-walled fibers are significant, although of much lower value than those for varietal influences. The tendency for a higher Pressley index to be directly associated with a larger, that is, a poorer, yarn-appearance grade among varieties in both groups A and C is apparently due to some indirect relationship, since the betas (table 11) show little tendency for heritable fiber strength to affect yarn appearance. For environment the negative coefficient in group A is supported by a significant beta. Conceivably this would be an index of weathering or biological deterioration, factors which would lead to fiber breakage in processing and poor yarn appearance.

MULTIPLE CORRELATIONS

Table 11 shows that in group A, upper-half mean length and surface area differences for varieties are significantly associated with yarn appearance, the two properties accounting for about 85

TABLE 10.—*Simple correlation coefficients for varietal (within-station) and environmental (within-variety) comparisons involving yarn-appearance grade and fiber properties for group A, carded yarns, and group C, combed yarns*

Group A, carded yarns			Group C, combed yarns		
Variate[1]	Varietal	Environmental	Variate[1]	Varietal	Environmental
YA with UHM	0.36*	−0.16*	YA with UQL	0.57*	0.10
YA with ML	.12	−.24*	YA with M	.26*	−.01
YA with SA	.41*	.42*	YA with CBS	.17	.20
YA with PI	.18*	−.17*	YA with WI	−.67*	−.32*
YA with XR	−.05	−.05	YA with TW	−.67*	−.29*

[1] YA = yarn-appearance grades, converted to numerical values: 1 = A+, 2 = A, 3 = A−, 4 = B+, 5 = B, 6 = B−, 7 = C+, 8 = C, 9 = C−, 10 = D+, 11 = D, 12 = D−; for group A, the code for yarn-appearance grade represents the average for 22s and 36s carded yarns; for group C, where all counts were common to all samples, the code represents the average grade for 60s, 80s, and 100s.

The identity of other symbols used for the variates is as follows: UHM = Fibrograph upper-half mean length, ML = Fibrograph mean length, SA = surface area or Arealometer measurement, PI = Pressley index, XR = X-ray angle, UQL = upper quartile length (array), M = mean length (array), CBS = estimated Chandler bundle strength, WI = weight per inch, TW = percentage of thick-walled (mature) fibers.

* = Correlation coefficient significant at odds of 99 : 1.

percent of the differences that were attributed to length, fineness, and Pressley index. An R^2 value of 0.23 percent admittedly is not great, but from the breeder's standpoint it is of considerable importance to be able to pin down two properties upon which he can work for improving yarn appearance of varieties that are used for making carded yarns. These results should also be interpreted as a challenge to the fiber technician to provide further improvements in measuring fineness. In group C, an R^2 value of 0.64 percent has very real significance, leaving a little more than one-third of the varietal variability unaccounted for. Here, as in group A, most of the variability accounted for is attributed to upper quartile fiber length and fineness, upper quartile being considered as roughly equivalent to upper-half mean length and weight per inch and percentage of thick-walled fibers as analogous to surface area.

For environmental differences, the R^2 value indicates that about one-third of the total variability in yarn-appearance grade for group A was accounted for by five fiber-property measurements. Pressley index ranked first but was closely followed by surface area and X-ray angle. No very good explanation is apparent for the significance of the X-ray angle relationship. Possibly growth conditions that resulted in the large X-ray angle also resulted in a well-developed fiber wall and a condition that was not completely measured by the Arealometer. Certainly the beta for surface area assumes greater relative importance when X-ray angle determinations are omitted, although the R^2 value itself is reduced by about 6 percent. It is also possible, as pointed out by Berkley and Barker (*3*), for the larger angle of orientation to be associated with better flexibility of the fibers and less brittleness during processing. The need for further study on this point is clearly

TABLE 11.—*Contribution of fiber properties to yarn-appearance grade for group A, carded yarns (22s and 36s), and for group C, combed yarns (60s, 80s, and 100s)*

Fiber properties,[1] R, and R^2	Correlation results					
	Varietal comparisons			Environmental comparisons		
	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect	
GROUP A						
		Percent			*Percent*	
UHM	0.30*	32		0.14	8	
ML	−.08	9		−.24	14	
SA	.29*	31		.43*	25	
PI	.13	14		−.49*	29	
XR	.14	15		−.38*	23	
R			0.48			0.57
R^2			.23			.32
UHM	.31*	45		−.10	11	
ML	−.08	11		−.14	15	
SA	.30*	42		.40*	44	
PI	.01	2		−.27*	30	
R			.48			.51
R^2			.23			.26
GROUP C						
UQL	0.54*	38		0.26	26	
M	−.23	16		−.17	18	
CBS	−.06	4		.21	21	
WI	−.20	14		−.21	21	
TW	−.40*	28		−.13	13	
R			0.80			0.42
R^2			.64			.18
UQL	.51*	39				
M	−.21	16				
WI	−.18	14				
TW	−.41*	31				
R			.80			
R^2			.64			

[1] Symbols: UHM = Fibrograph upper-half mean length; ML = Fibrograph mean length; SA = surface area or Arealometer measurement; PI = Pressley index; XR = X-ray angle; UQL = upper quartile length (array); M = mean length (array); CBS = estimated Chandler bundle strength; WI = weight per inch; TW = percentage of thick-walled (mature) fibers.

* = Beta values significant at odds of 99 : 1.

indicated. In group C, environmental influences in yarn appearance are not closely, or perhaps consistently, associated with the observed differences in fiber-property measurements. The R^2 value is very low, and none of the betas reached significance. Since R^2 was only 0.18, it seems scarcely worth while to speculate on interpretations other than to conclude that for combed yarns environmentally induced differences in yarn appearance and specific fiber property are not closely related.

Regression equations which may be of interest are—

1. For yarn-appearance grade, average of 22s and 36s, of singles carded yarns—
   (a) Among varieties at a given location:
   $$YA = 4.74\ UHM - 1.08\ ML + 1.09\ SA + 0.02\ PI - 2.09.$$
   (b) Among samples representing different growth conditions for a given variety:
   $$YA = -1.38\ UHM - 1.52\ ML + 1.54\ SA - 0.51\ PI + 7.28.$$
2. For yarn-appearance grade, average of 60s, 80s, and 100s, of singles combed yarns—
   (a) Among varieties at a given location:
   $$YA = 9.05\ UQL - 4.53\ M - 0.90\ WI - 0.13\ TW + 10.97.$$
   (b) Among samples representing different growth conditions for a given variety:
   $$YA = 4.43\ UQL - 2.81\ M - 0.92\ WI - 0.03\ TW + 8.77.$$

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APPENDIX

(TABLES 12 TO 29)

The appendix tables, which are briefly described on page 6 and elsewhere in the text, are arranged in order of fiber-length groups, or rather in order of the smallest yarn count into which the samples were spun. The sequence of the text references to the appendix tables, therefore, may not be consistent with the order of their listing.

TABLE 12.—*Simple correlation coefficients for varietal effects of fiber and yarn data on 36 samples*[1] *from the 1946 crop spun by the long-draft roving and spinning process into carded yarns of 14s, 22s, and 36s*

Fiber and yarn properties	Upper half mean	Mean length	Surface area	Pressley index	X-ray angle
Skein strength of 14s	0.55*	0.45*	0.16	0.29	−0.19
Skein strength of 22s	.57*	.46*	.21	.27	−.22
Skein strength of 36s	.62*	.48*	.38	.09	−.04
Upper-half mean length		.88*	.40	−.30	.26
Mean length			.12	−.24	.20
Surface area				−.51*	.56*
Pressley index					−.79*

[1] The samples represent 5 stations, thus giving 31 within-station observations for estimating varietal effects. Since there were 27 different strains and varieties, leaving only 9 observations that may be used for estimating environmental influences, data for environmental effects are omitted.

* = Significant at odds of 99 : 1.

TABLE 13.—*Mean values for fiber and yarn properties and variances for varietal effects of fiber and yarn data on 36 samples*[1] *from the 1946 crop spun by the long-draft roving and spinning process into carded yarns of 14s, 22s, and 36s*

Variate	Means	Variance
Skein strength of 14s	161.39 pounds	3,223.0823
Skein strength of 22s	94.37 pounds	1,225.0440
Skein strength of 36s	49.01 pounds	482.2357
Upper-half mean length	.885 inch	.0684
Mean length	.700 inch	.0601
Surface area	2.372 square centimeter per milligram	1.0031
Pressley index	6.708	5.1060
X-ray angle	34.4°	274.1148

[1] See footnote 1, table 12.

TABLE 14.—*Contribution of fiber properties to skein strength, as determined by multiple correlation studies of varietal effects, of fiber and yarn data on 36 samples[1] from the 1946 crop spun by the long-draft roving and spinning process into carded yarns of 14s, 22s, and 36s*

Fiber properties, R, and R^2	Correlation results with carded yarns								
	14s			22s			36s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*	
Upper half mean	0.60	39		0.55	32		0.48	29	
Mean length	.04	3		.10	5		.13	8	
Surface area	.25	16		.36	21		.48	29	
Pressley index	.53*	34		.46	27		.38	23	
X-ray angle	−.12	8		−.26	15		−.19	12	
R			0.75			0.78			0.76
R^2			.57			.61			.58
Upper half mean	.65	45		.64	43		.55	36	
Mean length	.00	0		.01	0		.07	4	
Surface area	.20	14		.25	17		.40	27	
Pressley index	.59*	41		.59*	40		.48*	32	
R			.75			.76			.75
R^2			.56			.58			.57
Upper half mean	.65*	45		.65*	43		.61*	42	
Surface area	.20	14		.25	17		.38	26	
Pressley index	.59*	41		.59*	40		.47*	32	
R			.75			.76			.75
R^2			.56			.58			.57
Upper half mean	.70*	58		.72*	60		.71*	70	
Pressley index	.51*	42		.49*	40		.31	30	
R			.73			.73			.69
R^2			.53			.54			.47

[1] See footnote 1, table 12.
* = Significant at odds of 99 : 1.

TABLE 15.—*Simple correlation coefficients for varietal effects of fiber and yarn data on 57 samples[1] from the 1941-44 crops spun by regular-draft process into carded yarns of 22s, 36s, and 44s*

Fiber and yarn properties	Upper half mean	Mean length	Surface area	Pressley index	X-ray angle
Skein strength of 22s	0.60*	0.53*	0.13	0.12	−0.10
Skein strength of 36s	.50*	.39*	.34	.07	−.07
Skein strength of 44s	.47*	.34	.40*	−.01	−.01
Upper-half mean length		.82*	.18	.05	−.07
Mean length			−.07	.17	−.08
Surface area				−.44*	.14
Pressley index					−.63

[1] The samples represent 15 station-years, thus giving 42 observations for estimating varietal effects. Since there were 39 different strains and varieties, leaving only 18 observations that may be used for estimating environmental influences, data for environmental effects are omitted.
* = Significant at odds of 99 : 1.

TABLE 16.—*Mean values for fiber and yarn properties and variances for varietal effects of fiber and yarn data on 57 samples*[1] *from the 1941–44 crops spun by regular-draft process into carded yarns of 22s, 36s, and 44s*

Variate	Means	Variance
Skein strength of 22s	90.53 pounds	905.8834
Skein strength of 36s	45.95 pounds	330.8834
Skein strength of 44s	32.84 pounds	326.2001
Upper-half mean length	0.921 inch	.1244
Mean length	0.752 inch	.0791
Surface area	2.733 square centimeters per milligram	2.7789
Pressley index	7.744	7.3666
X-ray angle	31.0°	272.7167

[1] See footnote 1, table 15.

TABLE 17.—*Contribution of fiber properties to skein strength as determined by multiple correlation studies of varietal effects of fiber and yarn data on 57 samples*[1] *from the 1941-44 crops spun by regular-draft process into carded yarns of 22s, 36s, and 44s*

Fiber properties, R, and R^2	Correlation results with carded yarns								
	22s			36s			44s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*	
Upper half mean	0.49	34		0.42	21		0.36	10	
Mean length	.06	4		−.02	1		−.02	1	
Surface area	.16	11		.58	28		.46	24	
Pressley index	.11	8		.22	11		.17	9	
X-ray angle	.02	2		.07	4		.10	6	
Weight per inch	−.22	15		−.17	8		−.31	17	
Thick-walled fiber	.37	26		.55	27		.45	24	
R			0.68			0.72			0.69
R^2			.46			.52			.47
Upper half mean	.46	55		.34	33		.32	34	
Mean length	.14	17		.11	11		.07	8	
Surface area	.11	13		.37	37		.41	43	
Pressley index	.12	15		.19	19		.14	15	
R			.62			.59			.59
R^2			.38			.35			.34
Upper half mean	.58	73		.43	44		.39	42	
Surface area	.08	10		.35	36		.40	43	
Pressley index	.13	16		.19	20		.14	15	
R			.61			.59			.58
R^2			.37			.35			.34
Upper half mean	.59	86		.50	93		.47	93	
Pressley index	.09	13		.04	7		−.03	7	
R			.61			.50			.47
R^2			.37			.25			.22

[1] See footnote 1, table 15.
* = Significant at odds of 99 : 1.

TABLE 18.—*Simple correlation coefficients for the varietal (within-station) and environmental (within-variety) effects of fiber and yarn data on 71 samples from the 1945 crop spun by the long-draft roving and spinning process into 22s and 36s carded yarns. The third count spun was 50s, except for 9 samples that were spun into 44s* [1]

Variates [2]	Coefficients		Variates [2]	Coefficients	
	Varietal differences	Environmental differences		Varietal differences	Environmental differences
22s with UHM	0.73*	0.34	UHM with ML	0.76*	0.92*
22s with ML	.46*	.40*	UHM with SA	.35*	−.26
22s with SA	.35*	.08	UHM with PI	.20	−.35*
22s with PI	.53*	.40*	UHM with XR	.01	.44*
22s with XR	−.28	−.12			
			ML with SA	−.03	−.38*
36s with UHM	.71*	.29	ML with PI	.10	−.34
36s with ML	.38*	.33	ML with XR	.04	.44*
36s with SA	.45*	.18			
36s with PI	.43*	.40*	PI with SA	−.12	.07
36s with XR	−.16	−.17	PI with XR	−.82*	−.76*
50s with UHM	.71*	.30	SA with XR	.33	.03
50s with ML	.39*	.30			
50s with SA	.50*	.22			
50s with PI	.37*	.31			
50s with XR	−.13	−.07			

[1] The data presented here is accordingly limited to the two counts that were common to all samples. The samples represent 20 stations, thus giving 51 within-station observations for estimating varietal effects. There were 22 different strains and varieties, giving 49 within-variety observations for estimating environmental influences.

[2] The identity of the symbols used for the variates are as follows: 22s, 36s, and 50s = skein strength of 22s, 36s, and 50s carded yarns, respectively; UHM = Fibrograph upper-half mean length; ML = Fibrograph mean length; SA = surface area or Arealometer measurement; PI = Pressley index; and XR = X-ray angle.

* = Significant at odds of 99:1.

TABLE 19.—*Mean measurements for fiber and yarn properties and variances for varietal and environmental comparisons of fiber and yarn data on 71 samples from the 1945 crop spun by the long-draft roving and spinning process into 22s and 36s carded yarns. The third count spun was 50s, except for 9 samples that were spun into 44s* [1]

Variate	Means	Variance	
		Varietal comparisons	Environmental comparisons
Skein strength of 22s	102.06 pounds	2,651.0046	2,704.2200
Skein strength of 36s	54.32 pounds	981.0000	923.9629
Skein strength of 50s	34.79 pounds	599.7810	538.5223
Upper-half mean length	.864 inch	.1543	.1482
Mean length	.743 inch	.1115	.2849
Surface area	2,758 square centimeters per milligram	3.0631	2.3396
Pressley index	6.272	8.6456	9.1260
X-ray angle	34.4°	325.4656	213.1843

[1] See footnote 1, table 18.

TABLE 20.—*Contribution of fiber properties to skein strength as determined by multiple correlation studies of varietal and environmental effects of fiber and yarn data on 71 samples from the 1945 crop spun by the long-draft roving and spinning process into 22s and 36s carded yarns. The third count spun was 50s, except for 9 samples that were spun into 44s* [1]

Fiber properties, R, and R^2	Correlation results with carded yarns											
	Varietal comparisons						Environmental comparisons					
	22s			36s			22s			36s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*			*Percent*	
Upper half mean	0.61*	45		0.69*	41		−0.25	11		−0.28	12	
Mean length	−.05	4		−.19	11		.96*	43		.98*	42	
Surface area	.18	13		.22	13		.34*	15		.45*	19	
Pressley index	.47*	35		.46*	27		.65*	29		.55*	24	
X-ray angle	.04	3		.14	8		.05	2		−.07	3	
R			0.85			0.83			0.76			0.74
R^2			.72			.69			.78			.55
Upper half mean	.61*	48		.68*	47		−.25	12		−.28	12	
Mean length	−.04	4		−.16	12		.98	44		.95*	42	
Surface area	.19	15		.25	18		.35*	16		.43*	19	
Pressley index	.44*	34		.34*	24		.62*	28		.60*	26	
R			.85			.82			.76			.74
R^2			.72			.68			.58			.55
Upper half mean	.57*	47		.53*	44		.60*	43		.56*	39	
Surface area	.21	17		.31*	26		.19	14		.28	20	
Pressley index	.44*	36		.36*	30		.59*	43		.57*	40	
R			.85			.82			.68			.66
R^2			.72			.67			.46			.44
Mean length	.42*	30		.35	26		.73*	44		.69*	41	
Surface area	.43	31		.52	39		.32*	19		.40*	24	
Pressley index	.54*	39		.45*	34		.63*	37		.60*	36	
R			.79			.75			.75			.73
R^2			.63			.56			.57			.54
Upper half mean	.65*	62		.65*	68							
Pressley index	.40*	38		.30*	32							
R			.83			.77						
R^2			.69			.59						
Mean length							.60*	50		.52*	48	
Pressley index							.60*	50		.57*	52	
R									.69			.63
R^2									.48			.40

[1] See footnote 1, table 18. * = Significant at odds of 99:1.

TABLE 21.—*Simple correlation coefficients for the varietal (within-station) and environmental (within-variety) effects of fiber and yarn data on 228 samples*[1] *from the 1946 crop spun by the long-draft roving and spinning process into 22s, 36s, and 50s singles carded yarns*

Variates[2]	Coefficients: Varietal differences	Coefficients: Environmental differences	Variates[2]	Coefficients: Varietal differences	Coefficients: Environmental differences
22s with UHM	0.65*	0.30*	UHM with ML	0.71*	0.84*
22s with ML	.47*	.31*	UHM with SA	.38*	.06
22s with SA	.35*	.23*	UHM with PI	.41*	.29*
22s with PI	.82*	.40*	UHM with XR	−.21*	.44*
22s with XR	−.66*	−.20			
			ML with SA	−.04	−.19
36s with UHM	.65*	.31*	ML with PI	.29*	−.20
36s with ML	.46*	.32*	ML with XR	−.13	.29*
36s with SA	.38*	.27*			
36s with PI	.82*	.41*	PI with SA	.16	.05
36s with XR	−.66*	−.19	PI with XR	−.77*	−.61*
50s with UHM	.65*	.33*	SA with XR	−.09	.05
50s with ML	.45*	.31*			
50s with SA	.42*	.35*			
50s with PI	.79*	.40*			
50s with XR	−.64*	−.15			

[1] The samples represent 28 stations, thus giving 200 within-station observations for estimating varietal effects. There were 101 strains and varieties, or 127 within-variety observations for estimating environmental influences.

[2] The identity of the symbols used for the variates is as follows: 22s, 36s, and 50s = skein strength of 22s, 36s, and 50s carded yarns, respectively; UHM = Fibrograph upper-half mean length; ML = Fibrograph mean length; SA = surface area or Arealometer measurement; PI = Pressley index; and XR = X-ray angle.

* = Significant at odds of 99:1.

TABLE 22.—*Mean measurements for fiber and yarn properties and variances for varietal and environmental comparisons of fiber and yarn data on 228 samples*[1] *from the 1946 crop spun by the long-draft roving and spinning process into 22s, 36s, and 50s single carded yarns*

Variate	Means	Variance: Varietal comparisons	Variance: Environmental comparisons
Skein strength of 22s	117.71 pounds	25,358.6465	8,419.1484
Skein strength of 36s	63.72 pounds	8,907.9493	3,311.2280
Skein strength of 50s	42.29 pounds	4,970.6829	1,736.5292
Upper-half mean length	1.077 inches	.5236	.2663
Mean length	.832 inch	.5381	.4923
Surface area	2.872 square centimeters per milligram	7.8453	7.4414
Pressley index	7.028	61.7604	24.9818
X-ray angle	35.8°	1,633.0458	564.4289

[1] See footnote 1, table 21.

TABLE 23.—*Contribution of fiber properties to skein strength as determined by multiple correlation studies of varietal and environmental effects of fiber and yarn data on 228 samples*[1] *from the 1946 crop spun by the long-draft roving and spinning process into 22s, 36s, and 50s singles carded yarns*

Fiber properties, R, and R^2	Correlation results with carded yarns																	
	Varietal comparisons									Environmental comparisons								
	22s			36s			50s			22s			36s			50s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*			*Percent*			*Percent*			*Percent*	
Upper half mean	0.26*	21		0.26*	20		0.23*	18		0.24	18		0.17	12		0.18	12	
Mean length	.11	9		.11	9		.14*	11		.28	21		.36	26		.35	24	
Surface area	.15*	12		.18*	15		.25*	20		.25*	19		.31*	22		.39*	27	
Pressley index	.54*	44		.52*	42		.48*	37		.42*	31		.44*	32		.45*	31	
X-ray angle	—.16*	13		—.17*	13		—.18*	14		.15	11		—.11	8		—.07	5	
R			0.91			0.91			0.90			0.64			0.67			0.70
R^2			.82			.82			.81			.42			.45			.50
Upper half mean	.24*	21		.24*	20		.21*	18		.17	14		.11	9		.14	10	
Mean length	.11	9		.10	9		.13	10		.32	26		.38*	29		.36*	26	
Surface area	.15*	13		.18*	15		.24*	20		.25*	20		.31*	24		.39*	28	
Pressley index	.67*	57		.66*	56		.63*	52		.49*	40		.50*	38		.49*	35	
R			.90			.90			.89			.64			.67			.70
R^2			.81			.81			.80			.40			.45			.49
Upper half mean	.36*	35		.39*	37		.41*	39		.37*	37		.37*	36		.46*	45	
Mean length	.01	1		—.01	1		—.02	2		.10	10		.11	11		.03	3	
Pressley index	.67*	64		.66*	63		.63*	59		.52*	53		.54*	53		.54*	52	
R			.89			.89			.87			.59			.61			.61
R^2			.80			.79			.76			.35			.37			.37
Upper half mean	.38*	36		.38*	37		.39*	38		.46*	46		.47*	46		.49*	48	
Pressley index	.67*	64		.66*	63		.63*	62		.53*	54		.54*	54		.54*	52	
R			.89			.89			.87			.59			.60			.61
R^2			.80			.79			.76			.35			.37			.37
Mean length	.25*	25		.24*	24		.24*	25		.40*	46		.42*	46		.41*	46	
Pressley index	.75*	75		.75*	76		.72*	75		.48*	54		.49*	54		.48*	54	
R			.86			.85			.82			.56			.58			.56
R^2			.74			.72			.68			.32			.33			.32

[1] See footnote 1, table 21. *=Significant at odds of 99:1.

TABLE 24.—*Simple correlation coefficients for the varietal (within-station) and environmental (within-variety) effects of fiber and yarn data on 157 samples*[1] *from the 1945 crop spun by the long-draft roving and spinning process into 22s, 36s, and 60s singles carded yarns*

Variates[2]	Coefficients		Variates[2]	Coefficients	
	Varietal differences	Environmental differences		Varietal differences	Environmental differences
22s with UHM	0.61*	0.32*	UHM with ML	0.68*	0.93*
22s with ML	.38*	.36*	UHM with SA	.12	−.12
22s with SA	.35*	.20	UHM with PI	.33*	−.40
22s with PI	.83*	.34*	UHM with XR	−.22	.60*
22s with XR	−.62*	.06			
			ML with SA	−.23*	−.23*
36s with UHM	.49*	.37*	ML with PI	−.17	−.35*
36s with ML	.39*	.41*	ML with XR	−.09	.51*
36s with SA	.32*	.17			
36s with PI	.83*	.36*	PI with SA	.38*	.06
36s with XR	−.64*	.04	PI with XR	−.82*	−.74*
60s with UHM	.54*	.46*	SA with XR	−.31*	.06
60s with ML	.41*	.48*			
60s with SA	.35*	.18			
60s with PI	.81*	.30*			
60s with XR	−.62*	.11			

[1] The samples represent 24 stations, thus giving 133 within-station comparisons for estimating varietal effects. There were 29 strains and varieties or 128 within-variety observations for evaluating environmental influences.

[2] The identity of the symbols used for the variates is as follows: 22s, 36s, and 60s = skein strength of 22s, 36s, and 60s carded yarns, respectively; UHM = Fibrograph upper-half mean length; ML = Fibrograph mean length; SA = surface area or Arealometer measurement; PI = Pressley index; and XR = X-ray angle.

* = Significant at odds of 99 : 1.

TABLE 25.—*Mean measurements for fiber and yarn properties and variances for varietal and environmental comparisons of fiber and yarn data on 157 samples*[1] *from the 1945 crop spun by the long-draft roving and spinning process into 22s, 36s, and 60s singles carded yarns*

Variate	Means	Variance	
		Varietal comparisons	Environmental comparisons
Skein strength of 22s	114.98 pounds	9,067.6958	9,424.4079
Skein strength of 36s	62.07 pounds	3,215.0238	3,138.2165
Skein strength of 60s	31.13 pounds	1,180.7247	1,232.4604
Upper-half mean length	1.090 inches	.1411	.5836
Mean length	.826 inch	.3290	.8600
Surface area	2.944 square centimeters per milligram	3.2991	4.2879
Pressley index	6.350	29.2374	24.5959
X-ray angle	35.6°	1,004.1045	691.2390

[1] See footnote 1, table 24.

TABLE 26.—*Contribution of fiber properties to skein strength as determined by multiple correlation studies of varietal and environmental effects of fiber and yarn data on 157 samples*[1] *from the 1945 crop spun by the long-draft roving and spinning process into 22s, 36s, and 60s singles carded yarns*

Fiber properties, R, and R^2	Correlation results with carded yarns																	
	Varietal comparisons									Environmental comparisons								
	22s			36s			60s			22s			36s			60s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*			*Percent*			*Percent*			*Percent*	
Upper half mean	0.13	10		0.07	5		0.13	10		−0.17	7		−0.05	3		0.05	3	
Mean length	.19*	14		.24*	18		.23*	18		.65*	29		.64*	32		.60*	31	
Surface area	.11	8		.09	7		.14*	10		.25*	11		.25*	12		.26*	13	
Pressley index	.80*	60		.81*	63		.74*	56		.78*	35		.76*	38		.74*	38	
X-ray angle	.11	8		.09	7		.08	6		.39*	17		.28*	14		.30*	16	
R			0.88			0.88			0.87			0.72			0.75			0.78
R^2			.77			.78			.76			.52			.57			.62
Upper half mean	.13	12		.07	6		.14	12		.00	0		.06	4		.18	11	
Mean length	.20*	17		.24*	21		.23*	20		.62*	42		.62*	40		.58*	36	
Surface area	.11	10		.09	8		.14*	12		.31*	21		.28*	18		.30*	19	
Pressley index	.71*	62		.74*	65		.67*	57		.54*	37		.58*	37		.56*	34	
R			.88			.88			.87			.69			.74			.76
R^2			.77			.77			.76			.47			.54			.58
Upper half mean	.27*	26		.24*	24		.30*	29		.58*	42		.64*	44		.72*	47	
Surface area	.04	4		.01	1		.06	5		.23*	17		.21*	14		.23*	15	
Pressley index	.72*	70		.75*	75		.69*	66		.56*	41		.60*	41		.57*	38	
R			.87			.86			.86			.65			.70			.74
R^2			.75			.75			.74			.42			.49			.54
Mean length	.29*	25		.29*	26		.33*	28		.62*	42		.69*	44		.75*	47	
Surface area	.14*	12		.11	9		.17*	14		.31*	21		.29*	19		.32*	20	
Pressley index	.72*	63		.74*	65		.69*	58		.54*	37		.58*	37		.54*	34	
R			.87			.88			.87			.69			.73			.76
R^2			.76			.77			.75			.47			.54			.58
Upper half mean	.27*	27		.24*	24		.30*	30										
Pressley index	.74*	73		.76*	76		.71*	70										
R			.87			.86			.86									
R^2			.75			.75			.73									
Mean length										.55*	51		.62*	52		.67*	56	
Pressley index										.54*	49		.57*	48		.53*	44	
R												.62			.68			.70
R^2												.38			.46			.48

[1] See footnote 1, table 24.

*=Significant at odds of 99:1.

TABLE 27.—*Simple correlation coefficients for the varietal (within-station) and environmental (within-variety) effects of fiber and yarn data on 57 samples*[1] *from the 1945-46 crops, spun by the long-draft roving and spinning process into 60s, 80s, and 100s singles combed yarns*

Variates[2]	Coefficients: Varietal differences	Coefficients: Environmental differences	Variates[2]	Coefficients: Varietal differences	Coefficients: Environmental differences
60s with UHM	0.62*	0.07	UHM with ML	0.71*	0.91*
60s with ML	.55*	.05	UHM with SA	.11	−.30
60s with SA	.29	.54*	UHM with PI	.25	−.28
60s with PI	.61*	.52*			
			ML with SA	−.21	−.39
80s with UHM	.67*	.11	ML with PI	.22	−.21
80s with ML	.57*	.07			
80s with SA	.32*	.54*	PI with SA	.14	.25
80s with PI	.51*	.48*			
100s with UHM	.63*	.08			
100s with ML	.59*	.02			
100s with SA	.30	.50*			
100s with PI	.44*	.41*			

[1] The samples represent 19 stations, thus giving 38 within-station observations for estimating varietal effects. There were 31 varieties, leaving 26 within-variety observations for evaluating environmental influences.

[2] The identity of the symbols used for the variates is as follows: 60s, 80s, and 100s = skein strength of 60s, 80s, and 100s combed yarns, respectively; UHM = Fibrograph upper-half mean length; ML = Fibrograph mean length; SA = surface area or Arealometer measurement; and PI = Pressley index.

* = Significant at odds of 99 : 1.

TABLE 28.—*Mean measurements for fiber and yarn properties and variances for varietal and environmental comparisons of fiber and yarn data on 57 samples*[1] *from the 1945–46 crops, spun by the long-draft roving and spinning process into 60s, 80s, and 100s singles combed yarns*

Variate	Means	Variance: Varietal comparisons	Variance: Environmental comparisons
Skein strength of 60s	48.18 pounds	441.5102	502.0527
Skein strength of 80s	32.77 pounds	223.4409	256.0778
Skein strength of 100s	24.99 pounds	144.7619	192.2887
Upper-half mean length	1.351 inches	.1612	.1291
Mean length	1.036 inches	.3054	.3373
Surface area	3.260 square centimeters per milligram	1.7212	1.1402
Pressley index	7.926	9.0891	8.7583

[1] See footnote 1, table 27.

TABLE 29.—*Contribution of fiber properties to skein strength as determined by multiple correlation studies of varietal and environmental effects of fiber and yarn data on 57 samples*[1] *from the 1945–46 crops, spun by the long-draft roving and spinning process into 60s, 80s, and 100s singles combed yarns*

Fiber properties, R, and R^2	Correlation results with combed yarns																	
	Varietal comparisons									Environmental comparisons								
	60s			80s			100s			60s			80s			100s		
	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value	Betas		Multiple correlation value
	Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect		Value	Relative effect	
		Percent			*Percent*			*Percent*			*Percent*			*Percent*			*Percent*	
Upper half mean	0.24	19		0.30	24		0.21	17		−0.13	10		0.35	25		0.39	29	
Mean length	.34	26		.35	27		.46	37		.14	11		.06	4		−.06	5	
Surface area	.27	21		.32*	25		.34*	27		.54*	42		.55*	39		.50	38	
Pressley index	.43*	34		.31*	24		.24	19		.48*	37		.46*	32		.38	28	
R			0.82			0.82			0.78			0.74			0.75			0.66
R^2			.68			.67			.61			.54			.56			.44
Upper half mean	.38	37		.47*	47		.38	41		.49	36		.60	39		.62	40	
Mean length	.17	17		.16	16		.25	28		−.27	20		−.36	23		−.44	28	
Pressley index	.48*	46		.36*	37		.29	31		.60*	44		.58*	38		.49	32	
R			.79			.77			.72			.58			.57			.49
R^2			.62			.59			.52			.34			.32			.24
Upper half mean	.50*	51		.58*	61		.56*	65		.38	39		.27	32		.21	31	
Pressley index	.48*	49		.37*	39		.30	35		.59*	61		.56*	68		.47	69	
R			.78			.76			.70			.58			.55			.45
R^2			.60			.58			.48			.33			.30			.20
Mean length	.43*	46		.48*	54		.52*	61		.16	23		.18	25		.11	21	
Pressley index	.51*	54		.41*	46		.32	39		.56*	77		.52*	75		.43	79	
R			.74			.70			.67			.54			.51			.42
R^2			.55			.48			.45			.30			.26			.18

[1] See footnote 1, table 27.   * = Significant at odds of 99:1.

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