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Biometrical Analysis of Upland Cotton Grown at Stillwater Oklahoma

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A BIOMETRICAL ANALYSIS OF UPLAND COTTON GROWN AT STILLWATER, OKLAHOMA[1]

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INTRODUCTION

A survey of published data on cotton investigation reveals the fact that there are three or four characters of major importance in this crop from the standpoint of production. The yield of seed cotton per acre seems to be considered the most important character. The lint per cent, the length of lint, and the number of bolls per pound of seed cotton are the other three items commonly included in data from variety tests. The belief is not uncommon that these four characters are closely associated and that in attempts to improve any one of them the others are influenced to a more or less extent. It was considered of interest to study the upland varieties of cotton in order to learn to what extent these four major characters are associated with each other and with the other characters of the crop subject to mathematical analysis in a random sample of upland varieties. The information obtained from such a study should be of value to those interested in the production of improved varieties of upland cotton.

Review of Literature

Apparently, little has been done in the way of measuring the mutual association of the various characteristics in the cotton plant. Dunlavy (3)[3] reported, in 1923, the results of a study of seven characters including the lint index, the weight of seed, the size of boll, the per cent of 5-lock bolls, the lint per cent, and the length of staple. Measurements were taken on 167 individual plant selections. Correlations were calculated and the coefficients obtained are as follows:

Lint index	with weight of seed	$+.70\pm.02$
Boll size	with weight of seed	$+.66\pm.03$
Boll size	with per cent of 5-lock bolls	$+.53\pm.06$
Weight of seed	with per cent of lint	$-.53\pm.04$
Boll size	with lint index	$+.48\pm.05$
Per cent of lint	with staple length	$-.44\pm.04$
Weight of seed	with staple length	$+.43\pm.04$
Boll size	with lint per cent	$-.39\pm.05$

As this study was made within a variety the correlations may not be due to genetic relations but rather to physiological association. Stroman (13) studied 16 varieties of cotton. Measurements were taken on 50 plants in each of the 16 varieties and correlation coefficients were calculated within each variety. He found consistently high positive correlations between the yield of lint and the yield of seed, the yield of lint and the number of 5-lock bolls, the yield of seed and the number of 5-lock bolls, the yield of lint and the number of 4-lock bolls. Other significant correlations were obtained but they were not consistent in the

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[3] Reference is made by number to "Literature Cited," page 32.

different varieties studied. In this study, as was the case in the study made by Dunlavy, correlations were made within the variety using the plant as the unit. It is apparent that all varieties do not react the same to their environment in so far as the characters studied are concerned.

Hodson (6) reports the results of a study in which he calculated correlation coefficients within the variety and also in a random sample of varieties. He studied the following characteristics: The number of base limbs, the number of fruit branches, the number of bolls per plant, the height of the plant, the number of days to the first bloom, the per cent of lint, the length of lint, the weight of seed, the weight per boll, and the number of days to first open boll. However, coefficients for all possible combinations were not calculated. The correlation coefficients between the number of base limbs and the number of fruit branches were all low and not consistently positive or negative. The correlation coefficient for the number of base limbs and the number of bolls per plant were all positive but of little importance except in the case of one variety in which the coefficient was $+.4348\pm.0938$. The number of base branches was not consistently positively or negatively associated with the height of the plant and the values of the correlation coefficients were low. The number of fruit branches was positively correlated with the height of the plant. The coefficients were consistently positive and of some importance, ranging from $+.2124\pm.0699$ to $+.5796\pm.0786$. The number of base limbs with the number of bolls per plant, and the number of fruit branches with the number of bolls per plant were inconsistent in their relations and the correlations were not important. The association of the number of days to first bloom was not close with any of the following characters: the per cent of lint, the length of lint, the weight of seed, the weight of boll, and the height of the plant. The correlation coefficient for the number of days to the first flower and the number of days to the first open boll was $+.5415\pm.0688$. The per cent of lint showed consistent negative correlation with all other characters although the coefficients were not high enough to signify any great importance, the coefficients for all varieties for 1917 and 1918 being $-.2702\pm.0903$ and $-.2445\pm.0680$ respectively. The lint length and the weight of the boll were consistently positive in their association within the varieties, the range being $+.0289\pm.1156$ to $+.3002\pm.0666$. For all varieties these two characters showed a correlation of $+.1956\pm.0695$ in 1917 and $+.1601\pm.0704$ in 1918. The length of lint was, for the greater part, positively correlated with the weight of the seed although the association was of little importance within the varieties. For all varieties the association of these two characters assumed some importance in 1918, the correlation coefficient being $+.2976\pm.0659$. The weight of the seed showed consistent and important association with the weight of boll, the correlation coefficients ranging from $+.5065\pm.0860$ to $+.8316\pm.0300$ within the various varieties. For all varieties these two characters gave a correlation coefficient of $+.8316\pm.0300$ in 1917 and $+.7802\pm.0283$ in 1918. The correlation coefficients for the per cent of lint with the weight per boll were as follows:

Trice	1911	=	$-.4550\pm.0917$
Trice	1912	=	$-.1837\pm.0707$
Foster	1917	=	$-.0909\pm.1447$
All varieties	1917	=	$-.1963\pm.0937$
All varieties	1918	=	$+.3951\pm.0610$

Apparently seasonal conditions influence the degree of association of these two characters.

Data have been published by Killough and Hafner (9) upon cotton varieties grown at the Texas Substation No. 3 at Angleton, by Karper and Jones (7) upon varieties grown at the Texas Substation No. 8 at Lubbock and by Killough and McNess upon the varieties grown at the Main station at College Station, Texas. A number of correlations were calculated by these workers. The results of their studies, in so far as the correlation of the various characters are concerned, are summarized in Tables I, II and III. It may be noted that the yield of lint is, as

Table I—Summary of the correlations obtained between the yield of lint and the characters, length of lint, lint per cent, size of boll, and earliness of cotton varieties grown at three Texas stations

Year	Length of lint			Lint per cent			Size of boll	Earliness
	Angleton	Lubbock	College Station	Angleton	Lubbock	College Station	College Station	College Station
1914	....	....	....	....	+.55±.06	....	....	....
1915	....	....	....	....	+.34±.09	....	....	....
1916	....	....	−.62±.06	....	+.66±.07	+.75±.04	+.51±.08	....
1917	....	....	+.35±.08	....	....	+.81±.03	....	....
1918	....	−.19±.12	−.11±.10	....	+.38±.10	+.59±.07	+.53±.07	....
1919	−.41±.18	−.27±.09	−.01±.11	−.04±.21	+.44±.08	+.24±.11	....	....
1920	−.82±.07	−.26±.16		+.62±.13	+.22±.19		....	....
1921	−.51±.16	−.22±.18	....	+.39±.18	+.06±.19	....	....	....
1922	−.45±.17	−.42±.15	−.25±.18	+.22±.20	+.37±.16	+.06±.19	....	+.11±.19
1923	....	+.04±.18	−.42±.16		−.11±.18	+.58±.13	....	+.17±.19
1924	....	−.06±.18	−.63±.10	....	+.45±.14	+.71±.08	....	−.29±.15
1925	−.66±.09	−.02±.17	−.40±.14	+.54±.12	−.07±.17	+.58±.11	+.57±.11	−.30±.15
1926	....	....	−.52±.12	....	....	+.34±.15	−.34±.15	+.50±.13

a rule, negatively associated with the length of lint, the one important exception being at College Station in the year 1917. The explanation given for this exception is that the season of 1917 was unusually dry resulting in a decrease in the yield and a lack of normal development in the length of lint. The highest correlation coefficient was obtained from the varieties grown at Angleton in 1920. It is of interest to note that the coefficients of correlation for these two characters are, on the average, much higher at the Angleton Station than at either of the other stations. At the Lubbock Station none of the correlations of the yield of lint with the length of lint assume any very great significance. Only in the year 1922, does there appear to be any important degree of relationship. At College Station, the association of these two characters assumes importance in the years 1916, 1924, and 1926.

The yield of lint was associated with the lint per cent to a reasonably high degree at the Angleton Station in 1920 and 1925, at the Lubbock Station in several seasons, and at the College Station in every year of the test except in the years 1919, 1922, and 1926. The relationships of any importance are all positive. That is, as the lint per cent increases the yield of the lint tends to increase also. Correlations were calculated for the yield of lint with the size of boll and earliness only at the College Station. The correlations between the yield of the lint and

Table II—Summary of the correlations obtained between the length of lint and the characters, lint per cent, size of boll, and earliness in cotton varieties grown at three Texas stations

Year	Lint per cent			Size of boll	Earliness
	Angleton	Lubbock	College Station	College Station	College Station
1916	....	....	−.52±.07	−.06±.10	....
1917	....	....	.00±.00	....	....
1918	....	−.45±.09	−.35±.09	+.01±.10	....
1919	−.67±.12	−.44±.08	−.28±.10	....	....
1920	−.76±.09	−.55±.14	....	....	....
1921	−.52±.15	−.37±.16	....	....	....
1922	−.71±.10	−.52±.14	−.54±.14	....	+.15±.18
1923	....	−.50±.14	−.43±.16	....	+.16±.19
1924	....	−.40±.15	−.62±.10	....	−.16±.16
1925	−.78±.06	−.74±.08	−.76±.07	−.52±.12	+.12±.17
1926	....	....	−.79±.06	−.08±.17	−.11±.17

Table III—Summary of the correlations of lint per cent with size of boll and earliness; and the size of boll with earliness in cotton varieties grown at College Station, Texas

Year	Lint per cent		Size of boll with earliness
	Size of boll	Earliness	
1916	+.56±.07	....	....
1918	+.60±.07	....	....
1922	....	−.81±.06	....
1923	....	−.24±.18	....
1924	....	−.32±.15	....
1925	+.69±.09	−.55±.12	−.13±.17
1926	+.45±.13	−.12±.17	−.57±.11

the size of boll were positive for three years out of the four reported and the relationship assumed considerable importance in those three years. The score for earliness was obtained by counting the number of blooms produced on 100 plants during the first 30 days of the blooming period. Apparently earliness was not a factor in the production of high yield of lint except possibly in the season of 1926.

The length of lint is consistently associated with the lint per cent in a negative relationship. That is, as the length of the lint increases the lint per cent tends to decrease. This is true in all the years of the study and at all three of the Texas stations. The association of the length of lint with the size of boll assumed some importance in the season of 1925. In this season the larger boll types tended to develop the longer staple. There is, apparently, no relation between the length of lint and earliness in any of the years of the study.

The lint per cent and the size of the boll show a positive relationship. Since the size of boll is recorded as the number of bolls it takes to make a pound of seed cotton, the relationship reported indicates the tendency for the smaller boll types to possess the higher gin turnout. It is surprising to note that the larger boll types tend to be earlier than the smaller boll types in the year 1926, the correlation coefficient being $-.57 \pm .11$.

In order to learn the extent of the variation to be found in the association of the four characters, the yield of seed cotton, the lint per cent, the lint length, and the number of bolls per pound, data were taken from several sources for variety tests in cotton. Correlations were calculated and are given in Table IV. The source of the data and the number of varieties included are as follows: Texas Spur Station 1917, (5) 50 varieties; Texas, College Station 1925, (13) 16 varieties; South Carolina 1910, (1) 31 varieties and 1923, 17 varieties; Arkansas, Burdette 1922, (16) 21 varieties; Scott 1922, (15) 21 varieties, and Scott 1921 and 1922, (16) 28 varieties; Mississippi (12) "standard soil" 1923 and 1924, and "hill soil" 1923 and 1924, 15 varieties; and Oklahoma 1924, (2) 36 varieties.

It may be noted that the correlation of yield with the other three characters is not consistent. The association of yield with the lint per cent varies in degree and is both positive and negative. In the tests at the Mississippi station the same 15 varieties were used in the seasons of 1923 and 1924 and on "standard" and "hill" soil. There appears to be very little difference in the relations of yield and the lint per cent due to different types of soil. However, there is considerable seasonal variation. This holds true for the correlations of yield with the length of lint and the number of bolls per pound in the data from Mississippi. There appears to be a consistent negative correlation between the lint per cent and the length of lint at all stations and in all years. The correlation coefficients range from $-.441 \pm .077$ for the Texas Spur Station to $-.901 \pm .033$ for the Mississippi "hill" soil in 1924. The lint per cent seems also to be rather uniformly negatively correlated with the number of bolls per pound although in a few cases the correlation coefficients are of little or no importance and hardly significant when considered in the light of their probable errors. The lint length with the number of bolls per pound shows considerable variation and in very few instances do the correlations appear statistically significant. In the South Carolina 1910 test the correlation coefficient is $-.411 \pm .101$ and at Burdette, Arkansas in 1922 the correlation coefficient is $+.425 \pm .121$. It is generally considered that the exceptionally long lint varieties of cotton are of the small boll type although the test for South Carolina mentioned above shows a tendency for the longer lint types to have the larger bolls.

The results published by Stroman (13) furnish data for 8 characters complete for 14 varieties. These characters are as follows: The yield of seed cotton, obtained by adding yields of lint and seed, the lint per cent, the length of lint in sixteenths of an inch, the total number of bolls, the per cent of the bolls that are 5-locked, the per cent of the bolls that are 4-locked, the weight per boll in grams, obtained by dividing the yield of seed cotton by the total number of bolls, and the weight of the lint. The correlation coefficients for the various characteristics

Table IV—Correlations calculated from data of variety tests of various state agricultural experiment stations

	Yield with			Lint per cent with		Lint length with bolls per pound
	Lint per cent	Lint length	Bolls per pound	Lint length	Bolls per pound	
Texas:						
Spur, 1917	−.120±.094	+.217±.091	+.081±.095	−.441±.077	−.313±.086	+.173±.093
College Station, 1925	+.105±.167	−.228±.160	−.379±.144	−.631±.101	−.538±.120	+.194±.162
South Carolina:						
1910	−.466±.095	+.136±.119	+.001±.121	−.593±.079	−.021±.121	−.411±.101
1923	+.331±.146	−.314±.147	+.084±.162	−.777±.065	+.009±.164	−.194±.157
Arkansas:						
Burdette, 1922	−.115±.127	−.203±.141	+.193±.142	−.542±.104	−.713±.072	+.425±.121
Scott, 1922	+.177±.143	−.246±.138	−.161±.143	−.754±.064	−.724±.070	+.375±.126
Scott, 1921	+.032±.127	−.208±.122	+.331±.114	−.784±.049	−.563±.087	+.230±.121
Scott, 1922	+.273±.118	−.356±.111	−.277±.118	−.837±.038	−.624±.078	+.327±.114
Mississippi:						
Standard Soil, 1923	−.123±.172	−.121±.172	−.005±.174	−.898±.034	−.539±.124	+.413±.144
Standard Soil, 1924	+.474±.135	−.589±.114	−.366±.151	−.892±.036	−.214±.166	+.215±.166
Hill Soil, 1923	+.012±.174	−.194±.168	+.126±.171	−.639±.103	−.318±.157	+.424±.143
Hill Soil, 1924	+.491±.132	−.491±.132	....	−.901±.033	....	....
Oklahoma:						
1924	+.082±.112	−.507±.084	+.312±.101	−.465±.088	−.494±.085	−.176±.109

with the yield of seed cotton, the lint per cent, the lint length, and the weight per boll are as follows:

Independent variable	Yield of seed cotton	Lint per cent	Lint length	Weight per boll
Lint per cent	−.0331±.1174	....	−.4289±.0326	+.5415±.0290
Lint length	−.0651±.0836	−.4289±.0326	....	−.2992±.0390
Weight per boll	+.3279±.0372	+.5415±.0290	−.2992±.0390	....
Total number of bolls	+.5898±.0277	−.4648±.0313	+.1901±.0488	−.5663±.0283
Per cent 5-lock bolls	+.5337±.0292	+.3831±.0345	−.4714±.0330	+.6268±.0269
Per cent 4-lock bolls	−.5345±.0292	−.3825±.0345	+.4171±.0330	−.6284±.0269
Yield of lint	+.9015±.0225	+.3852±.0344	−.2715±.0409	+.4710±.0311

It may be noted that the size of the boll and the number of locks per boll are significantly associated with the yield of seed cotton. The yield of lint is very closely associated with the yield of seed cotton, which is to be expected since it is a part of the yield of seed cotton. Undoubtedly any random sample of upland cotton varieties is largely represented by those varieties which have been developed for an increase in the lint per cent.

The lint per cent is negatively correlated with the lint length, the total number of bolls, and the percentage of 4-lock bolls; and positively correlated with the weight of the boll, the percentage of 5-lock bolls, and the yield of the lint. All of these correlations are significant when considered in the light of their probable errors and are of some importance although none of them are very high.

The lint length is positively correlated with the total number of bolls and the percentage of 4-lock bolls. This indicates that the smaller boll types in general tend to have the longer staples. This assumption is borne out by the fact that the length of lint is negatively correlated with the weight per boll and the percentage of 5-lock bolls. The 5-lock bolls tend to be larger than 4-lock bolls as is indicated by the positive association of the weight per boll and the percentage of 5-lock bolls.

The weight per boll is positively correlated with the lint per cent, the per cent of 5-lock bolls and the yield of lint and negatively correlated with the length of lint, the total number of bolls, and the percentage of 4-lock bolls.

Since the percentages of 4-lock and 5-lock bolls are component parts of 100 per cent their relations with all other characters are expected to be opposite in sign and the values of the correlation coefficients to be approximately the same. The results indicate that the higher the average number of locks per boll the greater the yield of seed cotton, the lint per cent, and the weight per boll, and the lower the length of the lint.

In general the data available suggest considerable variability in the degree of association of some of the characteristics in upland cottons. There appears to be a fairly consistent relationship between the lint per cent and the length of lint regardless of seasonal conditions or locality. The correlation coefficients obtained between these two characters are all negative and important. In several cases they are sufficiently high for use in prediction. These two characters are the only two so consistently associated. Their close relationship assumes added significance when one takes into consideration the fact that in all attempts at improvement the aim has been, no doubt, to increase both the length of the lint and the lint per cent. Information upon many other characters seems desirable and it is reasonable to assume that the location of the experiment may influence the results to the extent that it dictates very largely the varieties included in any random sample of the locally adapted varieties.

Materials and Methods

The present study includes observations made during the seasons of 1926 and 1927 at Stillwater, Oklahoma. According to the foregoing analysis of published data on cotton varieties in different years and in various localities of the cotton belt it is apparent that variation exists in the relationship of the various characteristics of upland cotton. No doubt some of the variation is traceable to the difference in varieties grown in the various sections although some variation is apparently due to seasonal differences. The data presented in this paper were taken from varieties in the regular variety test and which, therefore, form a random sample of the upland varieties showing promise for this section of the cotton belt. In the selection of varieties for use, only those grown in the variety test were used and only those were rejected which, obviously, were closely related as to their origin. For instance, there are a number of Mebane selections and to include all of them and only one of some other variety would in effect bias the results.

All of the correlation coefficients were calculated according to the methods suggested by Wallace and Snedecor (14) in their pamphlet "Correlation and Machine Calculation." The multiple correlations were corrected according to the formula on page 47 of their publication. The correlation ratios were calculated according to the method suggested by Kelly (8) and the use of Blakeman's test for linearity of regression was adapted from the same authority.

The study for 1926 included nineteen varieties and measurements were secured on 24 characters. Twenty-five plants were tagged in each of two series of the variety test making a total of 50 plants for each variety. The measurements were taken independently on each set of 25 plants and the score for any particular characteristic is an average of the two determinations. The characters studied and the methods of obtaining the measurements are as follows:

(a) The date of first flower. The date was recorded for the first blossom on each plant and the average taken for the variety.
(b) The date of first open boll. The date was recorded for the first open boll on each plant.
(c) The height of the plant. The height of each plant was recorded at maturity and was taken for all varieties at the same time.
(d) The height to the first branch. This character was measured at the same time as the height of the plant and is the distance from the ground to the node on the main stem of the plant where the first main branch appeared.
(e) The number of internodes in the main stem of the plant. This score was obtained at the same time as scores (c) and (d).
(f) The length of internodes of main stem, obtained from (c) and (e) by computation.
(g) The shape of plant. This character was obtained by measuring the angle and length of basal and median branches. The score given presumes to indicate the tendency toward conical shape, and the higher the score the more conical the plant shape.
(h) The total leaf area. The measurement of leaf area was taken for each plant on the day the first flower blossomed for that particular plant. While the actual date varied for the different varieties the time of measuring the leaf area represented a comparable period in the plant's development for all varieties. The leaves of the plant were grouped as to their positions and sizes. The number of each size was recorded and an outline of a representative of each size was traced on paper. Later the actual area in square inches of each size outline was measured with the aid of a planimeter and the total leaf area computed.
(i) The area of largest leaf. This score represents the area of the largest bract leaf. The measurement was made in the same manner as for the total leaf area and at the same date for each plant as for score "h."
(j) The number of fruit branches was determined at the time of maturity.
(k) The number of vegetative branches was also recorded at maturity.
(l) The total number of bolls was recorded just before the first picking was made.
(m) The number of bolls on the fruit branches, and
(n) The number of bolls on the vegetative branches were recorded at the same time as the total number of bolls, score "l."

Table V—A summary of data for various characteristics of nineteen varieties of upland cotton grown at Stillwater, Oklahoma, in 1926

Variety and Row		Date of first flower	Date of first open boll	Height of plant	Height to first branch	Number of internodes main stem	Length of internodes main stem	Shape of plant	Total leaf area	Area largest leaf	Number of fruit branches	Number of vegetable branches	Total number of bolls	Bolls on fruit branches	Bolls on vegetable branches	Bolls picked	Bolls per pound	Yield seed cotton	Per cent first pick	Lint per cent	Lint length	Yield lint	Weight 100 seeds	Lint index	Lint per cent ÷ lint length	Time to mature	Leaf area ÷ date first flower	Locks per boll
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(Σ)
Oklahoma Triumph No. 44	78	7–26	9–5	19.3	4.6	18.0	1.1	0.99	295	16.9	9.4	0.84	6.40	5.52	0.88	6.00	86.2	686	39.5	37.8	15	259	10	6.08	2.52	41	4.76	4.50
Acala 5–37	79	7–25	9–8	22.3	5.3	19.1	1.2	2.24	400	20.1	10.8	0.96	6.72	5.80	0.92	6.36	80.5	698	33.2	39.6	16	276	11	7.21	2.64	45	6.56	4.64
Acala 14	80	7–23	9–10	22.4	4.7	18.0	1.2	1.07	299	17.4	9.2	1.44	5.96	4.56	1.40	5.40	82.3	768	29.6	37.5	15	288	11	6.60	2.50	49	5.07	4.58
Imp. Meb.	81	7–30	9–23	19.2	4.2	16.0	1.2	2.98	431	26.2	8.9	1.32	6.44	4.68	1.76	6.28	60.7	579	15.1	38.6	16	224	13	8.17	2.41	55	6.53	4.77
Mebane	83	7–26	9–11	23.5	4.2	21.5	1.1	2.82	465	23.6	10.2	1.32	7.80	6.32	1.48	7.28	66.9	644	80.5	35.9	15	232	12	6.72	2.39	47	7.62	4.54
New Boykin	84	7–28	9–13	21.8	4.0	17.0	1.3	1.00	434	23.7	9.2	1.17	7.71	6.17	1.54	3.21	62.2	617	24.8	38.6	15	238	12	7.54	2.57	47	6.78	4.69
Lone Star	87	7–29	9–25	19.6	3.8	16.2	1.2	1.57	413	25.3	8.6	1.32	5.24	4.32	0.92	4.96	53.5	638	14.8	40.8	17	261	14	9.65	2.40	58	6.26	4.68
Rowden	88	7–26	9–22	22.2	4.0	17.7	1.3	1.91	303	20.5	9.6	1.56	6.00	5.00	1.00	5.56	57.9	625	21.0	37.0	16	231	14	8.22	2.31	58	4.89	4.62
Half and Half	89	8–4	9–19	21.0	5.7	17.2	1.2	0.96	302	22.9	9.0	0.48	6.68	2.16	0.52	5.76	80.0	759	30.3	48.0	12	364	9	8.31	4.00	46	4.25	4.51
Trice	91	7–21	9–1	23.7	5.0	18.1	1.3	1.84	276	17.5	10.7	0.84	6.72	6.52	0.20	6.68	91.3	610	52.0	37.0	14	226	10	5.87	2.64	32	4.84	4.49
Delfos	92	7–28	9–8	20.8	5.1	17.1	1.2	1.73	360	18.5	9.2	1.08	6.32	5.40	0.92	5.96	101.7	632	41.3	35.7	18	223	10	5.46	1.96	42	5.63	4.13
Delta Pine Land No. 4	93	7–31	9–17	19.2	4.4	16.2	1.2	1.72	384	21.3	8.6	1.56	6.28	5.20	1.08	5.88	77.0	658	24.3	37.7	16	248	11	6.66	2.36	48	5.73	4.41
Lightning Express	96	7–28	9–8	21.5	5.0	16.1	1.3	1.68	368	19.7	8.8	1.08	5.12	4.44	0.68	5.12	104.4	606	41.3	34.7	17	211	10	5.31	2.04	42	5.75	4.24
Super Seven	100	7–27	9–9	23.2	4.6	18.4	1.3	1.33	455	20.3	9.9	1.60	5.56	4.84	0.72	5.56	85.7	627	26.6	35.7	16	224	10	5.55	2.23	44	7.22	4.63
Dixie Triumph	101	8–1	9–17	19.9	5.5	14.4	1.4	1.36	404	23.2	7.3	1.76	4.16	3.56	0.69	4.00	80.6	598	40.1	40.1	15	240	10	6.99	2.67	47	5.94	4.64
Cleveland	103	7–30	9–10	22.0	4.8	17.2	1.3	2.10	435	23.9	8.8	1.12	5.32	5.08	0.24	5.20	82.1	626	26.2	32.7	13	205	11	5.34	2.52	42	6.59	4.50
Cook's Imp	105	7–30	9–14	20.7	4.9	16.2	1.3	2.13	355	21.5	8.6	0.88	4.12	3.56	0.56	4.04	91.7	734	28.8	38.3	14	281	9	5.59	2.74	46	5.38	4.47
Petty Toole	107	7–30	9–11	26.4	5.1	19.5	1.4	1.63	653	22.6	10.1	2.52	7.84	6.28	1.56	7.52	96.9	604	23.4	35.7	15	216	9	5.00	2.38	43	5.89	4.53
Plettner	111	7–28	9–26	21.1	3.3	15.7	1.4	1.25	432	24.0	8.0	1.44	5.64	4.40	1.24	5.28	58.0	580	24.5	34.4	17	200	13	6.82	2.02	60	6.75	4.77
Mean		28.05	13.53	21.51	4.64	17.35	1.26	1.70	392.84	21.58	9.20	1.28	6.11	4.94	0.96	5.58	78.93	646.79	29.86	37.65	15.37	244.58	11.00	6.69	2.49	46.95	6.13	4.54
Standard Deviation		3.15	6.81	1.78	0.61	1.55	0.07	0.56	84.41	2.73	0.85	0.43	1.03	1.06	0.44	1.05	14.89	55.22	9.28	3.18	1.41	37.35	1.56	1.23	0.41	6.67	1.25	0.21
Coefficient of Variability		11.23	50.33	8.28	1.31	8.93	5.56	3.29	21.49	12.65	9.24	33.59	16.86	21.46	45.83	18.82	18.86	8.54	31.08	8.45	9.17	15.27	14.18	18.39	16.47	14.21	20.39	4.63
Error of C.V.		1.23	5.51	0.91	0.14	0.98	0.61	0.36	2.35	1.38	1.01	3.68	1.84	2.35	5.01	2.06	2.06	0.93	3.40	0.92	1.00	1.67	1.55	2.01	1.80	1.55	2.23	0.51

Table VI—Summary of the measurements for the various characteristics of the varieties of upland cotton under observations at Stillwater, Oklahoma, in 1927

Variety	Row numbers	Date of first flower	Date of first open boll	Blossoms for 18 days	Number of squares at first flower	Number of bolls open at 18 days	Locks per boll	Number of flowers and bolls on at 18 days	Per cent shed at 18 days	Weight seed cotton	Lint		Time to mature	Weight of 100 seeds	Number of bolls to make 1 pound seed cotton	Area largest leaf	Height		Number of inter-nodes main stem	Length of internodes inches	Number of branches		Number of bolls, total	Weight seed	Link index	Per cent picked at first picking
											Per cent	Length					Of plant	To first branch			Fruit	Vegetable				
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)
Oklahoma Triumph No. 44	1 + 74	7–24	9–14	10.24	13.36	4.16	4.32	7.50	26.65	22.75	38.34	15.7	52	12.0	77.8	16.65	23.12	5.40	16.20	1.09	13.52	0.78	5.32	14.03	7.46	62.9
Acala 5	3 + 76	7–25	9–16	8.82	11.78	3.20	4.38	6.02	32.59	18.20	38.77	15.3	53	10.0	76.3	17.87	30.90	6.42	19.24	1.27	16.98	0.74	4.51	11.14	6.33	59.9
Mebane	4 + 77	7–27	10–2	6.04	8.50	2.03	4.64	3.00	50.33	8.67	36.84	15.3	67	13.6	61.4	25.34	31.58	5.06	18.44	1.44	16.98	0.82	2.35	5.47	7.93	31.5
New Boykin	5 + 78	7–31	9–26	6.73	8.90	2.26	4.58	4.20	37.57	12.75	37.05	14.3	57	11.8	70.7	23.14	31.54	5.24	18.30	1.44	16.68	0.94	3.26	8.03	6.95	39.5
Lone Star	7 + 80	7–26	10–1	7.50	10.58	2.12	4.59	3.86	48.52	9.39	36.39	16.3	67	13.3	62.0	26.77	33.80	5.17	18.65	1.54	17.18	0.88	2.99	5.97	7.61	38.3
Rowden	8 + 81	7–23	9–21	8.44	11.64	3.07	4.50	5.42	36.10	15.74	35.45	16.0	60	14.3	64.8	22.46	36.18	6.26	18.42	1.62	17.30	0.52	4.48	10.16	7.85	48.3
Half and Half	9 + 82	7–29	9–21	8.92	12.06	3.74	4.44	6.76	24.44	18.59	43.97	12.7	54	11.0	79.7	23.26	30.40	6.32	15.77	1.53	15.13	0.23	5.62	10.42	8.63	54.5
Trice	11 + 84	7–22	9–12	9.60	13.56	4.84	4.37	7.82	18.69	23.50	34.97	15.3	52	12.0	84.2	17.72	27.78	6.52	15.42	1.38	15.18	0.20	6.97	15.28	6.45	68.2
Delta Pine Land No. 4	12 + 85	7–29	9–23	7.06	9.15	2.65	4.32	4.16	41.17	16.83	35.26	16.0	56	12.0	88.7	19.57	29.64	6.06	17.04	1.38	16.44	0.50	3.68	10.90	6.54	56.7
Delfos	15 + 88	7–24	9–14	8.42	11.52	3.78	4.15	6.52	22.65	21.47	33.25	16.7	52	11.2	92.1	17.03	25.39	5.33	15.04	1.33	14.50	0.50	6.20	14.33	5.58	60.4
Lightning Express	16 + 89	7–27	9–16	5.14	7.62	2.80	4.09	4.08	20.90	17.06	32.13	18.0	51	10.7	96.8	17.80	29.04	6.24	16.27	1.40	15.69	0.54	4.00	11.58	5.07	58.2
Hartsville 21	17 + 90	8–1	10–13	6.42	9.12	1.40	4.45	2.98	53.08	10.02	28.63	18.7	73	13.7	81.7	22.37	28.22	6.42	15.68	1.39	15.16	0.26	2.01	7.15	5.50	26.3
Delta Type Webber	18 + 91	7–31	10–6	6.58	9.98	2.32	4.50	4.17	37.07	9.29	31.29	19.3	67	12.5	85.4	20.93	31.10	6.18	16.28	1.53	16.14	0.44	2.74	6.38	5.69	25.9
Super Seven	20 + 93	8–2	10–1	6.84	9.98	2.56	4.45	4.80	30.27	11.04	33.29	16.7	60	10.0	102.6	21.44	31.78	6.72	17.88	1.40	16.90	0.70	4.21	7.36	4.99	39.3
Dixie Triumph	21 + 94	8–1	9–29	7.58	10.71	2.67	4.11	5.21	31.35	16.60	33.80	15.3	59	10.0	89.1	22.51	27.60	5.18	15.76	1.42	14.92	0.80	4.15	10.99	5.11	43.5
Cleveland Big Boll	22 + 95	8–1	9–24	6.04	8.22	2.55	4.38	4.42	26.79	14.67	35.35	13.7	54	11.0	83.6	22.80	28.10	5.92	13.96	1.59	13.58	0.28	4.00	9.48	6.01	41.6
Plettner	23 + 96	7–24	9–21	7.56	10.24	2.35	4.67	4.53	50.20	14.06	35.75	16.7	59	14.0	63.7	23.01	30.30	5.48	16.20	1.53	15.14	0.90	3.64	9.03	7.79	40.0
Kasch	24 + 97	7–28	9–27	6.16	7.50	2.23	4.65	3.02	50.56	12.01	39.26	14.3	61	12.3	59.5	21.19	28.52	4.68	17.44	1.37	16.28	1.02	3.01	7.29	7.95	43.8
Mean		27.7222	24.2777	7.4494	10.2455	2.8183	4.4216	4.9150	35.4961	15.1466	35.5438	15.9055	58.5555	11.9666	78.8944	21.2144	29.7217	5.8111	16.7778	1.4250	15.7611	0.6139	4.0633	9.7217	6.6356	46.6000
Standard Deviation		3.4611	8.1773	1.3383	1.7676	0.8269	0.1735	1.4437	10.8742	4.5170	3.3266	1.6263	6.2383	1.3567	12.5403	2.8195	2.89	0.5970	1.4202	0.1217	1.1532	0.2558	1.2816	2.8348	1.1359	12.3122
Coefficient of Variability		12.4849	33.6824	17.9652	17.2525	29.3404	3.9239	29.3733	30.6349	29.8219	9.3592	10.2248	10.6537	11.3374	15.8950	13.2905	9.74	10.2734	8.4648	8.5404	7.3167	41.6680	31.5409	29.1595	17.1183	26.4210
Error of C.V.		1.40	3.79	2.02	1.94	3.30	0.44	3.30	3.44	3.35	1.05	1.15	1.20	1.27	1.79	1.49	1.09	1.15	0.95	0.96	0.82	4.68	3.55	3.28	1.92	2.97

(o) The number of bolls picked per plant represents the bolls which were actually matured and picked. It does not include the bolls which were too immature to open naturally.
(p) The number of bolls per pound of seed cotton was taken from the regular variety test data. The method of computing this item was to take a 25-boll sample from each of the three replicates of the test for each variety and determine the number of bolls per pound by actual weight.
(q) The yield of seed cotton represents the average yield of the three series computed to pounds per acre.
(r) The per cent at first pick is the actual percentage of the total yield of a variety that was picked at the first picking. All varieties were picked at the same date.
(s) The lint per cent was determined from the 25-boll samples harvested for the determination of the boll size and the lint length. It represents the gin turnout. The samples were ginned on a small experimental gin in the laboratory.
(t) The lint length is recorded in sixteenths of an inch and was also determined from the 25-boll sample. Several samples were made for each variety and the average taken for the several samples.
(u) The yield of lint represents the yield of seed cotton times the lint per cent.
(v) The weight of 100 seeds was obtained from seeds of the 25-boll samples.
(w) The lint index was determined according to the method described by Dunlavy (3) and is the "weight in grams of the fibres produced by 100 seeds." The common method of determination is to divide the weight of 100 seeds by the difference between 100 and the lint per cent for a variety, and multiply the quotient by the lint per cent.
(y) The time to mature represents the time between the date of the first blossom and the date of the first open boll.
(Σ) The number of locks per boll was determined in the field just previous to the time of the first picking.

The varieties studied in the season of 1926 and the averages for the characters measured are given in Table V. The mean, the standard deviation, and the coefficient of variability are given for each character.

Some characters are much more variable than others as is indicated by their coefficients of variability. The varieties used varied considerably for the date of the first open boll, the C.V. being 50.33±5.51. Other characters varying nearly as much are the number of vegetative branches, the number of bolls on the vegetative branches and the per cent of the crop picked at the first picking. The least variable character was the height to the first branch, the C.V. being only 1.31± 0.14. This particular characteristeric appears to be more dependent upon environmental conditions or else it is inherently similar for all upland varieties under observation.

During the season of 1926 careful observations were made in the hope of discovering characters, other than those already under investigation, which might be associated with the four important economic characteristics of the cotton crop. The study was repeated in a similar fashion in 1927 with some few characters omitted and others added for study. During the season of 1927, 18 varieties were included in the study and the scores were obtained on 25 characteristics, some of which were the same as for 1926. The methods of securing the measurements and assembling the data were the same in the season of 1927 as for the season of 1926. The data are given in Table VI. The characteristics studied are listed below together with the method used in obtaining the score in all cases of characters under observation for the first time. The characters studied are as follows:

(a) The date of the first open blossom.
(b) The date of the first open boll.
(c) The number of blossoms which had opened up to and including 18 days after the first flower opened. This measurement was made for the first

time in 1927 and was selected as a possible measure for the rapidity of fruiting. Counts were made on all varieties each day during the 18 days.

(d) The number of squares at first flower. On the day each plant opened its first blossom the number of squares was counted. This character also was expected to indicate the rapidity of fruiting.

(e) The number of bolls open at 18 days after the first open boll. This observation was made for each individual plant and the average taken. It also was considered a possible index to the rapidity of fruiting.

(f) The number of locks per boll.

(g) The number of flowers and bolls on at 18 days after the first blossom opened. This score represents the number of flowers and bolls that were on the plant 18 days after the day the first flower opened. Some varieties seem to shed more than others and it was thought there might be some variation among varieties as to their ability to fruit rapidly and also to retain the young bolls.

(h) The per cent shed at 18 days. A corollary of characters (c) and (g).

(i) The weight of seed cotton. This score represents the actual average yield per plot in pounds of seed cotton.

(j) The lint per cent.

(k) The lint length.

(l) The time to mature.

(m) The weight of 100 seeds.

(n) The number of bolls per pound.

(o) The area of the largest leaf in square inches.

(p) The height of the plant in inches.

(q) The height to the first branch in inches.

(r) The number of internodes in the main stem.

(s) The length of internodes in inches.

(t) The number of fruit branches.

(u) The number of vegetative branches.

(v) The total number of bolls per plant.

(w) The yield of seed.

(x) The lint index.

(y) The per cent picked at the first picking.

There is considerable variability in most of the characters under observation in 1927. (See Table VI.) The least variability was found in the character "the number of locks per boll," the C.V. being $3.92 \pm .44$. It is of especial interest to note the variability in those characters which are assumed to measure the rapidity of fruiting, such as, the number of squares at first flower and the number of flowers and bolls at 18 days after the first blossom. The coefficients of variability for these two characters are 17.25 ± 1.94 and 29.37 ± 3.30 respectively.

EXPERIMENTAL RESULTS

Correlation coefficients were obtained for all possible character combinations in the season of 1926. The data are given in Table VII. Several characters were found to be associated to a considerable degree with the four important economic characters, the yield of seed cotton, the lint per cent, the lint length, and the size of the boll.

Correlation coefficients were calculated for practically all character combinations in the season of 1927 and for all characters studied with the four characters, the yield of seed cotton, the lint per cent, the length of lint, and the number of bolls per pound. The data are given in Table VIII. The number of squares on the plant the day the first blossom opens is rather closely associated with the yield of seed cotton but hardly of any importance with respect to the lint per cent, the lint length, or the size of boll. The number of flowers and bolls on the plant 18 days from the date of the first blossom is even more closely associated with the yield of seed cotton, the correlation coefficient between these two variables being $+.8792 \pm .0361$. This one characteristic is a reasonably good indicator of yielding ability. Other characters of interest from the standpoint of their association

Table VII—Correlation coefficients for the various combinations of the characteristics studied in varieties of upland cotton grown at Stillwater, Oklahoma, in 1926

	Date of first boll open	Height of plant	Height to first branch	Number of nodes	Length of nodes	Shape of plant	Leaf area	Area of largest leaf	Number of fruit branches	Number of vegetable branches	Total bolls	Bolls on fruit branches	Bolls on vegetable branches	Bolls picked	Bolls per pound	Yield of seed cotton	Per cent of first pick	Lint per cent	Lint length	Yield lint	Weight of 100 seeds	Lint index	Lint per cent ÷ lint length	Time to mature	Leaf area ÷ date of first bloom	Lock per boll
Date of first bloom (a)	+.519± .113	−.377± .133	+.241± .146	−.485± .118	−.041± .154	−.083± .154	+.286± .142	+.619± .095	−.612± .097	+.038± .156	−.258± .144	−.663± .087	−.064± .154	−.252± .145	−.057± .154	+.005± .155	−.368± .134	+.433± .126	−.239± .146	+.269± .144	−.183± .150	+.183± .150	+.400± .130	+.240± .146	+.082± .154	+.166± .150
Date of first boll open (b)		−.432± .126	−.508± .115	−.491± .117	+.158± .135	+.046± .154	+.131± .152	+.698± .079	−.597± .100	+.208± .148	−.235± .146	−.521± .113	+.326± .138	−.260± .144	−.750± .068	−.171± .150	−.746± .069	+.307± .140	+.185± .149	+.086± .154	+.631± .093	+.710± .077	+.060± .154	+.920± .024	+.020± .155	+.442± .125
Height of plant (c)			+.211± .148	+.694± .080	+.050± .154	+.059± .154	+.469± .121	−.136± .152	+.662± .087	+.364± .134	+.452± .123	+.470± .121	+.057± .154	+.479± .119	+.289± .142	−.088± .154	+.119± .153	−.310± .140	−.212± .148	−.223± .147	−.253± .145	−.450± .123	−.080± .154	−.365± .134	+.556± .107	+.228± .147
Height to first branch (d)				+.044± .154	−.193± .149	−.085± .154	−.123± .152	−.326± .138	+.154± .151	−.226± .147	−.114± .153	−.252± .145	−.505± .115	+.134± .152	+.735± .071	+.377± .133	+.567± .105	+.344± .136	−.443± .124	+.417± .128	−.812± .053	−.366± .134	+.494± .117	−.675± .084	−.179± .150	−.204± .148
Number of nodes in main stem (e)					−.812± .053	+.260± .144	+.244± .146	−.228± .147	+.861± .040	+.041± .154	+.678± .084	+.583± .102	+.209± .148	+.704± .078	+.102± .153	+.201± .148	+.068± .154	−.154± .151	−.181± .150	+.024± .155	−.094± .153	−.227± .147	+.049± .154	−.319± .139	+.365± .134	+.186± .149
Length of nodes in main stem (f)						−.263± .144	+.450± .123	+.286± .142	−.383± .132	+.526± .112	−.445± .124	−.183± .150	−.237± .146	−.369± .134	+.118± .153	−.573± .104	−.018± .155	−.292± .142	−.022± .155	−.493± .117	−.140± .152	−.331± .138	−.215± .148	+.065± .154	+.374± .133	+.520± .113
Shape of plant (g)							+.223± .147	+.234± .146	+.263± .144	+.015± .155	+.080± .154	+.271± .143	+.159± .151	+.410± .129	−.125± .152	−.257± .145	−.182± .150	−.259± .145	+.091± .153	−.305± .140	+.261± .144	+.004± .155	−.224± .147	+.065± .154	+.259± .144	+.076± .154
Leaf area (h)								+.548± .108	+.064± .154	+.710± .077	+.285± .142	+.301± .141	+.451± .123	+.239± .146	−.037± .155	−.466± .121	−.435± .125	−.308± .140	+.137± .152	−.441± .125	−.002± .155	−.210± .148	−.291± .142	+.106± .153	+.976± .007	+.261± .144
Area of largest leaf (i)									−.405± .129	+.209± .148	−.048± .154	−.259± .144	+.254± .145	−.173± .150	−.599± .099	−.379± .133	−.684± .082	+.137± .152	−.102± .153	−.126± .152	+.433± .126	+.442± .125	+.102± .153	+.539± .110	+.432± .126	+.543± .109
Number of fruit branches (j)										−.121± .152	+.637± .092	+.639± .092	+.041± .154	+.662± .087	+.203± .148	+.128± .152	+.208± .148	−.091± .153	−.108± .153	+.014± .155	−.127± .152	−.203± .148	−.009± .155	−.464± .121	+.194± .149	+.157± .151
Number of vegetable branches (k)											+.093± .153	+.263± .144	+.479± .119	+.193± .149	−.081± .154	−.458± .122	−.382± .132	−.374± .133	+.309± .140	−.490± .118	+.134± .152	−.150± .151	−.468± .121	+.267± .144	+.695± .080	+.237± .146
Total bolls (l)												+.633± .093	+.535± .110	+.585± .102	−.114± .153	−.050± .154	−.062± .154	+.045± .154	−.090± .153	+.003± .155	+.060± .154	+.043± .154	+.078± .154	−.175± .150	+.370± .134	+.161± .151
Bolls on fruit branches (m)													+.307± .140	+.448± .124	+.050± .154	−.382± .132	+.154± .151	−.567± .105	+.231± .146	−.566± .105	+.138± .152	−.323± .139	−.519± .113	−.343± .137	+.452± .123	+.053± .154
Bolls on vegetable branches (n)														+.202± .148	−.426± .127	−.165± .151	−.544± .109	−.083± .154	+.374± .133	−.156± .151	+.427± .127	+.251± .145	−.308± .140	+.495± .117	+.494± .117	+.321± .139
Bolls picked (o)															+.180± .150	−.052± .154	+.090± .153	−.138± .152	+.021± .155	−.099± .153	−.090± .153	−.195± .149	−.076± .154	−.228± .147	+.300± .141	−.006± .155
Bolls per pound (p)																+.189± .149	+.682± .083	−.200± .149	−.108± .153	−.004± .155	−.872± .037	−.821± .050	−.026± .155	−.807± .054	−.038± .155	−.775± .062
Yield of seed cotton (q)																	+.070± .154	+.522± .113	−.465± .121	+.864± .039	−.358± .135	+.065± .154	+.584± .102	−.128± .152	−.488± .118	+.116± .153
Per cent of first pick (r)																		−.079± .154	−.115± .153	−.004± .155	−.598± .099	−.523± .112	+.044± .154	−.778± .061	−.381± .132	−.362± .134
Lint per cent (s)																			−.411± .129	+.869± .038	−.114± .153	+.632± .093	+.829± .048	+.123± .152	−.422± .127	+.396± .130
Lint length (t)																				−.504± .115	+.431± .126	+.047± .154	−.831± .048	+.372± .133	+.174± .150	+.137± .152
Yield of lint (u)																					−.282± .143	+.402± .130	+.839± .046	−.002± .155	−.510± .114	+.147± .151
Weight of 100 seeds (v)																						+.678± .084	−.364± .134	+.779± .061	+.024± .155	+.555± .107
Lint index (w)																							+.327± .138	+.647± .090	−.260± .144	+.540± .110
Lint per cent ÷ lint length (x)																								−.161± .151	−.378± .133	+.221± .147
Time to mature (y)																									+.052± .154	+.579± .103
Leaf area ÷ date of first boll (z)																										+.274± .143
Locks per boll (Σ)																										

Table VIII—Correlation coefficients for the various character combinations in upland cotton grown at Stillwater, Oklahoma, in 1927

	Date of first flower	Date of first boll	Flowers for 18 days	Number of squares at first flower	Bolls open at 18 days	Locks per boll	Number of flowers at 18 days	Per cent shed at 18 days	Yield of seed cotton	Lint per cent	Lint length	Time to mature	Weight of 100 seeds	Number of bolls per pound seed cotton	Area of largest leaf	Height of plant
Date of first flower (a)	1.000	.7055± .0797	−.5970± .1032	−.5581± .1094	−.5959± .1025	−.0165± .1546	−.5118± .1173	.1557± .1551	−.5481± .1112	−.2649± .1478	+.0331± .1588	.3700± .1372	−.3388± .1407	+.3674± .1375	.3618± .1381	+.0411± .1587
Date of first boll (b)		1.000	−.5738± .1067	−.4999± .1269	−.8354± .0481	.4102± .1322	.7478± .0700	.6773± .0861	−.8802± .0358	−.4051± .1329	+.3450± .1400	.9194± .0247	.3074± .1442	+.1170± .1568	.6575± .0903	
Flowers for 18 days (c)			1.000	.9960± .0106	.7961± .0582	−.1370± .1559	.8906± .0327	−.3988± .1336	+.7196± .0765	+.4201± .1309	−.2684± .1475	−.4209± .1308	−.0528± .1585	+.0516± .1585	−.3832± .1356	
Number of squares at first flower (d)				1.000	.7881± .0602	−.1897± .1553	.8967± .0313	−.4581± .1256	+.6652± .0886	+.2661± .1477	−.1190± .1567	−.3457± .1400	−.0605± .1583	+.0610± .1583	−.3555± .1388	−.1793± .1539
Number of bolls open at 18 days (e)					1.000	−.4307± .1294	.9517± .0148	.7900± .0597	+.9121± .0267	+.3545± .1389	−.3080± .1438	−.7644± .0661	−.3267± .1419	+.2612± .1481	−.6488± .0920	
Locks per boll (f)						1.000	−.4196± .1309	.7131± .0781	−.6124± .0994	+.2955± .1451	−.1438± .1556	.5474± .1114	.6362± .0946	−.7643± .0661	.6246± .0968	
Number of flowers on at 18 days (g)							1.000	−.7605± .0671	+.8792± .0361	+.3335± .1412	−.2804± .1465	−.6962± .0819	−.3472± .1398	+.2773± .1467	−.5760± .1062	−.3789± .1361
Per cent of flowers shed at 18 days (h)								1.000	−.7538± .0685	−.0838± .1578	+.1910± .1531	.8015± .0567	.6705± .0874	−.6552± .0907	.6194± .0980	
Weight of seed cotton (i)									1.000	+.2669± .1476	−.2864± .1549	−.8496± .0441	−.3812± .1359	+.3207± .1425	−.7493± .0697	−.5664± .1080
Lint per cent (j)									+.2669± .1476	1.000	−.8308± .0491	−.3839± .1355	−.1239± .1565	−.4584± .1256	.1229± .1565	+.0695± .1582
Lint length (k)									−.2864± .1549	−.8308± .0491	1.000	.4340± .1290	.2654± .1478	+.3049± .1441	−.1913± .1531	+.0276± .1589
Time to mature (l)									−.8496± .0441	−.3839± .1355	+.4340± .1290	1.000	.5914± .1034	−.3572± .1387	.6613± .0895	+.4106± .1321
Weight of 100 seeds (m)									−.3812± .1359	−.1239± .1565	+.2654± .1478		1.000	−.6886± .0835	.4298± .1295	
Number of bolls per pound seed cotton (n)									+.3207± .1425	−.4584± .1256	+.3049± .1441			1.000	−.5268± .1148	−.3739± .1367
Area of largest leaf (o)									−.7493± .0697	+.1229± .1565	−.1913± .1531			−.5268± .1148	1.000	+.6190± .0981
Height of plant (p)									−.5664± .1080	+.0695± .1582	+.0276± .1589			−.3739± .1367		1.000
Height to first branch (q)									+.1798± .1538	−.2537± .1487	+.2708± .1473			+.5627± .1086		
Number of internodes in main stem (r)									−.3895± .1348	+.2593± .1483	−.0205± .1589			−.4599± .1253		
Length of internodes (s)									−.4846± .1214	−.0605± .1584	−.0552± .1585			−.2334± .1503		
Number of fruit branches (t)									−.5290± .1145	+.0483± .1586	+.1191± .1567			−.3141± .1433		
Number of vegetative branches (u)									−.3156± .1431	+.2425± .1496	−.0999± .1574			−.4916± .1207		
Total number of bolls (v)									+.9553± .0140	+.2972± .1450	−.3325± .1414			+.3554± .1389		
Yield of seed (w)									+.9842± .0050	+.0989± .1574	−.1579± .1550			+.4021± .1333		
Lint index (x)									−.0259± .1589	+.7696± .0647	−.5345± .1135			−.8232± .0513		
Per cent picked at first picking (y)									+.9303± .0215	+.3669± .1375	−.3131± .1434					

Table IX—Characters associated with yield of seed cotton to the extent that the values of "r" are around .4 or higher; values for "η" and $\eta^2 - r^2$ for use in testing linearity of regression. 1926

	Value for "r"		Value for "η"		$\eta^2 - r^2$	
f	−.573±.104	−.4693±.1207*	fq = .5290±.1113	qf = .6942±.0802	fq = .0596±.0721	qf = .2617±.1287
i	−.379±.133	−.3455±.1362	iq = .3905±.1311	qi = .4658±.1211	iq = .0331±.0547	qi = .0976±.0885
k	−.458±.122	−.4088±.1289	kq = .5557±.1069	qk = .6336±.0927	kq = .1417±.1032	qk = .2343±.1221
t	−.465±.121	−.3537±.1353	tq = .3806±.1323	qt = .4767±.1195	tq = .0198±.0428	qt = .1021±.0902
s	+.522±.113	+.4748±.1198	sq = .5558±.1069	qs = .5213±.1127	sq = .0835±.0838	qs = .0463±.0643
u	+.864±.039	+.8701±.0376	uq = .9100±.0266	qu = .8959±.0305	uq = .0710±.0812	qu = .0455±.0653

f = length of stem internode.
i = area of largest leaf.
k = number of vegetative branches.
t = lint length.
s = lint per cent.
u = yield of lint.
q = yield of seed cotton.

* This value of "r" calculated from the same scatter diagram as that from which "η" was calculated.

Table X—Total, partial and multiple correlations in the series of variables as follows: Length of stem internode, area of largest leaf, number of vegetative branches, lint length, lint per cent, and yield of lint with yield of seed cotton as the dependent variable. 1926

	Total correlations	Partial correlations of yield with variable indicated at left and influence of character in vertical held constant $r_{fq.i}$, etc.						Partial correlations of yield with variable indicated at left and influence of others held constant in series with characters:		Multiple correlations in series	
		f	i	k	t	s	u	f, i, k, t, s, and u; $r_{fq.iktsu}$, etc.	f, i, k, t, and s; $r_{fq.ikts}$, etc.	$r_{q.fiktsu}$	$r_{q.fikts}$
f	−.573±.104	....	−.5240±.1123	−.4393±.1249	−.6590±.0875	−.5156±.1135	−.3335±.1376	−.2173±.1475	−.5222±.1126	.9421±.0174	.7661±.0639
i	−.379±.133	−.2739±.1431	....	−.3259±.1383	−.4842±.1185	−.5332±.1108	−.5407±.1095	−.2814±.1425	−.5088±.1146	....	....
k	−.458±.122	−.2246±.1469	−.4186±.1276	....	−.3733±.1332	−.3322±.1377	−.0788±.1538	+.2076±.1480	+.1044±.1531	....	....
t	−.465±.121	−.5829±.1021	−.5471±.1084	−.3827±.1320	....	−.3222±.1387	−.0678±.1540	−.1960±.1488	−.5352±.1104	....	....
s	+.522±.113	+.4525±.1230	+.6260±.0941	+.4254±.1268	+.4100±.1287	....	−.9185±.0241	−.8697±.0376	+.4151±.1281	....	....
u	+.864±.039	+.8155±.0517	+.8891±.0324	+.8254±.0494	+.8234±.0494	+.9725±.0082	....	+.9395±.0180	....	....	....

f = length of stem internode.
i = area of largest leaf.
k = number of vegetative branches.
t = lint length.
s = lint per cent.
u = yield of lint.
q = yield of seed cotton.

with yield of seed cotton are, the date of the first flower, the date of the first open boll, the total number of flowers opened at 18 days from the first flower, the number of bolls open 18 days after the first open boll, the number of locks per boll, the per cent of shed at 18 days after the first bloom, the time to mature, the area of the largest leaf, the height of the plant, the number of fruit branches, the total number of bolls, the yield of seed, and the per cent picked at the first picking.

As mentioned previously, there are four characters of importance from the standpoint of the producer. Other characters are important but their measurement is more detailed and laborious. Such characters are, quality of the fiber as indicated by the hardness and the strength of the fiber and the uniformity of the fiber length. The spinning test and the strength of yarn serve as the ultimate test upon any variety of cotton. The present study is confined to the four characters, the yield of seed cotton, the lint per cent, the lint length and the number of bolls per pound of seed cotton. These four characters are studied in their relations to each other and to the other characters under observation.

The Yield of Seed Cotton

In Table IX, are given the simple correlation coefficients for the various characters of importance in their association with the yield of seed cotton in the season of 1926. Also values of eta and $\eta^2 - r^2$ are included for use in testing the linearity of regression. Since the number of variates was small, a rather coarse grouping was used in the calculation of eta. This was necessary in order to bring two or more variates into each class. Kelly (8) points out that $\eta^2 - r^2$ from raw eta is likely to give a value that is too large and a value for its probable error that is "relatively too small" if fine grouping is used where the population is small. The groupings in the calculations here reported were so coarse that it amounted to a rather intensive coding of the scores. For this reason, if for no other, it seemed wise to calculate the correlation coefficients used in $\eta^2 - r^2$ from the same scatter diagram from which eta was calculated. Consequently there are two values for "r" given in Table IX and succeeding tables of a similar nature. A comparison of these two correlation coefficients suggests that the coding was generally instrumental in reducing the size of "r."

The characters which appear to be of importance from the standpoint of the yield of seed cotton in the season of 1926 are, the length of the internode on the main stem, the area of the largest leaf, the number of vegetative branches, the length of lint, the lint per cent, the total leaf area, and the yield of lint. The first five and the last of these characters are considered of importance from the standpoint of computing multiple and partial correlations. The total leaf area is only slightly better than the area of the largest leaf and since the latter score is much more easily obtained it is considered more desirable. The yield of lint is a part of the yield of seed cotton and offers no particular advantage from the standpoint of use in prediction but is included as a matter of interest. Apparently the regression upon the yield of seed cotton of each of the characters listed is linear since none of the values of $\eta^2 - r^2 \pm E\eta^2 - r^2$ is statistically of great significance.

The partial, total, and multiple correlations of the six characters, mentioned above, with yield as the dependent variable are given in Table X for the season of 1926. It is of interest to note the interrelation of these various characters in their associations with the yield of seed cotton. The number of vegetative branches is of little or no importance if the influence of the yield of lint is eliminated, the value of $r_{kq.u.}$ being $-.0788 \pm .1538$. Also the lint length is of no importance so far as yield is concerned when the influence of the yield of lint is removed. Also when the influence of the yield of lint is eliminated the correlation of the lint per cent with yield is $-.9185 \pm .0241$ as compared with $+.522 \pm .113$ as a total correlation. Here the value not only is increased but the sign is changed. The correlation of the lint per cent with yield is practically the same when the influence of the yield of lint is eliminated as when the influence of all the other variables, including the yield of lint, is removed. Apparently the number of vegetative branches is of little importance in itself since the value of $r_{kq.fitsu}$ is only $+.1044\pm.1531$ and $r_{kq.fits}$ is $+.2076\pm.1480$. The four other characters, the length of the stem internode, the area of the largest leaf, the lint length, and the lint per cent, seem not to be influenced to any great extent by each other in their association with the yield of seed cotton, the partial correlation of each with yield, with the influence of the other three held constant, being approximately the same as the total correlation of that particular variable with yield.

The multiple correlation ($r_{q.fitsu}$) of yield with the six characters, the length of the stem internode, the area of the largest leaf, the number of vegetative branches, the lint length, the lint per cent, and the yield of lint is $.9421\pm.0174$ and without the yield of lint ($r_{q.fikts}$) it is $.7661\pm.0639$. Since the yield of lint is a part of yield itself, there seems to be no particular advantage in its use. The yield of lint alone has practically as much influence on the yield of seed cotton, if the influence of the other five characters is eliminated, as have all six characters combined. The value of $r_{uq.fikts}$ is $+.9395\pm.0180$ and of $r_{q.fiktsu}$ is $.9421\pm.0174$. The correlation of the lint per cent and the yield of lint with the influence of the other five variables eliminated ($r_{su.fiktq}$) is $+.9654\pm.0106$. This result is to be expected since with the yield of seed cotton held constant, the yield of lint is practically dependent upon lint per cent.

In the season of 1927, six characters were selected for further analysis with respect to the yield of seed cotton. Their correlation coefficients and etas are given in Table XI. The values for $\eta^2 - r^2$ also are given for testing the linearity of regression. The regression in each case is considered to be linear although there might be some doubt in regard to the regression of the number of squares at first blossom on yield. However, in this case the value for $\eta^2 - r^2$ is less than three times its probable error.

In Table XII are given the total, partial, and multiple correlations for the season of 1927, in the series of variables, the date of first flower, the time to mature, the area of the largest leaf, the height of the plant, the number of squares at first blossom, the number of flowers and bolls on at 18 days from the first blossom, and the yield of seed cotton with the yield of seed cotton as the dependent variable. The interrelation of this series of variables appears somewhat complicated. For instance the number of blossoms and bolls on at 18 days after the first flower, appears to be independent of each of the other characters individually. This is shown by the fact that its partial correlation with yield, with the influence of each of the other characters eliminated is approximately the same as its total correlation with yield. However, when the combined influence of the other five variables is eliminated, the number of flowers and bolls on at 18 days has little significance in its relation to the yield of seed cotton. The height of the plant, in general, seems to be the least affected by the other variables, although in a sample in which the leaf size is made constant the height of the plant is of practically no importance so far as yield is concerned. Its partial correlation, however, ($r_{pi.alodg}$) is practically the same as $r_{pi.}$ the former being $-.5378\pm.1130$ and the latter being $-.5664\pm.1080$.

Several multiple correlations were calculated. (See Table XII.) The combination of the six characters, the date of first flower, the time to mature, the area of the largest leaf, the height of the plant, the number of squares at first flower and the flowers and bolls on at 18 days, with yield as the dependent variable gives a multiple correlation coefficient of $.9565\pm.0134$. In other words 91.5 per cent of the variability in the yield of seed cotton may be attributed to the variability of these six characters. However, the three characters, the date of the first blossom, the number of squares at this date, and the number of flowers and bolls on at 18 days after the first blossom are practically as good as all six, $r_{i.adg}$ being $.9303\pm.0215$. The variability of these three variables account for 86.5 per cent of the variability in the yield of seed cotton. Knowing the size of the leaf would be of some advantage also, $r_{i.adgo}$ being $.9408\pm.0182$.

The combination of these three oı four characters in their relation to yielding ability may be of particular interest from the standpoint of the plant breeder working with cotton. Cotton is classed as a naturally self-pollinated crop, but cross pollination occurs to the extent of 10 per cent or more between rows three and a half feet apart. This amount of natural crossing necessitates the use of

Table XI—Characters associated with yield of seed cotton to the extent that "r" is greater than .5, values for "η" and $\eta^2 - r^2$ for use in testing linearity of regression. 1927

	Value for "r"		Value for "η"		$\eta^2 - r^2$	
a	−.5481±.1112	−.5885±.1038	ai = .7030±.0804	ia = .6040±.1010	ai = .1479±.1113	ia = .0185±.0427
l	−.8496±.0441	−.7743±.0637	li = .8338±.0487	il = .8650±.0400	li = .0957±.0950	il = .1487±.1159
o	−.7493±.0698	−.7569±.0679	oi = .8731±.0378	io = .7638±.0662	oi = .1894±.1294	io = .0105±.0324
p	−.5664±.1080	−.5720±.1070	pi = .6808±.0853	ip = .6826±.0848	pi = .1363±.1067	ip = .1387±.1081
d	+.6652±.0887	+.4931±.1203	di = .7641±.0662	id = .7495±.0696	di = .3407±.1438	id = .3187±.1411
g	+.8792±.0361	+.7805±.0620	gi = .8264±.0505	ig = .8937±.0319	gi = .0737±.0840	ig = .1895±.1304

a = date of first flower.
l = time to mature.
o = area of largest leaf.
p = height of plant.
d = number of squares at first flower.
g = number of flowers on at 18 days.
i = yield of seed cotton.

Table XII—Total, partial, and multiple correlations in the series of variables as follows: date of first flower, time to mature, area of largest leaf, height of plant, number of squares at first flower, number of flowers on at 18 days, and yield of seed cotton with yield of seed cotton as the dependent variable. 1927

	Total correlations r_{ai}, etc.	Partial correlations of yield with variables indicated at left and influence of variable in vertical column held constant. $r_{ai.l}$, etc.						Partial correlations of yield with variables indicated at left and all others held constant. $r_{ai.lopdg}$, etc., and $r_{ai.dg}$, etc.		Multiple correlations with yield of seed cotton as dependent
		a	l	o	p	d	g	a, l, o, p, d, g series	a, d, g, series	
a	−.5481±.1112	....	−.4769±.1228	−.4486±.1269	−.6374±.0945	−.2855±.1460	−.2397±.1498	−.3506±.1394	−.5004±.1192	$r_{i.alopdg}$ = .9565±.0134
l	−.8496±.0441	−.8322±.0489	....	−.7130±.0782	−.8210±.0518	−.8843±.0347	−.6944±.0824	−.4887±.1210	....	$r_{i.adg}$ = .9303±.0215
o	−.7493±.0697	−.7066±.0800	−.4740±.1233	....	−.6160±.0987	−.7348±.0731	−.6238±.0971	−.2339±.1503	....	$r_{i.ald}$ = .9271±.0224
p	−.5664±.1080	−.6509±.0916	−.4525±.1264	−.1973±.1528	....	−.6086±.1000	−.5291±.1145	−.5378±.1130	....	$r_{i.ag}$ = .8866±.0339
d	+.6652±.0886	+.5177±.1163	+.7505±.0693	+.6442±.0930	+.6952±.0822	....	−.5842±.1048	+.1591±.1550	−.6901±.0833	$r_{i.alodg}$ = .9423±.0179
g	+.8792±.0361	+.8331±.0487	+.7599±.0672	+.8267±.0502	+.8715±.0381	+.8554±.0428	....	+.0775±.1580	+.8839±.0347	$r_{i.aod}$ = .8680±.0392
										$r_{i.adgo}$ = .9408±.0182

a = date of first flower.
l = time to mature.
o = area of largest leaf.
p = height of plant.
d = number of squares at first flower.
g = flowers on at 18 days.
i = yield of seed cotton.

artificial means of securing self fertilized seed in order to obtain pure strains. Eaton (4) has shown that the cotton plant will produce a good crop of bolls if defruited early in the season. Due to the close association of the three characters, the date of the first flower, the number of squares at first flower, and the number of flowers and bolls on at 18 days after the first bloom, with yielding ability, the breeder, selecting in hybrid materials, could identify the better yielding plants early in the growing season. This could be done about two weeks after the first bloom. The plants, selected as desirable, could then be defruited and some artificial means used to insure self pollination for the remainder of the season. It seems reasonable to assume that some such plan is feasible. The value of the three characteristics mentioned above is enhanced by the fact that they are not at all closely associated with any of the other three characters, the lint length, the lint per cent and the size of boll. One could select for yield early in the season and be assured of a random sample for each of the other important characteristics. A score could be prepared for each plant selected, on the basis of early blossoming and the number of squares at first flower, and one could prepare an elimination line for the character "the number of flowers and bolls on at 18 days from first flower." Only plants coming up to a certain standard would need to be reserved for self pollination. These three characters show promise of value in this respect, however the date of first flower was not closely associated with yield in 1926 and the consistency of the performance of all three characters should be ascertained before their establishment as criteria in selecting for yielding ability.

A summary of the correlation coefficients for yield with the several characters which were associated with it, in 1926 and 1927, to the extent of indicating importance is given in Table XIII. There is some variation in the size of the correlation eoefficients for the two years. However, the signs are the same for both years cxcept in the case of the date of the first flower and the total number of bolls. These characters were of no importance in 1926 but of considerable value in 1927. No reason can be assigned for these variations. It may be noted also that the characters, the per cent picked at the first picking and the date of the first open boll, agree in sign for the two years but are of no importance in 1926 and very important in 1927. Only three characters of those studied in both years are consistent in sign and value, the length of the stem internode, the area of the

Table XIII—Summary of the characters associated with the yield of seed cotton. 1926 and 1927

Independent variable	Correlation coefficients	
	1926	1927
Length of stem internode	$-.573\pm.104$	$-.4846\pm.1214$
Area of largest leaf	$-.379\pm.133$	$-.7493\pm.0698$
Number of vegetative branches	$-.458\pm.122$	$-.3156\pm.1431$
Length of lint	$-.465\pm.121$	$-.2864\pm.1549$
Lint per cent	$+.522\pm.113$	$+.2669\pm.1476$
Yield of lint	$+.864\pm.039$	....
Date of first flower	$+.005\pm.155$	$-.5481\pm.1112$
Time to mature	$-.128\pm.152$	$-.8496\pm.0441$
Height of plant	$-.088\pm.154$	$-.5664\pm.1080$
Number of squares at first bloom	....	$+.6652\pm.0887$
Number of flowers and bolls on at 18 days	....	$+.8792\pm.0361$
Per cent picked at the first picking	$+.070\pm.154$	$+.9303\pm.0215$
Date of the first open boll	$-.171\pm.150$	$-.8802\pm.0358$
Number of bolls open at 18 days	....	$+.9121\pm.0267$
Per cent shed at 18 days	....	$-.7538\pm.0685$
Total number of bolls	$-.050\pm.154$	$+.9553\pm.0140$
Number of bolls per pound	$+.189\pm.149$	$+.3207\pm.1425$

Table XIV—Characters associated with lint per cent to the extent that "r" is greater than .4 also values are given for "η" and $\eta^2 - r^2$ for use in testing linearity of regression. 1926

	Value for "r"		Value for "η"		$\eta^2 - r^2$	
a	+.433±.126	+.3151±.1394	as = .8064±.0542	sa = .4911±.1174	as = .5510±.0956	sa = .1419±.0923
m	−.567±.105	−.4763±.1197	ms = .8317±.0476	sm = .5691±.1046	ms = .4648±.1488	sm = .0970±.0894
q	+.522±.113	+.4838±.1185	qs = .5811±.1025	sq = .5830±.1021	qs = .1036±.0929	sq = .1058±.0928
t	−.411±.129	−.3617±.1345	ts = .4161±.1280	st = .4995±.1161	ts = .0424±.0614	st = .1187±.0958

a = date of first flower.
m = number of bolls on fruit branches.
q = yield of seed cotton.
t = lint length.
s = lint per cent.

Table XV—Total, partial, and multiple correlations in the series of variables as follows: date of first flower, number of bolls on fruit branches, yield of seed cotton, lint length, and lint per cent with lint per cent as the dependent variable. 1926

	Total correlations with lint per cent	Partial correlations of lint per cent with variables indicated at left and influence of character in vertical held constant. $r_{as.m}$, etc.				Partial correlations of lint per cent with variable indicated at left and influence of others held constant. $r_{as.mqt}$, etc.	Multiple correlation $r_{s.amqt}$
		a	m	q	t		
a	+.433±.126	....	+.0958±.1533	+.5046±.1153	+.3782±.1326	+.2214±.1472	.5926±.1003
m	−.567±.105	−.4281±.1264	....	−.4663±.1211	−.5323±.1109	−.2035±.1483	....
q	+.522±.113	+.5767±.1032	+.4012±.1299	....	+.4100±.1287	+.3643±.1342	....
t	−.411±.129	−.3513±.1357	−.3494±.1359	−.2229±.1470	....	−.1432±.1516	....

a = date of first flower.
m = number of bolls on fruit branches.
q = yield of seed cotton.
t = length of lint.
s = lint per cent.

Table XVI—Correlation coefficients of characters significantly associated with lint per cent. Also values for "η" and $\eta^2 - r^2$ for use in testing linearity of regression. 1927

	Value for "r"		Values for "η"		$\eta^2 - r^2$	
b	−.4051±.1329	−.2708±.1473	bj = .5004±.1186	jb = .5697±.1073	bj = .1771±.1122	jb = .2513±.1232
k	−.8308±.0492	−.7436±.0710	kj = .7754±.0635	jk = .7839±.0615	jk = .0483±.0685	kj = .0616±.0769
n	−.4584±.1256	−.5212±.1158	nj = .8275±.0500	jn = .7412±.0717	nj = .4132±.1542	jn = .2778±.1374

b = date of first open boll. n = number of bolls per pound.
k = lint length. j = lint per cent.

Table XVII—Total, partial, and multiple correlations in the series of variables as follows: Date of first open boll, lint length, number of bolls per pound, and lint per cent with lint per cent as the dependent variable. 1927

	Total correlations with lint per cent	Partial correlations with variables indicated at left and the influence of variable in vertical column held constant. $r_{bj.k}$, etc.			Partial correlations of lint per cent with variables indicated at left and influence of all others held constant. $r_{bj.kn}$, etc.	Multiple correlation
		b	k	n		
b	−.4051±.1329	....	−.2268±.1508	−.3982±.1338	−.2404±.1498	$r_{j.bkn}$ = .8379±.0473
k	−.8308±.0492	−.8052±.0560	....	−.8163±.0531	−.7915±.0593	....
n	−.4584±.1256	−.4526±.1264	−.3869±.1352	....	−.3944±.1343	....

b = date of first open boll. n = number of bolls per pound.
k = lint length. j = lint per cent.

largest leaf, and the number of vegetative branches. The length of lint and the lint per cent might also be included although their coefficients are less than two times their probable errors in the season of 1927.

The several characters studied only in 1927 offer material of promise. The number of squares at the time of the first bloom and the number of flowers and bolls on at 18 days after the first bloom appear of especial value. Their association with yield is reasonably close and their scores for any plant or strain should be, therefore, a fair index to yielding ability. The particular virtue of characters such as these is that they may be identified early in the growing season and the plants selected may then be induced to self pollinate.

Lint Per Cent

Only four characters were found to be associated to any extent, in 1926, with the lint per cent (See Table XIV). These characters are, the date of the first flower, the number of bolls on the fruit branches, the yield of seed cotton, and the length of the lint. The total correlations, correlation ratios, and values for $\eta^2 - r^2$ are given in Table XIV. The value for $\eta^2 - r^2$ using ηas suggests non-linearity of regression but when ηsa is used $\eta^2 - r^2$ is not significantly greater than its probable error. The same may be said for ηms and ηsm. As stated before, Blakeman's test is rather severe when the grouping is too fine and "n" is small. The regression is therefore considered to be sensibly linear in these two cases. None of the correlation coefficients are very high and the value for $r_{s.amqt.}$ is only $.5926 \pm .1003$ (See Table XV). This suggests that in selecting for improvement in lint per cent these four characters should be given some consideration. However, none of the characters are so closely associated with lint per cent but what one might obtain considerable improvement in this character without any sacrifice in the others.

Only three characters were found to be of importance from the standpoint of their association with lint per cent in the season of 1927 (See Table XVI), the date of the first open boll, the length of lint, and the number of bolls per pound. Their regressions on the lint per cent are considered to be linear. The correlation coefficient of the lint length with the lint per cent is $-.8308 \pm .0492$. This value is somewhat higher than that obtained in the 1926 observations. It is apparent that these two characters are closely associated and that any great improvement in one of them must be done at a more or less sacrifice in the other. It is probable that the lint per cent may be increased to some extent without seriously affecting the length of lint but any marked improvement in the lint per cent would certainly be done at a sacrifice in the length of lint. The correlation coefficient of the lint length with the lint per cent is practically identical with the multiple correlation coefficient obtained by using all three of the characters mentioned, r_{kj} being $-.8308 \pm .0492$ and $r_{j.bku.}$ being $.8379 \pm .0473$. (See Table XVII.)

The correlation coefficients for the characters of importance from the standpoint of the lint per cent for both years are given in Table XVIII. The relations

Table XVIII—Correlation coefficients for lint per cent and the characters of importance in relation to lint per cent for the two years 1926 and 1927

Independent variable	Correlation coefficient	
	1926	1927
Date of first flower	$+.433 \pm .126$	$-.2649 \pm .1478$
Number of bolls on fruit branches	$-.567 \pm .105$	....
Yield of seed cotton	$+.522 \pm .113$	$+.2669 \pm .1476$
Lint length	$-.411 \pm .129$	$-.8308 \pm .0492$
Number of bolls per pound	$-.200 \pm .149$	$-.4584 \pm .1256$
Date of first open boll	$+.307 \pm .140$	$-.4051 \pm .1329$
Lint index	$+.632 \pm .093$	$+.7696 \pm .0647$

Table XIX—Characters associated with lint length to the extent that "r" is approximately .4 or greater. Also values are given for "η" and $\eta^2 - r^2$ for use in testing the linearity of regression. 1926

	Value for "r"		Value for "η"		$\eta^2 - r^2$	
d	−.443±.124	−.3091±.1400	dt = .3220±.1387	td = .4760±.1197	dt = .0082±.0278	td = .1311±.0990
q	−.465±.121	−.2699±.1435	qt = .4439±.1242	tq = .3307±.1378	qt = .1252±.0970	tq = .0366±.0572
s	−.411±.129	−.3616±.1345	st = .4995±.1161	ts = .4161±.1280	st = .1188±.0959	ts = .0424±.0614
v	+.431±.126	+.3626±.1344	vt = .6040±.0983	tv = .5543±.1072	vt = .2333±.1205	tv = .1757±.1105
y	+.372±.133	+.1987±.1486	yt = .5237±.1123	ty = .4290±.1263	yt = .2348±.1166	ty = .1445±.1014

d = height to first branch.
q = yield of seed cotton.
s = lint per cent.
v = weight of 100 seeds.
y = time to mature.
t = length of lint.

Table XX—Total, partial, and multiple correlations in the series of variables as follows: height to the first branch, yield of seed cotton, lint per cent, weight of 100 seeds, time to mature, and length of lint with length of lint as the dependent variable. 1926

	Total correlations with lint length	Partial correlations of lint length with other variables indicated at left and influence of character in vertical column held constant. $r_{dt.q}$, etc.					Partial correlations of lint length with variable indicated at left and influence of others held constant. $r_{dt.qsvy}$, etc.	Multiple correlation $r_{t.dqsvy}$
		d	q	s	v	y		
d	−.443±.124	....	−.3265±.1382	−.3523±.1356	−.1766±.1499	−.2802±.1426	+.0938±.1534	.3326±.1376
q	−.465±.121	−.3589±.1348	....	−.3222±.1387	−.3688±.1337	−.4534±.1230	−.2317±.1464	....
s	−.411±.129	−.3072±.1402	−.2229±.1470	....	−.4037±.1295	−.4959±.1167	−.3180±.1391	....
v	+.431±.126	+.1363±.1519	+.3200±.1389	+.4241±.1269	....	+.2426±.1456	+.0520±.1543	....
y	+.372±.133	+.1104±.1529	+.3559±.1351	+.4761±.1197	+.0642±.1541	....	+.2681±.1436	....

d = height to first branch.
q = yield of seed cotton.
s = lint per cent.
v = weight of 100 seeds.
y = time to mature.
t = length of lint.

Table XXI—Correlation coefficients of characters significantly associated with lint length. Also values for "η" and $\eta^2 - r^2$ for use in testing linearity of regression. 1927

	Value for "r"		Value for "η"		$\eta^2 - r^2$	
j	$-.8308 \pm .0492$	$-.7438 \pm .0710$	jk = $.7839 \pm .0613$	kj = $.7754 \pm$	jk = $.0613 \pm .0767$	kj = $.0480 \pm .0682$
l	$+.4340 \pm .1290$	$+.3934 \pm .1344$	lk = $.5042 \pm .1186$	kl = $.5444 \pm$	lk = $.0994 \pm .0920$	kl = $.1416 \pm .1057$

j = lint per cent. l = time to mature.
k = lint length.

are consistent for the two seasons in respect to the characters, the yield of seed cotton, the length of lint, and the lint index. The score for the last mentioned character is dependent very largely on the lint per cent and should, therefore, show a close relationship. It would seem to have no particular value from the standpoint of its use in the prediction of lint per cent since it is necessary to obtain the lint per cent first and the latter score is more easily obtained than the former. The lint per cent and the lint length are consistently opposed to each other although for the season of 1926 the correlation coefficient is not very high.

Lint Length

Five characters were found to be of importance in their association with the length of lint in 1926 (See Table XIX), the height to the first branch, the yield of seed cotton, the lint per cent, the weight of 100 seeds, and the time to mature. No single character, however, is very closely associated with the lint length. The regression of each of the independent variables upon lint length is apparently linear. The partial correlations are given in Table XX and also the multiple correlation. The association of the combined score of the five characters here considered is hardly significant when considered in the light of its probable error, $r_{t.dqsvy.}$ being .3326± .1376.

In Table XXI are given the characters associated with lint length in the season of 1927. Only two characters appear to be of any great importance, the lint per cent and the time to mature. There is no advantage gained by using the time to mature since $r_{k.jl}$ is only .8179± .0526 while r_{jk} is −.8308± .0492 (See Table XXII).

There are three characters that are consistently of importance in their association with the length of lint (See Table XXIII). These are the lint per cent,

Table XXII—Total, partial, and multiple correlations with the series of variables as follows: lint per cent, time to mature, and lint length with lint length as the dependent variable. 1927

	Total correlations with lint length	Partial correlations of lint length with variable indicated at left and with the influence of variable in vertical column held constant. $r_{jk.l}$, etc.		Multiple correlation $r_{k.jl}$
		j	l	
j	−.8308± .0492	....	−.7985± .0575	.8179± .0526
l	+.4340± .1290	+.2241± .1510	....	....

j = lint per cent. l = time to mature.
k = lint length.

Table XXIII—Correlation coefficients for lint length with the several characters of importance in their association with lint length for the seasons 1926 and 1927

Independent variable	Correlation coefficients	
	1926	1927
Height to the first branch........................	−.443± .124	+.2708± .1473
Yield of seed cotton..............................	−.465± .121	−.2864± .1549
Lint per cent.....................................	−.411± .129	−.8308± .0492
Weight of 100 seeds...............................	+.431± .126	+.2654± .1478
Time to mature....................................	+.372± .133	+.4340± .1290
Number of bolls per pound.........................	−.108± .153	+.3049± .1441
Lint index..	−.821± .050	−.5345± .1135

Table XXIV—Characters associated with number of bolls per pound. Correlation coefficients are given together with "η" and $\eta^2 - r^2$ for testing linearity of regression. 1926

	Value for "r"		Value for "η"		$\eta^2 - r^2$	
b	−.750±.068	−.7029±.0783	bp = .7559±.0663	pb = .7927±	bp = .0773±.0829	pb = .1343±.1066
d	+.735±.071	+.6698±.0853	dp = .9089±.0269	pd = .8621±	dp = .3775±.1621	pd = .2946±.1493
i	−.599±.099	−.6418±.0910	ip = .7763±.0616	pi = .7282±	ip = .1907±.1221	pi = .1184±.0996
v	−.872±.037	−.8418±.0450	vp = .9012±.0291	pv = .9143±	vp = .1036±.0941	pv = .1273±.1050
Σ	−.775±.062	−.8082±.0537	Σp = .8451±.0443	pΣ = .8327±	Σp = .0610±.0749	pΣ = .0402±.1044

b = date of first open boll.
d = height to first branch.
i = area of largest leaf.
v = weight of 100 seeds.
Σ = number of locks per boll.
p = number of bolls per pound.

Table XXV—Total, partial, and multiple correlations in the series of variables as follows: date of first open boll, height to first branch, area of largest leaf, weight of 100 seeds, number of locks per boll, and number of bolls per pound of seed cotton with number of bolls per pound as the dependent variable. 1926

	Total correlations with bolls per pound	Partial correlations of bolls per pound with variables indicated at left and influence of character in vertical column held constant. $r_{bp.d}$, etc.					Partial correlations of bolls per pound with variable indicated at left and influence of all others held constant. $r_{bp.div\Sigma}$, etc.	Multiple correlation $r_{p.bdiv\Sigma}$
		b	d	i	v	Σ		
b	−.750±.068	....	−.6449±.0904	−.5788±.1029	−.5263±.1119	−.7186±.0747	−.8982±.0300	.9936±.0019
d	+.735±.071	+.6214±.0951	....	+.7129±.0761	+.0942±.1534	+.9324±.0203	+.9378±.0186	....
i	−.599±.099	−.1594±.1508	−.5606±.1060	....	−.5019±.1157	−.3357±.1373	+.5751±.1036	....
v	−.872±.037	−.7770±.0613	−.6593±.0875	−.8487±.0432	....	−.8404±.0456	+.1591±.1508	....
Σ	−.775±.062	−.7475±.0682	−.9416±.0174	−.6688±.0855	−.7146±.0756	....	−.9720±.0085	....

b = date of first open boll.
d = height to first branch.
i = area of largest leaf.
v = weight of 100 seeds.
Σ = number of locks per boll.
p = number of bolls per pound.

Table XXVI—Correlation coefficients of characters significantly associated with number of bolls per pound. Also values for "η" and $\eta^2 - r^2$ for use in testing linearity of regression. 1927

	Values for "r"		Values for "η"		$\eta^2 - r^2$	
f	−.7643±.0661	−.7604±.0672	fn = .8278±.0500	nf = .8606±.0411	fn = .1071±.0999	nf = .1624±.1209
h	−.6552±.0907	−.6294±.0961	hn = .6700±.0876	nh = .7395±.0719	hn = .0528±.0708	nh = .1502±.1129
m	−.6886±.0835	−.6952±.0822	mn = .7230±.0759	nm = .8161±.0531	mn = .0394±.0484	nm = .1827±.1249
o	−.5268±.1148	−.5562±.1098	on = .6000±.1017	no = .6597±.0897	on = .0506±.0691	no = .1258±.1035
q	+.5627±.1086	+.4240±.1304	qn = .7233±.0759	nq = .7493±.0698	qn = .3234±.1370	nq = .3817±.1416
r	−.4599±.1253	−.4321±.1293	rn = .4447±.1275	nr = .7252±.0754	rn = .0111±.0332	nr = .3392±.1390
u	−.4916±.1207	−.4404±.1282	un = .6125±.0992	nu = .6310±.0957	un = .1812±.1163	nu = .2042±.1213
w	+.4021±.1333	+.4039±.1330	wn = .5233±.1155	nw = .6366±.0945	wn = .1107±.0962	nw = .2422±.1265
j	−.4584±.1256	−.5212±.1158	jn = .7412±.0717	nj = .7461±.0705	jn = .2778±.1374	nj = .2851±.1386

f = number of locks per boll.
h = per cent shed at 18 days.
m = weight of 100 seeds.
n = number of bolls per pound.
o = area of largest leaf.
q = height to first branch.
r = number of internodes per plant.
u = number of vegetative branches.
w = yield of seed.
j = lint per cent.

the time to mature, and the lint index. The relation of the lint per cent to the lint length has been discussed above and the other characters appear to be of little importance.

The Number of Bolls Per Pound

The size of the boll apparently was rather closely associated with several characteristics in 1926. Of the five variables considered to be of importance, the weight of 100 seeds seems to be most closely associated with the number of bolls per pound, r_{vp} being $-.872 \pm .037$ (See Table XXIV). Next in the order of their importance are the number of locks per boll, the date of the first open boll, the height to the first branch, and the area of the largest leaf. All of the regressions are sensibly linear as indicated by Blakeman's test.

The apparent close relation of the weight of 100 seeds with the number of bolls per pound is evidently due in great part to the associated influence of the other independent variables in this season] since $r_{vp.bdi\Sigma}$ is $+.159 \pm .1508$ while r_{vp} is $-.872 \pm .037$. (See Table XXV.) When the influence of the other independent variables is eliminated, the number of locks per boll is most closely associated with the size of boll, $r_{\Sigma p.bdiv}$ being $-.9720 \pm .0085$. The degree of the association of the number of bolls per pound with the date of the first open boll and the height to the first branch is also improved when the influence of the other independent variables is eliminated. The inference is that in selecting to improve the size of the boll, all of these characters, except possibly the weight of 100 seeds, must be considered of importance. The varieties which tend to have the largest bolls are inclined also to be later in maturing, to have the first branch close to the ground, to have large leaves, and to have a large percentage of 5-lock bolls. The multiple correlation ($r_{p.bdiv\Sigma}$) is $.9936 \pm .0019$ which is high enough for practically perfect prediction. In other words 98.7 per cent of the variability in the size of the boll may be attributed to its relation to these other five characters.

In all, nine characters were found to be important in their association with the size of boll in the season of 1927. These nine characters are listed in Table XXVI together with their simple correlations, correlation ratios, and the values for $\eta^2 - r^2 \pm E\eta^2 - r^2$. The regressions are considered to be linear although there are some cases in which doubt might be expressed. In Table XXVII, are given the total, partial, and multiple correlations considering the nine characters as independent variables and the number of bolls per pound as the dependent

Table XXVIII—Correlation coefficients for the number of bolls per pound of seed cotton with the variables of importance in respect to this particular character. 1926 and 1927

Independent variable	Correlation coefficients	
	1926	1927
Date of the first open boll	$-.750 \pm .068$	$+.1170 \pm .1568$
Height to the first branch	$+.735 \pm .071$	$+.5627 \pm .1086$
Area of the largest leaf	$-.599 \pm .099$	$-.5268 \pm .1148$
Weight of 100 seeds	$-.872 \pm .037$	$-.6886 \pm .0835$
The number of locks per boll	$-.775 \pm .062$	$-.7643 \pm .0661$
Lint per cent	$-.200 \pm .149$	$-.4584 \pm .1256$
Lint length	$-.108 \pm .153$	$+.3049 \pm .1441$
Yield of seed cotton	$+.189 \pm .149$	$+.3207 \pm .1425$
Per cent shed at 18 days	....	$-.6552 \pm .0907$
Number of internodes per plant	$+.102 \pm .153$	$-.4599 \pm .1253$
Number of vegetative branches	$-.081 \pm .154$	$-.4916 \pm .1207$
Lint index	$-.821 \pm .050$	$-.8232 \pm .0513$

Table XXVII—Total, partial, and multiple correlations in the series of variables as follows: number of locks per boll, per cent shed at 18 days, lint per cent, weight of 100 seeds, area of largest leaf, height to first branch, number of internodes in main stem, number of vegetative branches, yield of seed and number of bolls per pound with the last mentioned variable as the dependent. 1927

	Total correlations with bolls per pound	Partial correlations of number of bolls per pound with the variables indicated at left and influence of the variable in the vertical column held constant. $r_{fn.h}$, etc.									Partial correlations of bolls per pound with the variable at left and influence of all others in the series held constant. $r_{fn.hymoqruw}$, $r_{fn.hmoq}$, etc.		Multiple correlations
		f	h	j	m	o	q	r	u	w	Series f, h, j, m, o, q, r, u, and w	Series f, h, m, o and q	
f	−.7643±.0661	....	−.5610±.1089	−.7051±.0800	−.5831±.1049	−.6491±.0920	−.7992±.0575	−.6667±.0883	−.6839±.0846	−.6849±.0846	−.5030±.1186	−.6274±.0965	$r_{n.fhymoqruw}$ = .9272±.0224
h	−.6552±.0907	−.2438±.1495	....	−.7831±.0615	−.3597±.1384	−.4929±.1203	−.5724±.1071	−.5706±.1071	−.5507±.1107	−.5880±.1040	−.2232±.1511	+.1752±.1541	$r_{n.fhmoq}$ = .8601±.0414
j	−.4584±.1256	−.3774±.1364	−.6819±.0850	....	−.7557±.0681	−.4667±.1243	−.3932±.1344	−.3971±.1339	−.4020±.1333	−.5448±.1118	−.3669±.1376	....	....
m	−.6886±.0835	−.4068±.1326	−.4449±.1275	−.8451±.0455	....	−.6030±.1012	−.7117±.0784	−.6942±.0824	−.7510±.0693	−.6346±.0949	−.4162±.1315	−.4847±.1216	....
o	−.5268±.1148	−.0971±.1575	−.2040±.1524	−.5334±.1138	−.3525±.1392	....	−.4577±.1256	−.4621±.1250	−.4842±.1217	−.3726±.1369	−.1378±.1560	+.0240±.1589	....
q	+.5627±.1086	+.6377±.0945	+.4416±.1279	+.5183±.1163	+.5989±.1019	+.5022±.1189	....	+.6128±.0992	+.3497±.1395	+.5393±.1128	+.6223±.0975	+.6721±.0872	....
r	−.4599±.1253	−.2112±.1519	−.2615±.1481	−.3989±.1337	−.4726±.1234	−.3764±.1365	−.5153±.1168	....	−.2329±.1503	−.3416±.1404	−.5391±.1128	....	....
u	−.4916±.1207	−.3529±.1392	−.2725±.1471	−.4416±.1279	−.6058±.1006	−.4431±.1278	−.1616±.1548	−.3007±.1446	....	−.4089±.1324	+.3610±.1383	....	....
w	+.4021±.1333	−.2367±.1501	−.1971±.1528	+.5036±.1186	+.2185±.1514	−.0266±.1589	+.6301±.0959	+.2467±.1493	+.2816±.1463	....	−.3438±.1402	....	....

f = number of locks per boll.
h = per cent shed at 18 days.
j = lint per cent.
m = weight of 100 seeds.
o = area of largest leaf.
q = height to first branch.
r = number of internodes to main stem.
u = number of vegetative branches.
w = yield of seed.
n = number of bolls per pound.

variable. Of the variability in number of bolls per pound, 86.0 per cent may be attributed to the variability of the nine characters listed, since $r_{n.fhjmoquw}$ is $.9272 \pm .0224$. When the influence of the other variables in the series is eliminated the height to the first branch appears to be the most closely associated with the number of bolls per pound. The next in importance is the number of internodes in the main stem followed by the number of locks per boll.

In all, there are eight characters consistently related to the number of bolls per pound of seed cotton for the two years of observations. (See Table XXVIII.) Of these eight characters, five are of importance as indicated by their correlation coefficients, the height to the first branch, the area of the largest leaf, the weight of 100 seeds, the number of locks per boll, and the lint index. The area of the largest leaf appears to be an important factor in gaging the size of the boll, the larger boll types of cotton tending to have the larger leaves. This is in agreement with the fact that the smaller leaf types tend to yield higher than the larger leaf types and that the small boll types have a slight tendency to yield more than the larger types.

Correlation Surfaces for the Four Main Characters Considered

The correlation coefficient indicates the tendency for two characters to vary together in the same direction or for one to increase as the other decreases. This measure, if relationship is close, enables one to predict with more or less accuracy, the relative scores of the variates for one variable knowing the scores of the other. In the event that several variables are closely associated with a particular character one may be enabled to predict with more accuracy. For instance it has been shown above (See Table XVIII) that the three characters, the date of first flower, the number of squares at first flower, and the number of bolls and flowers on at 18 days give the simple correlations with yield of $-.5481$, $\pm .6652$, and $+.8792$, respectively. The multiple correlation of these three characters with yield is .9303 which is much higher than for any one of the characters alone. The regression equation for this four variable problem is as follows: $\bar{I} = 21.1662 - .3046a - 1.9092d + 4.4731g$ where "$\bar{I}$" is the estimated value for yield, "a" is the date of the first flower, "d" is the number of squares at first flower, and "g" is the number of flowers and bolls on at 18 days. The estimated values for yield when correlated with the actual values for yield give a correlation coefficient of .9425 which is practically the same as the multiple correlation and might be used

Chart I—Scatter diagram for the variables yield of seed cotton and lint per cent. 1927

Lint per cent	Yield of seed cotton										f_y
	8.7–10.1	10.2–11.6	11.7–13.1	13.2–14.6	14.7–16.1	16.2–17.6	17.7–19.1	19.2–20.6	20.7–22.1	22.2–23.6	
28.6–30.2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
30.3–31.9	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
32.0–33.6	.....	1	.....	.....	.....	1	.....	.....	1	.....	3
33.7–35.3	.....	.....	.....	.....	.....	2	.....	.....	.....	1	3
35.4–37.0	2	.....	.....	1	2	.....	.....	.....	.....	.....	5
37.1–38.7	.....	.....	1	.....	.....	.....	.....	.....	.....	1	2
38.8–40.4	.....	.....	1	.....	.....	.....	1	.....	.....	.....	2
40.5–42.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
42.2–43.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
43.9–45.5	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
f_x	4	1	2	1	2	3	2	.....	1	2	18

$r_{xy} = +.2669 \pm .1476$.

as a check upon the multiple correlation. If such a relationship were consistent from one year to another one could use these characters as criteria in selecting for yielding ability.

There is another consideration, however, that should be emphasized and that is, that if the correlation is not perfect, there may be one important reason for it. The digression from a perfect correlation may be due to some one individual or some very few individuals diverging from the general tendency. In those instances where correlation is close it may be these exceptions that are of particular interest to the plant breeder. The correlation coefficient is a general index to the situation but it does not give all of the facts. For this reason scatter diagrams are given here for the four characters, the yield of seed cotton, the lint per cent, the lint length, and the number of bolls per pound of seed cotton for the season of 1927.

It may be noted from Chart I that some of the best yielding varieties are reasonably good from the standpoint of their lint per cent. A lint per cent of

Chart II—Scatter diagram for the characters yield of seed cotton and lint length. 1927

Lint length	Yield of seed cotton										f_y
	8.7–10.1	10.2–11.6	11.7–13.1	13.2–14.6	14.7–16.1	16.2–17.6	17.7–19.1	19.2–20.6	20.7–22.1	22.2–23.6	
12.7–13.3	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
13.4–14.0	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
14.1–14.7	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	2
14.8–15.4	1	.....	.....	.....	.....	1	1	.....	.....	1	4
15.5–16.1	.....	.....	.....	.....	1	1	.....	.....	.....	1	3
16.2–16.8	1	1	.....	1	.....	.....	.....	.....	1	.....	4
16.9–17.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17.6–18.2	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
18.3–19.0	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
19.1–19.7	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
f_x	4	1	2	1	2	3	2	......	1	2	18

$r_{xy} = -.2864 \pm .1549$.

Chart III—Scatter diagram for the characters yield of seed cotton and the number of bolls per pound of seed cotton. 1927

Number of bolls per pound seed cotton	Yield of seed cotton										f_y
	8.7–10.1	10.2–11.6	11.7–13.1	13.2–14.6	14.7–16.1	16.2–17.6	17.7–19.1	19.2–20.6	20.7–22.1	22.2–23.6	
59.5–63.9	2	.....	1	1	.....	.....	.....	.....	.....	.....	4
64.0–68.4	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
68.5–72.9	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
73.0–77.4	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
77.5–81.9	1	.....	.....	.....	.....	.....	1	.....	.....	1	3
82.0–86.4	1	.....	.....	.....	1	.....	.....	.....	.....	1	3
86.5–90.9	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2
91.0–95.4	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1
95.5–99.9	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
100.0–104.4	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1
f_x	4	1	2	1	2	3	2	......	1	2	18

$r_{xy} = +.3207 \pm .1425$.

from 35 to 40 is considered good even in upland cotton varieties. The indications are that, if one goes above 40 for lint per cent, he will do so at some sacrifice in the yield of seed cotton. This assumption is made in spite of the fact that the correlation coefficient suggests a slight tendency for the lint per cent to increase with an increase in the yield of seed cotton. It is also suggested in Chart II that an increase in the length of lint beyond an inch staple is very likely accomplished at a sacrifice in yielding ability, although an inch and a sixteenth may be possible without any great sacrifice of yield. Although the correlation coefficient between the yield of seed cotton and the number of bolls per pound is only $+.3207 \pm .1425$, it is apparent from a glance at Chart III that none of the highest yielders are of the large boll varieties. If the one individual in the lower left-hand corner of the scatter diagram is omitted r_{xy} is $+.5211 \pm .1192$ which is considerably higher than it is with this individual included. If the widely divergent individual were

Chart IV—Scatter diagram for the variables lint per cent and lint length. 1927

Lint length	Lint per cent										f_y
	28.6–30.2	30.3–31.9	32.0–33.6	33.7–35.3	35.4–37.0	37.1–38.7	38.8–40.4	40.5–42.1	42.2–43.8	43.9–45.5	
12.7–13.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
13.4–14.0	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
14.1–14.7	.....	.....	.....	.....	.....	1	1	.....	.....	.....	2
14.8–15.4	.....	.....	.....	2	1	.....	1	.....	.....	.....	4
15.5–16.1	.....	.....	.....	1	1	1	.....	.....	.....	.....	3
16.2–16.8	.....	.....	2	.....	2	.....	.....	.....	.....	.....	4
16.9–17.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17.6–18.2	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
18.3–19.0	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
19.1–19.7	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1
f_x	1	1	3	3	5	2	2	.....	.....	1	18

$r_{xy} = -.8308 \pm .0491$.

Chart V—Scatter diagram for the characters lint per cent and the number of bolls per pound of seed cotton. 1927

Number of bolls per pound seed cotton	Lint per cent										f_y
	28.6–30.2	30.3–31.9	32.0–33.6	33.7–35.3	35.4–37.0	37.1–38.7	38.8–40.4	40.5–42.1	42.2–43.8	43.9–45.5	
59.5– 63.9	.....	.....	.....	.....	3	.....	1	.....	.....	.....	4
64.0– 68.4	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
68.5– 72.9	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
73.0– 77.4	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
77.5– 81.9	1	.....	.....	.....	.....	1	.....	.....	.....	1	3
82.0– 86.4	.....	1	.....	1	1	.....	.....	.....	.....	.....	3
86.5– 90.9	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	2
91.0– 95.4	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
95.5– 99.9	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
100.0–104.4	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
f_x	1	1	3	3	5	2	2	.....	.....	1	18

$r_{xy} = -.4584 \pm .1256$.

in the upper right-hand corner of the scatter diagram it would have considerable value from the standpoint of the plant breeder.

A glance at Chart IV reveals the close relationship of the lint per cent and the lint length. There are no exceptional individuals here and it is apparent that the increase in either variable will result in a corresponding decrease in the other. The evidence suggests that it is doubtful if one can expect to obtain a variety with a gin turnout greater than 37 per cent if he desires an inch and a sixteenth staple. A fiber length of an inch and an eighth is considered the most desirable. With this length of staple it seems unlikely that the gin turnout can be increased beyond 34 per cent. It is apparent from Chart V that with a lint per cent of 40 one can expect to obtain the very largest boll types, which run about 60 bolls to the pound of seed cotton. Some sacrifice in the size of boll may be necessary if one desires a higher lint per cent.

Chart VI—Scatter diagram for the variables lint length and the number of bolls per pound of seed cotton. 1927

Number of bolls per pound seed cotton	Lint length										f_y
	12.7–13.3	13.4–14.0	14.1–14.7	14.8–15.4	15.5–16.1	16.2–16.8	16.9–17.5	17.6–18.2	18.3–19.0	19.1–19.7	
59.5– 63.9	....	....	1	1	....	2	....	....	....	....	4
64.0– 68.4	....	....	....	....	1	....	....	....	....	....	1
68.5– 72.9	....	....	1	....	....	....	....	....	....	....	1
73.0– 77.4	....	....	....	1	....	....	....	....	....	....	1
77.5– 81.9	1	....	....	....	1	....	....	....	1	....	3
82.0– 86.4	....	1	....	1	....	....	....	....	....	1	3
86.5– 90.9	....	....	....	1	1	....	....	....	....	....	2
91.0– 95.4	....	....	....	....	....	1	....	....	....	....	1
95.5– 99.9	....	....	....	....	....	....	....	1	....	....	1
100.0–104.4	....	....	....	....	....	1	....	....	....	....	1
f_x	1	1	2	4	3	4	......	1	1	1	18

$r_{xy} = +.3049 \pm .1441.$

It is evident from Chart VI that the extreme staple lengths are found only in the smaller boll types although one can obtain a length of an inch and a sixteenth in the very largest boll types.

The varieties included in this study are fairly representative of those grown in this section of the cotton belt and are probably reasonably indicative of the general relationships of the various characters studied. The present study may be considered as fairly comprehensive although obviously preliminary. It is highly desirable to obtain further information on the relationship of several of the most promising characters in observations extending over a longer period of time and perhaps including a larger number of varieties.

SUMMARY

1. A review is given for the correlation studies in cotton and correlation coefficients are calculated from published data of variety tests in a number of localities of the cotton belt. The four characters given emphasis in these studies are the yield of seed cotton, the lint per cent, the lint length, and the size of boll. There is considerable variability in the degree of association among these four characters as expressed by their correlation coefficients. The correlations vary from year to year and from one locality to another with the exception of the two characters, lint length and lint per cent. These two are negatively correlated in all years and in all sections. In several instances the relation is sufficiently close to be of value in predicting one character from values of the other.

2. Original data are given for observations on a random sample of upland varieties of cotton for the two years 1926 and 1927 at Stillwater, Oklahoma. Nineteen varieties were included in the study for 1926 and scores were obtained on 24 characters including the yield of seed cotton, the lint per cent, the length of lint, and the number of bolls per pound of seed cotton. Twenty-five characters were studied in the season of 1927 and on 18 varieties. Correlations were calculated with particular reference to the four characters of economic importance.

3. The characters of importance in their association with the yield of seed cotton in 1926 and their correlation coefficients with yield are as follows: the length of stem internode, $-.573 \pm .104$; the area of the largest leaf, $-.379 \pm .133$; the number of vegetative branches, $-.458 \pm .122$; the lint length, $-.465 \pm .121$; the lint per cent, $+.522 \pm .113$; and the yield of lint, $+.864 \pm .039$. The multiple correlation of these six characters with yield is $.9421 \pm .0174$ and without the yield of lint included it is $.7661 \pm .0639$.

4. Six characters were found to be of interest from the standpoint of their relations to yield in the season of 1927. These characters and their correlation coefficients with yield are as follows: the date of the first flower, $-.5481 \pm .1112$; the time to mature, $-.8496 \pm .0441$; the area of the largest leaf, $-.7493 \pm .0698$; the height of the plant, $-.5664 \pm .1080$; the number of squares at first flower, $+.6652 \pm .0887$; and the number of flowers on at 18 days, $+.8792 \pm .0361$. With these six variables and yield as the dependent variable the multiple correlation coefficient was $.9565 \pm .0134$. Omitting the characters, time to mature and the height of the plant, "R" was $.9423 \pm .0179$.

5. Four characters were considered of interest from the standpoint of their association with the lint per cent in 1926. These characters and their correlation coefficients with lint per cent are as follows: the date of the first blossom, $+.433 \pm .126$; the number of bolls on fruit branches, $-.567 \pm .105$; the yield of seed cotton, $+.522 \pm .113$; and the lint length, $-.411 \pm .129$. The multiple correlation obtained by the use of the four characters mentioned with the lint per cent as the dependent variable is $.5926 \pm .1003$. Only three characters were of importance in respect to lint per cent in 1927. The date of the first open boll, the length of lint, and the number of bolls per pound are the three characters and their correlation coefficients with lint per cent are $-.4051 \pm .1329$, $-.8308 \pm .0492$, and $-.4584 \pm .1256$, respectively. Using these three characters in a multiple correlation problem with the lint per cent, "R" is $.8379 \pm .0473$.

6. The length of lint, in 1926, was associated to a considerable degree with the characters, the height to the first branch, the yield of seed cotton, the lint per cent, the weight of 100 seeds, and the time to mature. The correlation coefficients obtained are $-.443 \pm .124$, $-.465 \pm .121$, $-.411 \pm .129$, $+.431 \pm .126$, and $+.372 \pm .133$, respectively. The multiple correlation obtained was not significant when considered in the light of its probable error. In 1927, only two characters appear to be of any importance from the standpoint of lint length. These characters are lint per cent and time to mature. The two characters combined do not give as high a correlation coefficient as does lint per cent alone.

7. There were five characters in 1926 and nine in 1927 which were important in their associations with the number of bolls per pound of seed cotton. For the season of 1926 the characters and their correlation coefficients with the number of bolls per pound are as follows: the date of the first open boll, $-.750 \pm .068$; the height to the first branch, $+.735 \pm .071$; the area of the largest leaf, $-.599 \pm .099$; the weight of 100 seeds, $-.872 \pm .037$; and the number of locks per boll, $-.775 \pm .062$. Using these five variables with the number of bolls per pound as the dependent variable the multiple correlation coefficient is $.9936 \pm .0019$. The characters associated with the number of bolls per pound in 1927 are as follows: the number of locks per boll, $-.7643 \pm .0661$; the per cent shed at 18 days, $-.6552 \pm .0907$; the weight of 100 seeds, $-.6886 \pm .0835$; the area of the largest leaf, $-.5268 \pm .1148$; the height to the first branch, $+.5627 \pm .1066$; the number of internodes per plant, $-.4599 \pm .1253$; the number of vegetative branches, $-.4916 \pm .1207$; the yield of seed, $+.4021 \pm .1333$; and the lint per cent, $-.4584 \pm .1256$. With these nine variables and the number of bolls per pound as the dependent variable the multiple correlation coefficient is $.9272 \pm .0224$.

8. Scatter diagrams are given for the interrelations of the four characters, the yield of seed cotton, the lint per cent, the length of lint, and the number of bolls per pound, for the season of 1927. The indications are that these characters are not closely associated except for the two characters, lint length and lint per cent. It is reasonable to assume that in advancing the length of lint beyond an inch and a sixteenth that one must expect a reduction in the lint per cent.

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