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**The Effect of Exposure in the Field
On Grade, Strength, and Color
Of Raw Cotton**



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T. O. WALTON, President

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Attempts to reduce the costs of cotton production have resulted in the adoption of methods of harvesting which encourage the postponement of picking until most of the bolls are open. As a result the bolls which open early are often exposed to the weather for weeks or even months. This study was undertaken to measure the extent to which the cotton was lowered in grade, staple, strength, and color when thus exposed under normal weather conditions for various periods of time.

The cotton used was of the same variety, grown for two seasons at Temple, Chillicothe, and Lubbock regions where soil and climate differ. The grade, strength, and color of unexposed cotton and cotton exposed from one to 33 weeks were determined. A drop of one grade had occurred after one week of exposure at one station and after an average of less than 4 weeks for all stations and seasons. A drop of 4 and 5 grades, a decrease in length of from 1/16 to 3/16 inches, and a decrease in price of from 150 to 265 points occurred during exposure. The monetary loss due to exposure was in some cases nearly one-half the price of the unexposed cotton, or at 1932 and 1933 prices approximately \$13.00 per 500 pound bale.

All of the cotton lost strength, but not equally, upon exposure. There was an average loss of 4 per cent after 4 weeks and a maximum loss of approximately 14 per cent for the season. Cotton grown at Temple lost the lowest and that at Lubbock the highest percentage of the original strength. These differences were not due entirely to differences in rainfall but may have been due in part to greater ultra-violet in the sunlight at the higher altitude.

There were regional and seasonal differences in the color. All cottons became darker and less creamy as the exposure increased. In all cases there was a decrease in either creaminess or brightness, or in both, within 3 to 5 weeks after opening. Precipitation apparently caused greater darkening than it did loss in creaminess. The grades appear to follow brightness more closely than they do creaminess.

Three lots of lint cotton stored in a vault for one year had lost respectively 7, 15, and 18 per cent of their original strength, and after two years of storage two lots had lost 25 and 33 per cent.

It is concluded that cotton should be harvested, so far as is practicable, not later than 4 or 5 weeks and preferably within 1 or 2 weeks after opening to assure a product of high quality in grade, strength, and color.

CONTENTS

	Page
Introduction	5
Source of material	6
Method of procedure	6
The effect of exposure on the grade and staple of cotton	8
The effect of exposure on the price of cotton	12
The effect of exposure on the strength of cotton	13
The strength of unexposed cotton	13
The strength of exposed cotton	17
The effect of exposure on the color of cotton	23
The effect of storage on the strength of cotton	30
Summary and conclusions	32
Literature cited	35

THE EFFECT OF EXPOSURE IN THE FIELD ON GRADE, STRENGTH, AND COLOR OF RAW COTTON

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In the development of cotton growing in the Western Cotton Belt economies in production have been sought by the growers. Among high costs of producing cotton the expense of picking is important. Snapping of the bolls has become a general practice in some sections as a means of lowering the expense of picking, and stripping is resorted to in many instances. These methods of harvesting tend to encourage the delay of picking until a fair proportion of all the bolls is open. In consequence the indeterminate habit of growth of the cotton plant often causes harvesting to be delayed for one or even two or more months, during which time the lint cotton is exposed to weather conditions in the field.

It is conceded that permitting cotton to remain in the field for a considerable length of time after ripening causes a lowering of the quality. Consequently, cotton picked late in the season commands a lower price than cotton from the same field picked early in the season. This price discrimination has raised many questions. What differences in the price are due to exposure? What differences in quality are the cause of the differences in price? How long may cotton remain open in the field exposed to normal weather conditions before the quality is lowered? To what extent is it lowered in one season? What attributes comprising quality are most affected? What are the effects of various lengths of exposure upon the grade, staple, color, and strength?

This study was undertaken with the hope of obtaining answers to some of these questions which would serve as a basis for the formulation of definite advice to the cotton grower with respect to the time of picking and its effect on the quality of cotton.

A profitable approach appeared to be to compare measurable characteristics of cottons, which, as classified by a cotton classer, differed in grade. Two factors, color and strength, which are considered by the cotton classer to be of great importance in determining the grade of cotton, may be measured objectively. Such objective determinations, it was thought, might be used to ascertain to what extent two grades of cotton owe their respective grades to differences in color, strength, or other factors.

¹The author is grateful to Mr. D. T. Killough of the Division of Agronomy for his valuable aid in formulating plans for this study, for ginning the cotton, and for helpful suggestions and criticisms; to Messrs. D. L. Jones, J. R. Quinby, and Henry Dunlavy, superintendents of the substations at Lubbock, Chillicothe, and Temple, respectively, for growing, tagging, picking, and shipping the cotton; to Mr. J. G. Powers of the Department of Textile Engineering for classing each lot of cotton; and to Mr. S. R. Senter for permission to include a portion of a previous report.

SOURCE OF MATERIAL

Ferguson Triumph 406 was selected for this study because this variety is widely grown, has been line bred for a number of years, possesses good uniformity of type, and is well adapted to conditions in the western part of the state where early maturity is desirable.

The three stations chosen for growing the cotton used in this study are located in regions of the state differing widely in soil and climatic conditions.

The Temple Station is located in Bell county, at approximately 740 feet above sea-level, on land typical of the Houston series predominating throughout the Blackland region. The average annual rainfall for twenty-three years is 35.28 inches.

The Chillicothe Station is located in Hardeman county at an elevation of 1406 feet above sea-level. The soils are fine sandy loams, loams, and clay loams of the Foard and Vernon series. The average rainfall over thirty years is 24.92 inches.

The Lubbock Station is located in Lubbock county on the High Plains region of the state. The elevation is approximately 3195 feet above sea-level. The soil is of the Amarillo and Richfield fine sandy loam type, which is typical of a great portion of the region. The average annual rainfall for twenty-five years is 18.60 inches.

Cotton grown for two seasons, 1931 and 1932, at each of the three stations was chosen for this study. A record of the rainfall and temperature for each of the two seasons was furnished by each station. The plans for tagging and picking were made by D. T. Killough of the Division of Agronomy and carried out under the immediate supervision of the superintendents of these substations, J. R. Quinby, Substation No. 12 at Chillicothe; Henry Dunlavy, Substation No. 5 at Temple; and D. L. Jones, Substation No. 8 at Lubbock.

A portion of the cotton from each of the three stations was used in a study on the stability of color in cotton, conducted and published by the Division of Cotton Marketing, Bureau of Agricultural Economics, U. S. D. A. (6).

The cotton grown at Chillicothe during the 1931 season was analyzed, except as to color, by S. R. Senter; his study was reported as a Master's thesis (8). A portion of the data secured by Mr. Senter is included in the present report.

METHOD OF PROCEDURE

Tagging. When the cotton began opening freely, approximately 3000 bolls were tagged at each station. Thirty of these were picked and sent immediately to College Station for ginning, classing, and study. The

following week, and each week thereafter as long as cotton remained in the field, thirty of the bolls were sent in for study. At those stations where cotton opened after a killing frost, 1000 bolls were tagged, 30 of which were picked at once and 30 each week following as long as cotton remained in the field. These methods of tagging and picking were repeated the second season except that the cotton was picked at intervals of two weeks instead of one.

Picking. The period included in the picking for the 1931-32 season was from September 3 to February 3 inclusive, and for the 1932-33 season from September 1 to April 20 inclusive. In each of the two seasons cotton which opened before frost and cotton which opened after frost were included.

Ginning. Upon arrival at College Station each lot of cotton was ginned on a hand roller gin, graded, and analyzed for color and strength.

The classing of the cotton was done by J. G. Powers, an official and licensed cotton classer. The data on grade and staple are based upon his classification. The nine official American grades of cotton used in classifying the samples of cotton are designated as follows:

1. Middling fair (M F)
2. Strict good middling (S G M)
3. Good middling (G M)
4. Strict middling (S M)
5. Middling (M)
6. Strict low middling (S L M)
7. Low middling (L M)
8. Strict good ordinary (S G O)
9. Good ordinary (G O)

Strength determinations were made by the Chandler bundle method as modified by workers in the Division of Cotton Marketing, U.S.D.A. (7 and 2). The results are the average of fifteen successful breaks for each lot of cotton and are expressed in thousands of pounds per square inch of cellulose. The method used differed in one respect from that given in A. S. T. M. (2), since corrections for variation from a circumference of 0.125 inches were made with 1.2 pounds as the correction factor for each 0.001 inch variation (7). All tests were made under standard atmospheric conditions.

Color analyses were made with a spectrophotometer with magnesium carbonate as a standard. The cotton was combed until all visible foreign matter was removed and the fibers were parallel. Sufficient cotton was used to prevent light penetrating to the card upon which the cotton was placed. The color analysis was made on the middle portion of the fiber. This method of preparation made it possible to obtain the color analysis of the fiber and not of the leaf, soil, and other foreign material except

very minute particles which might cling to the fiber. It gives results which are of course different from those obtained when a larger area containing the normal amount of foreign matter is used for the analysis. Five such specimens were prepared and analyzed for each sample of cotton and the average of the results used. Readings were taken at every 10 millimicrons from 430 to 700 millimicrons inclusive. An average of 10 readings taken at each point was considered the true reading. A reading for 420 millimicrons was obtained by extrapolation. The results thus obtained were expressed in two ways, first as a curve with reflection expressed in percentage on the ordinate and wave lengths in millimicrons on the abscissa, and second as dominant wave length, colorimetric purity, and luminosity, according to the method reported by Judd (4) for illuminant B.

Precipitation. The precipitation which was thought to have affected the quality of the cotton was divided into three periods: first, that which occurred from September 1 to the date of planting, or the preseasonal; second, that from the planting date to the first picking, or the growing period; and third, that between the date of the opening of the bolls and the date of picking, or during exposure to weathering.

THE EFFECT OF EXPOSURE ON THE GRADE AND STAPLE OF COTTON

The first pickings of the 1931 cotton which opened before frost at Chillicothe and Lubbock were classified as strict middling and that at Temple as strict middling spotted. The cotton at Temple maintained this grade, with the exception of that exposed one week, which was classed as strict middling plus, until the seventh week of exposure when it dropped one grade, as shown in Table 1.

The cotton from Lubbock dropped one grade after only one week of exposure and that from Chillicothe dropped one grade after three weeks, as shown in Tables 2 and 3.

A drop of two grades had occurred after 3, 4, and 11 weeks and a drop of three grades after 8, 5, and 13 weeks, at Lubbock, Chillicothe, and Temple respectively. After 14 to 17 weeks the grade was lowered to strict good ordinary at the three stations; after this there was little change.

All 1932 cotton was also strict middling at the first of the season and had dropped one grade after 3 to 5 weeks of exposure and two grades after 5 to 7 weeks, as shown in Tables 4, 5, and 6. After exposure of 16 to 21 weeks the cotton had dropped to strict good ordinary. After 25 weeks of exposure the Temple cotton was classed as good ordinary. The lowering in grade may have occurred somewhat earlier in the 1932 season but cotton in this season was picked at less frequent intervals than in 1931.

TABLE 1. The grade, staple, premiums, and discounts of cotton grown at Temple in 1931-32 and subjected to exposure.

Date of picking	Weeks exposed	Grade			Length in inches	Cumulative precipitation in inches	Points* + on — off	Price per lb. 7/8 M Houston basis	Price of cotton as picked
		Name	No.	Drop from 1st picking					
9/ 3/31	0	SM sp	5	0	31/32	.....	+50	6.25	6.75
9/10	1	SM +	3½	+1½	31/32	.....	+88	6.20	7.08
9/18	2	SM sp	5	0	31/32	0.38	+50	5.90	6.40
9/24	3	SM sp	5	0	31/32	0.38	+45	5.75	6.20
10/4	4	SM sp	5	0	31/32	0.38	+45	5.00	5.45
10/8	5	SM sp	5	0	31/32	0.38	+45	5.10	5.55
10/15	6	SM sp	5	0	31/32	0.38	+45	5.60	6.05
10/22	7	M sp	6	1	31/32	0.58	even	6.10	6.10
10/29	8	M sp	6	1	15/16	1.16	-10	6.10	6.00
11/ 6	9	SLM	6	1	15/16	1.16	-5	6.20	6.15
11/12	10	SLM	6	1	15/16	1.20	+5	6.10	6.15
11/19	11	LM	7	2	31/32	1.70	-30	5.75	5.45
11/27	12	LM	7	2	15/16	2.11	-20	5.65	5.45
12/ 3	13	LM sp	8	3	15/16	2.96	-80	5.70	4.90
12/10	14	LM sp	8	3	31/32	3.72	-70	5.60	4.90
12/17	15	SGO +	7½	2½	15/16	5.08	-50	5.70	5.20
12/28	16	SGO	8	3	31/32	5.65	-60	5.85	5.25
12/31	17	GO	9	4	15/16	5.65	-120	6.00	4.80
1/ 7/32	18	SGO	8	3	15/16	8.51	-70	5.90	5.20
1/14	19	SGO	8	3	15/16	9.68	-70	6.20	5.50
1/21	20	SGO	8	3	15/16	9.84	-70	6.20	5.50
1/28	21	SGO	8	3	15/16	10.57	-70	6.20	5.50
2/ 4	22	SGO	8	3	15/16	10.87	-70	6.35	5.65
2/11	23	SGO	8	3	31/32	10.87	-60	6.30	5.70

*Basis—Houston middling ⅞.

TABLE 2. The grade, staple, premiums, and discounts of cotton grown at Lubbock in 1931-32 and subjected to exposure.

Date of picking	Weeks exposed	Grade			Length in inches	Cumulative precipitation in inches	Points* + on — off	Price per lb. 7/8 M Houston basis	Price of cotton as picked
		Name	No.	Drop from 1st picking					
10/ 3/31	0	SM	4	.....	15/16	.....	+60	5.00	5.60
10/10	1	SM sp	5	1	31/32	.....	+45	5.30	5.75
10/17	2	SM sp	5	1	15/16	0.57	+30	5.90	6.20
10/24	3	M sp	6	2	15/16	3.46	-10	6.35	6.25
10/31	4	M sp	6	2	29/32	3.46	-30	6.10	5.80
11/ 4	5	M sp	6	2	15/16	3.46	-10	6.00	5.90
11/ 7	6	M sp	6	2	31/32	3.46	+5	6.15	6.20
11/21	7	M sp	6	2	29/32	4.37	-25	5.60	5.35
11/28	8	SLM sp	7	3	15/16	4.79	-40	5.70	5.30
12/ 5	9	SLM sp	7	3	15/16	5.10	-40	5.65	5.25
12/12	10	SLM sp	7	3	15/16	5.39	-40	5.60	5.20
12/19	11	SLM sp	7	3	15/16	6.02	-40	5.90	5.50
12/26	12	SLM sp	7	3	15/16	6.29	-40	5.90	5.50
1/ 4/32	13	LM	7	3	15/16	6.29	-30	5.75	5.45
1/ 9	14	LM	7	3	15/16	7.12	-30	6.00	5.70
1/17	15	LM	7	3	15/16	7.21	-30	6.25	5.95
1/23	16	LM	7	3	15/16	7.21	-30	6.15	5.85
1/30	17	SGO	8	4	29/32	7.22	-90	6.30	5.40
2/ 6	18	SGO	8	4	29/32	7.22	-80	6.35	5.55
2/13	19	SGO	8	4	15/16	7.25	-70	6.45	5.75

*Basis—Houston middling ⅞.

TABLE 3. The grade, staple, premiums, and discounts of cotton grown at Chillicothe in 1931-32 and subjected to exposure.

Date of picking	Weeks exposed	Grade			Length in inches	Cumulative precipitation in inches	Points* + on - off	Price per lb. 7/8 M Houston basis	Price of cotton as picked
		Name	No.	Drop from 1st picking					
9/15/31	0	SM	4	.....	1	.....	+100	6.20	7.20
9/22	1	SM	4	0	15/16	0.03	+60	5.70	6.30
9/29	2	GM	3	+1	15/16	0.18	+75	5.45	6.20
10/ 6	3	SM sp	5	1	15/16	0.18	+30	5.20	5.50
10/14	4	M sp	6	2	15/16	2.63	-10	5.60	5.50
10/20	5	SLM sp	7	3	31/32	3.11	-60	6.10	5.50
10/27	6	LM	7	3	15/16	4.46	-60	6.25	5.65
11/ 2	7	LM	7	3	15/16	4.46	-60	6.10	5.50
11/10	8	SLM	6	2	15/16	4.46	- 5	6.20	6.15
11/17	9	SLM	6	2	15/16	5.49	- 5	5.85	5.80
12/ 1	11	LM	7	3	15/16	7.93	-30	5.60	5.30
12/ 8	12	LM	7	3	15/16	7.98	-30	5.55	5.25
12/15	13	LM	7	3	15/16	8.18	-30	5.65	5.35
12/22	14	SGO	8	4	15/16	10.36	-70	6.00	5.30
12/29	15	LM	7	3	15/16	10.36	-30	6.00	5.70
1/ 6/32	16	SGO	8	4	15/16	11.51	-70	5.90	5.20
1/12	17	SGO	8	4	15/16	11.58	-70	6.00	5.30
1/19	18	SGO	8	4	15/16	12.05	-70	6.25	5.55
1/26	19	LM	7	3	15/16	12.46	-30	6.20	5.90

COTTON OPENED AFTER FROST

12/29/31	0	M sp	6	.....	1 1/32	.....	+26	6.00	6.26
1/ 6/32	1	SLM sp	7	1	1 1/32	1.15	-17	5.90	5.73
1/12	2	SLM sp	7	1	31/32	1.22	-30	6.00	5.70
1/19	3	SLM sp	7	1	1 1/32	1.69	-17	6.25	6.08
1/26	4	SLM sp	7	1	15/16	2.10	-40	6.20	5.80

*Basis—Houston middling %.

TABLE 4. The grade, staple, premiums, and discounts of cotton grown at Temple in 1932-33 and subjected to exposure.

Date of picking	Weeks exposed	Grade			Length in inches	Cumulative precipitation in inches	Points* + on - off	Price per lb. 7/8 M Houston basis	Price of cotton as picked
		Name	No.	Drop from 1st picking					
8/25/32	0	SM	4	.....	31/32	.....	+45	8.15	8.60
9/ 1	1	SM	4	0	31/32	0.01	+45	8.10	8.55
9/15	3	M	5	1	15/16	3.07	+15	7.10	7.25
9/29	5	SLM +	5½	1½	1	3.97	+19	6.75	6.94
10/13	7	SLM	6	2	15/16	3.97	-20	6.30	6.10
10/27	9	SLM	6	2	15/16	4.04	-20	6.25	6.05
11/10	11	SLM	6	2	15/16	4.13	-20	6.25	6.05
11/28	13	SLM	6	2	1	4.60	even	5.60	5.60
12/ 1	14	SLM	6	2	15/16	4.60	-20	5.70	5.50
12/19	15	SLM	6	2	15/16	5.79	-15	5.90	5.75
12/31	18	LM	7	3	29/32	8.48	-70	5.85	5.15
1/12/33	20	SGO	8	4	13/16	9.41	-190	6.10	4.20
1/26	22	SGO	8	4	7/8	9.77	-90	6.00	5.10
2/11	23	SGO	8	4	7/8	10.88	-90	5.95	5.05
2/23	25	GO	9	5	7/8	10.98	-120	5.85	4.65
3/9	27	M Bl St	9	5	13/16	13.04	-220	6.10	3.90
3/23	29	M Bl St	9	5	13/16	13.07	-220	6.20	4.00
4/ 6	31	GO	9	5	7/8	13.40	-120	6.40	5.20
4/20	33	SGO	8	4	13/16	13.51	-180	7.25	5.45

*Basis—Houston middling %.

TABLE 5. The grade, staple, premiums, and discounts of cotton grown at Lubbock in 1932-33 and subjected to exposure.

Date of picking	Weeks exposed	Grade			Length in inches	Cumulative precipitation in inches	Points* + on - off	Price per lb. 7/8 M Houston basis	Price of cotton as picked
		Name	No.	Drop from 1st picking					
10/12/32	0	SM	4	.....	1	.....	+70	6.60	7.30
10/26	2	SM	4	0	1	0.95	+70	6.20	6.90
11/16	5	M	5	1	31/32	0.95	+25	6.25	6.50
11/30	7	M sp	6	2	1	0.95	even	5.70	5.70
12/21	10	SLM	6	2	1	1.78	+ 5	5.80	5.85
1/ 4/33	12	SLM sp	7	3	1	3.43	-30	6.05	5.75
1/18	14	LM	7	3	15/16	3.77	-45	6.00	5.55
2/ 1	16	SGO	8	4	29/32	3.80	-80	5.70	4.90
2/15	18	LM	7	3	29/32	4.19	-40	5.85	5.45
3/ 1	20	SGO	8	4	7/8	4.75	-80	5.90	5.10

COTTON OPENED AFTER FROST

11/ 9/32	0	GM sp	4	.....	1	.....	+65	5.95	6.60
11/16	1	GM sp	4	0	1	.....	+65	6.25	6.90
11/23	2	GM sp	4	0	1	.....	+65	5.85	6.50
11/30	3	GM sp	4	0	1	.....	+65	5.70	6.35
12/21	6	GM sp	4	0	1	0.83	+65	5.80	6.45
12/28	7	GM sp	4	0	1	2.46	+65	5.80	6.45
1/ 4/33	8	GM sp	4	0	1	2.48	+65	6.05	6.70
1/11	9	M sp	6	2	1	2.73	+ 5	6.10	6.15
1/18	10	M sp	6	2	31/32	2.82	- 5	6.00	5.95
1/25	11	SLM sp	7	3	15/16	2.85	-50	6.05	5.55
2/ 1	12	SLM sp	7	3	31/32	2.85	-45	5.70	5.25
2/ 8	13	SLM sp	7	3	1	3.22	-35	5.90	5.55
2/15	14	LM	7	3	15/16	3.24	-35	5.85	5.50
2/22	15	SLM sp	7	3	15/16	3.24	-40	5.90	5.50

*Basis—Houston middling %.

TABLE 6. The grade, staple, premiums, and discounts of cotton grown at Chillicothe in 1932-33 and subjected to exposure.

Date of picking	Weeks exposed	Grade			Length in inches	Cumulative precipitation in inches	Points* + on - off	Price per lb. 7/8 M Houston basis	Price of cotton as picked
		Name	No.	Drop from 1st picking					
9/23/32	0	SM	4	.....	1	.....	+65	7.15	7.80
10/ 6	2	SM	4	0	1	0.89	+70	6.90	7.60
10/19	4	M+	4½	½	31/32	0.89	+40	6.30	6.70
10/31	5	SLM	6	2	31/32	1.54	-10	5.95	5.85
11/16	8	SLM+	5½	1½	15/16	1.79	- 5	6.25	6.20
1/ 2/33	14	LM	7	3	15/16	5.50	-45	5.85	5.40
1/16	16	SLM	6	2	15/16	5.63	-15	5.95	5.80
2/ 1	18	LM	7	3	15/16	5.65	-45	5.70	5.25
2/18	21	SGO	8	4	7/8	5.85	-80	5.95	5.15
3/ 2	23	LM	7	3	29/32	6.84	-40	5.90	5.50
3/16	25	SGO	8	4	29/32	7.13	-70	6.60	5.90
4/ 4	28	SGO	8	4	29/32	7.36	-70	6.25	5.55

*Basis—Houston middling %.

The two lots of cotton which opened after frost were spotted. The cotton grown at Chillicothe in 1931 was middling spotted and after one week of weathering had dropped one grade, where it remained after 4 weeks of exposure (Table 3). The cotton grown at Lubbock in 1932 which had opened after frost was good middling spotted and showed no change in grade until after 9 weeks of exposure, when the classer found it to be two grades lower, but it dropped another grade after two more weeks (Table 5).

A comparison between seasons at each station with respect to the weeks of exposure necessary to lower the grade shows that in two-thirds of the cases the grade was lowered earlier when the precipitation was greater. It is evident that the rainfall was an important factor in lowering the quality of the cotton (Tables 1-6 inclusive). But when stations are compared, differences in exposure periods occurring with lowering of quality are not explained entirely by differences in precipitation. For example, in 1931 the cotton at Lubbock was exposed only one week with no precipitation yet the quality was lowered one grade, in contrast to the cotton at Temple which required 7 weeks with 0.58 inch of precipitation which fell during the second and seventh weeks of exposure before it was lowered one grade; and in contrast to the cotton at Chillicothe which was lowered one grade in 3 weeks of exposure and after 0.18 inch of precipitation. Further evidence that precipitation is not the only factor affecting quality is shown in the cotton from Temple, which in 1931 and 1932 had after 23 weeks of exposure received equal precipitation (approximately 11 inches) on the same number of rainy days (43 days), but the 1931 cotton had lowered three grades and the 1932 four grades.

After an average of approximately 4 weeks of exposure at the three stations for two seasons the cotton had dropped one grade, after 6 weeks two grades, after 12 weeks three grades, after 18 weeks four grades, and after 25 weeks five grades. The quality was lowered one grade for each period of approximately 4 weeks. While the lowering in grade was not uniform at each station for each season these findings indicate that to be classed as a product of the highest grade, cotton should be picked as soon as possible after opening and within the first four weeks.

As the period of exposure in the field lengthened, the staple was classed as shorter, probably because the ends of the fibers were weakened and more easily broken during ginning and classing. The decrease in the length of the cotton as classed during the exposure periods was 1/16 to 3/16 inches. The greatest decrease occurred in the 1932-33 season.

THE EFFECT OF EXPOSURE ON THE PRICE OF COTTON

The grades and staples assigned by the cotton classer to the cotton picked at the various intervals of exposure were used in determining the monetary value of the cotton. The quotations for middling 7/8 cotton at

Houston on the same dates were used as a base in determining the premiums, discounts, and prices of each lot of cotton. These data are given in detail in Tables 1 to 6 inclusive.

The unexposed cotton received a premium of 45 to 100 points, with an average of 65 points. After only one week of exposure there was an average drop of 5 points. After 4, 8, 14, 20, 25, and 31 weeks of exposure the average drop in points was 54, 80, 112, 140, 160, and 185 points respectively. When these points are used in conjunction with the average price at Houston at the time of the first pickings as the basis, there was a loss of approximately 8, 11, 16, 19, 22, and 26 per cent after 4, 8, 14, 20, 25, and 31 weeks of exposure respectively. If the price is determined on the basis of the grade and staple of the first picking, but at the price prevailing at the time of the various exposure periods, the average losses are approximately 7, 12, 17, 20, and 23 per cent after 4, 8, 14, 20, and 25 weeks of exposure respectively. Even at the low prices prevailing during these two seasons the loss due to late harvesting was in some cases as much as \$13.00 for a 500-pound bale.

It is evident that exposure in the field reduces the monetary value of the cotton and the reduction increases with the exposure period. As short an exposure period as 4 weeks may materially reduce the price received.

THE EFFECT OF EXPOSURE ON THE STRENGTH OF COTTON

The Strength of Unexposed Cotton

There was wide variation in the strength of the cotton grown at the three stations, as shown in Figure 1 and Tables 7 to 9 inclusive. The

TABLE 7. The grade, length, strength, and color of cotton and the cumulative precipitation at various periods of exposure.

TEMPLE 1931-32

Date of picking	Wks. ex-posed	Grade			Length in inches	Strength		Cumulative precipitation in inches	Color	
		Name	No.	Drop		1000 lbs. per sq. in.	Loss in %		Purity	Luminosity
9/ 3/31	0	SM sp	5	.....	31/32	67.9±0.98	.....	.....	.15873	.734
10/ 4	4	SM sp	5	0	31/32	64.9±0.97	4.42	0.38	.14655	.746
11/ 6	9	SLM	6	1	15/16	65.2±0.75	3.98	1.16	.15244	.751
12/10	14	LM sp	8	3	31/32	62.5±0.51	7.95	3.72	.09259	.678
1/14/32	19	SGO	8	3	15/16	64.7±0.96	4.71	9.68	.06570	.661
2/11	23	SGO	8	3	31/32	62.9±0.73	7.36	10.87	.12655	.576

TEMPLE 1932-33

8/25/32	0	SM	4	.....	31/32	68.4±0.62	.....	.....	.11208	.773
9/29	5	SLM+	5½	1½	1	65.9±0.58	3.65	3.97	.10155	.746
11/28	13	SLM	6	2	1	66.8±0.76	2.34	4.60	.10212	.668
12/31	18	LM	7	3	29/32	66.8±0.83	2.34	8.48	.09783	.653
2/11	23	SGO	8	4	7/8	63.5±0.78	7.16	10.88	.10102	.632
3/23	29	M Bl st	9	5	13/16	63.5±0.76	7.16	13.07	.07112	.564
4/20	33	SGO	8	4	13/16	61.1±0.90	10.67	13.51	.07141	.581

TABLE 8. The grade, length, strength, and color of cotton and the cumulative precipitation at various periods of exposure.

LUBBOCK 1931-32

Date of picking	Wks. ex-posed	Grade			Length in inches	Strength		Cumulative precipitation in inches	Color	
		Name	No.	Drop		1000 lbs. per sq. in.	Loss in %		Purity	Lumi-nosity
10/ 3/31	0	SM	4	.....	15/16	62.6±0.93	.....	.....	.10105	.780
10/31	4	M sp	6	2	29/32	62.4±1.29	0.31	3.46	.09768	.739
12/ 5	9	SLM sp	7	3	15/16	61.4±0.92	1.92	5.10	.07620	.685
1/ 9/32	14	LM	7	3	15/16	57.3±1.34	8.47	7.12	.08973	.686
2/13	19	SGO	8	4	15/16	54.7±1.07	12.62	7.25	.07380	.637

LUBBOCK 1932-33

10/12/32	0	SM	4	.....	1	56.3±0.97	.....	.....	.14282	.722
11/16	5	M	5	1	31/32	51.5±0.87	8.53	0.95	.14936	.665
12/21	10	SLM	6	2	1	48.3±0.90	14.21	1.78	.14029	.650
1/18/33	14	LM	7	3	15/16	49.1±1.08	12.79	3.77	.13897	.615
3/ 1	20	SGO	8	4	7/8	53.1±2.12	5.68	4.75	.13121	.603

LUBBOCK COTTON OPENED AFTER FROST 1932-33

11/ 9/32	0	GM sp	4	.....	1	59.5±0.81	.....	.....	.23523	.764
12/21	6	GM sp	4	0	1	57.9±1.23	2.69	0.83	.22584	.717
1/18/33	10	M sp	6	2	31/32	56.3±0.81	5.38	2.82	.22416	.684
2/22	15	SLM sp	7	3	15/16	55.5±1.27	6.72	3.24	.21848	.658

TABLE 9. The grade, length, strength, and color of cotton and the cumulative precipitation at various periods of exposure.

CHILLICOTHE 1931-32

Date of picking	Wks. ex-posed	Grade			Length in inches	Strength		Cumulative precipitation in inches	Color	
		Name	No.	Drop		1000 lbs. per sq. in.	Loss in %		Purity	Lumi-nosity
9/15/31	0	SM	4	.....	1	55.9±1.50	.....	.....	.14212	.735
10/14	4	M sp	6	2	15/16	54.4±1.16	2.68	2.63	.14205	.703
11/17	9	SLM	6	2	15/16	55.5±1.09	0.72	5.49	.14989	.659
12/22	14	SGO	8	4	15/16	52.7±1.17	5.72	10.36	.14336	.652
1/26/32	19	LM	7	3	15/16	53.8±1.09	3.76	12.46	.11905	.644

COTTON OPENED AFTER FROST

12/29/31	0	M sp	6	.....	1 1/32	.....	.....	.....	.17212	.707
1/26/32	4	SLM sp	7	1	15/16	.....	.....	2.10	.12079	.678

CHILLICOTHE 1932-33

9/23/32	0	SM	4	.....	1	59.5±0.96	.....	.....	.14684	.762
10/19	4	M+	4½	½	31/32	55.5±0.96	6.72	0.89	.14043	.735
11/16	8	SLM+	5½	1½	15/16	56.3±0.63	5.92	1.79	.14743	.673
1/ 2/33	14	LM	7	3	15/16	54.7±0.60	8.07	5.50	.13856	.666
2/ 1	18	LM	7	3	15/16	53.9±1.30	9.41	5.65	.13285	.668
3/ 2	23	LM	7	3	29/32	51.5±0.86	13.45	6.84	.13032	.617
4/ 4	28	SGO	8	4	29/32	51.5±0.91	13.45	7.36	.12387	.567

TABLE 10. Precipitation by periods at each station for each season.

Station	Season	Pre-seasonal period		Growing period		Total preseasonal and growing in inches	Exposure period	
		Date	Inches	Date	Inches		Date	Inches
Lubbock.....	1931-32	9/ 1/30 - 5/10/31	12.78	5/11/31 - 10/ 2/31	6.68	19.46	10/ 3/31 - 2/12/32	7.25
Do.	1932-33	9/ 1/31 - 5/17/32	12.17	5/18/32 - 10/11/32	15.58	27.75	10/12/32 - 2/28/33	4.75
Chillicothe.....	1931-32	9/ 1/30 - 5/13/31	19.33	5/14/31 - 9/14/31	3.60	22.93	9/15/31 - 1/25/32	12.46
Do.	1932-33	9/ 1/31 - 5/23/32	18.54	5/24/32 - 9/22/32	10.34	28.88	9/23/32 - 4/ 3/33	7.36
Temple.....	1931-32	9/ 1/30 - 5/11/31	28.42	5/12/31 - 9/ 2/31	4.50	32.92	9/ 3/31 - 2/10/32	10.87
Do.	1932-33	9/ 1/31 - 5/ 5/32	18.10	5/ 6/32 - 8/24/32	10.37	28.47	8/25/32 - 4/19/33	13.51

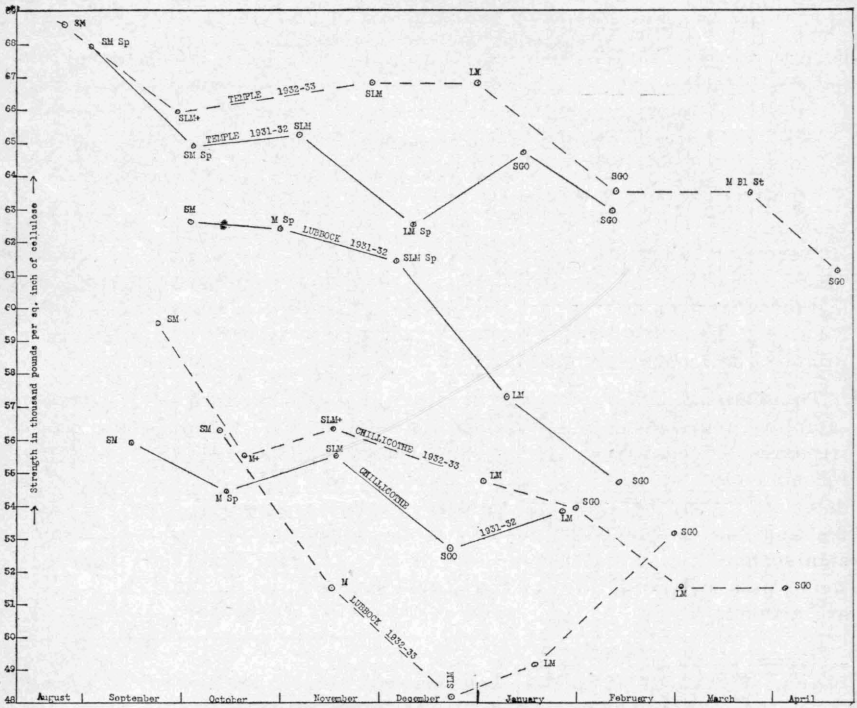


Figure 1. The strength of cotton at various periods of exposure at each of three stations each of two seasons.

cotton grown at Temple was significantly stronger each of the two seasons than the cotton grown the same seasons at Chillicothe and Lubbock. This difference was apparently due to soil differences, and to climatic conditions other than rainfall, as evidenced by the 1932 season when the total precipitation during the preseasonal and growing period were approximately equal at the three stations (Table 10).

The cotton grown at Lubbock in 1931 was much stronger than that grown at Chillicothe each of the two seasons. The cotton grown at Chillicothe in 1931 and that grown at Lubbock in 1932 were approximately equal in strength and less strong than that from Lubbock in 1931 or that from Chillicothe in 1932.

There was no significant seasonal difference in the strength of the cotton from Temple. The precipitation was below normal both seasons, with the lower rainfall during the 1931 growing season (Table 10). The cotton from Chillicothe was slightly stronger in 1932 than in 1931. This difference may have been due to a difference in rainfall. Although the rainfall for both years was below normal, that during the growing season in 1932 was nearly three times as great as that in 1931. The cotton

from Lubbock in 1931 was much stronger than that from Lubbock in 1932. The cotton grown at Lubbock in 1931 received more nearly normal rainfall than did that at Lubbock in 1932, which received approximately 5 inches above normal rainfall during the growing season.

The Strength of Exposed Cotton

All of the cotton suffered a loss in strength upon exposure, the loss generally increasing with the exposure period and amount of rainfall. However, the decrease in strength was not uniform in rate or extent. These variations are no doubt due, in part, to the imperfections in the method of testing and in part to variations inherent in the cotton sample. Figures 2 to 7 inclusive give the strength and grade, and cumulative rainfall (on an inverted scale) at various periods of exposure.

To eliminate differences which might be attributed to variations in sampling and method of breaking, the significance of the differences in strength for the various periods of exposure was tested by the method recommended by Snedecor (9). It was found that by this method of determining strength significant differences in strength were between 2.2 and 3.5 thousand pounds per square inch of cellulose and highly significant differences between 3.0 and 4.7. The differences between weeks and the significance of the differences for each station each season are given in Table 11.

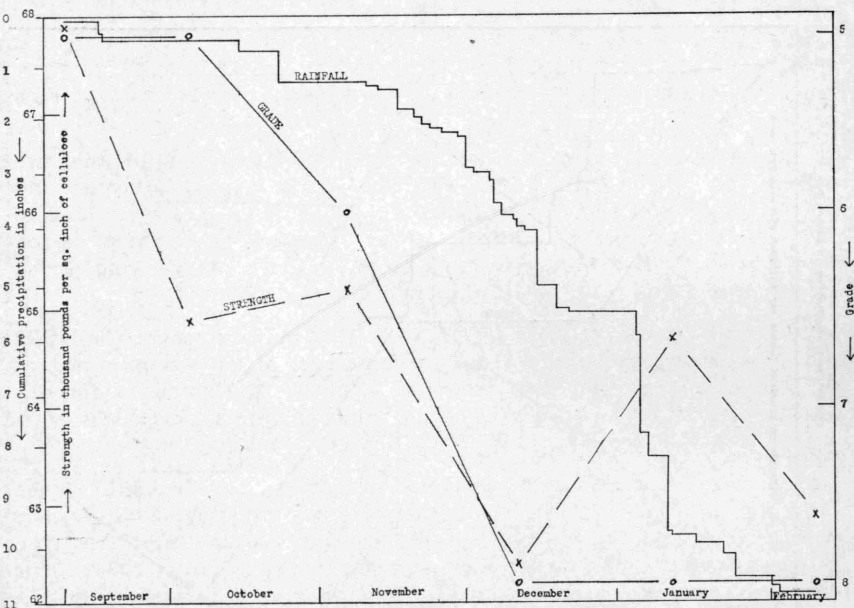


Figure 2. Temple 1931-32. The cumulative precipitation, and the grade and strength of cotton at various periods of exposure.

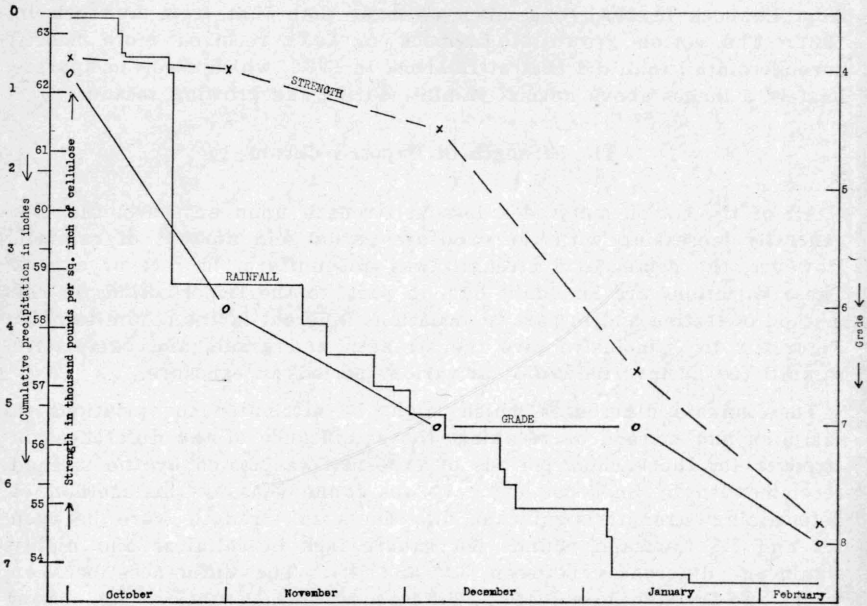


Figure 3. Lubbock 1931-32. The cumulative precipitation, and the grade and strength of cotton at various periods of exposure.

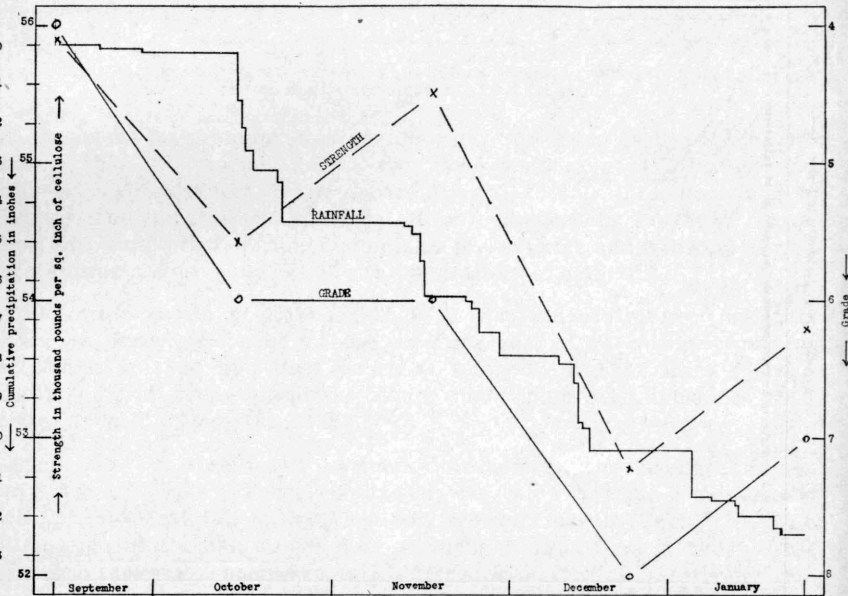


Figure 4. Chillicothe 1931-32. The cumulative precipitation, and the grade and strength of cotton at various periods of exposure.

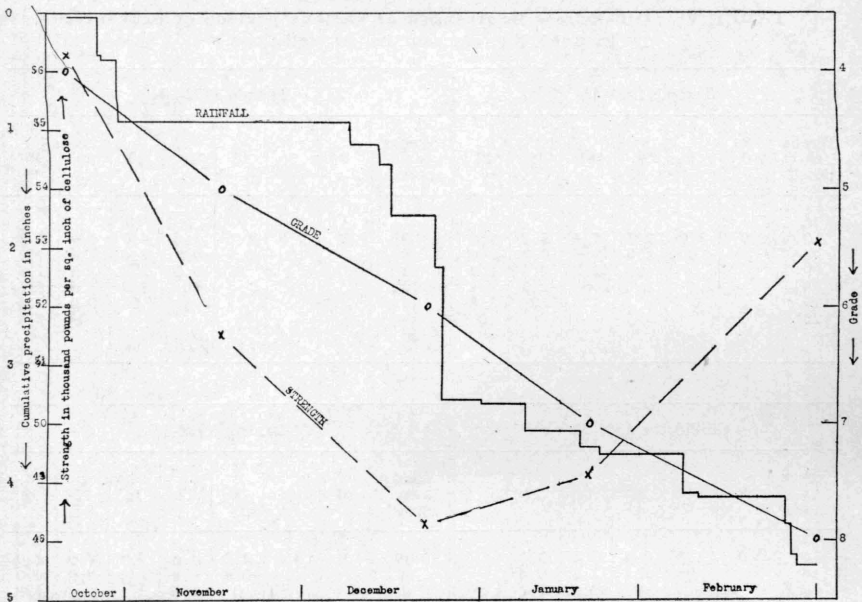


Figure 5. Temple 1932-33. The cumulative precipitation, and the grade and strength of cotton at various periods of exposure.

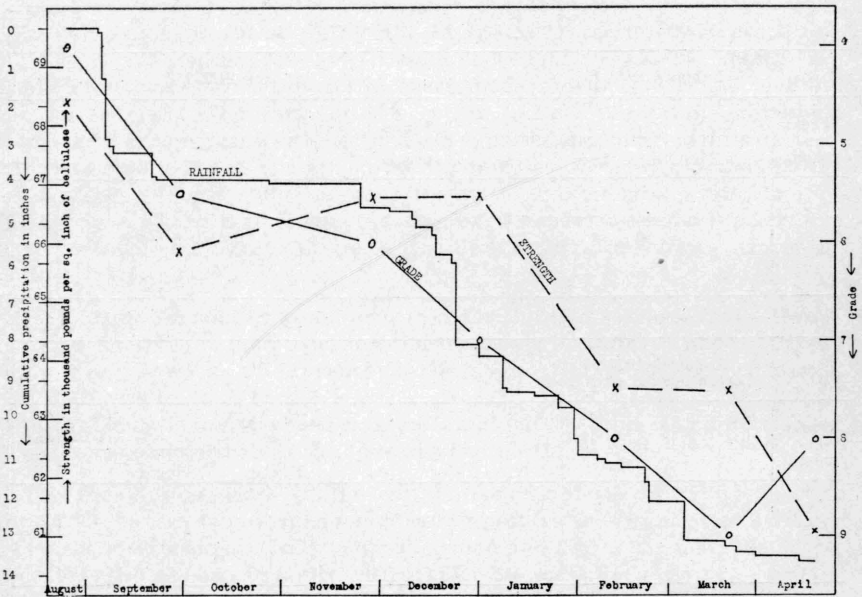


Figure 6. Lubbock 1932-33. The cumulative precipitation, and the grade and strength of cotton at various periods of exposure.

TABLE 11. Differences in strength at various periods of exposure.*
(In 1000 lbs. per sq. in. of cellulose.)

Temple 1931-32							Temple 1932-33							
Weeks exposed	0	4	9	14	19	23	Weeks exposed	0	5	13	18	23	29	33
0	0	3.0	2.7	5.4	3.2	5.0	0	0	2.5	1.6	1.6	4.9	4.9	7.3
4		0	-3.0	2.4	0.2	2.0	5		0	-0.9	-0.9	2.4	2.4	4.8
9			0	2.7	0.5	2.3	13			0	0	3.3	3.3	5.7
14				0	-2.2	0.4	18				0	3.3	3.3	5.7
19					0	1.8	23					0	0	2.4
23						0	29						0	2.4
							33							0

Chillicothe 1931-32						Chillicothe 1932-33							
Weeks exposed	0	4	9	14	19	Weeks exposed	0	4	8	14	18	23	28
0	0	1.5	0.4	3.2	2.1	0	0	4.0	3.2	4.8	5.6	8.0	8.0
4		0	-1.1	1.7	0.6	4		0	-0.8	0.8	1.6	4.0	4.0
9			0	2.8	1.7	8			0	1.6	2.4	4.8	4.8
14				0	-1.1	14				0	0.8	3.2	3.2
19					0	18					0	2.4	2.4
						23						0	0.0
						28							0

Lubbock 1931-23						Lubbock 1932-33					
Weeks exposed	0	4	9	14	19	Weeks exposed	0	5	10	14	20
0	0	0.2	1.2	5.3	7.9	0	0	4.8	8.0	7.2	3.2
4		0	1.0	5.1	7.7	5		0	3.2	2.4	-1.6
9			0	4.1	6.7	10			0	-0.8	-4.8
14				0	2.6	14				0	-4.0
19					0	20					0

Lubbock 1932-33 Cotton opened after frost				
Weeks exposed	0	6	10	15
0	0	1.6	3.2	4.0
6		0	1.6	2.4
10			0	0.8
15				0

*Blackface indicates significant differences. Italic indicates highly significant differences.

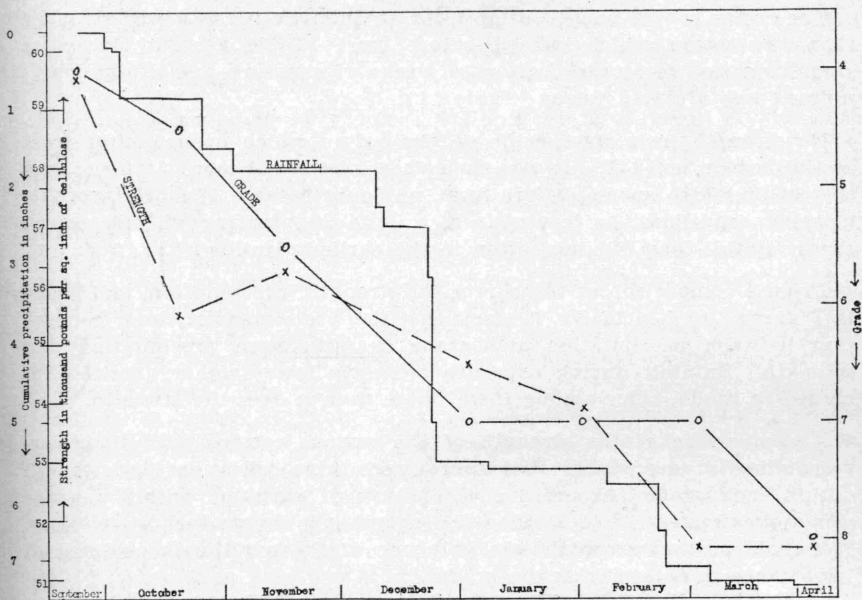


Figure 7. Chillicothe 1932-33. The cumulative precipitation, and the grade and strength of cotton at various periods of exposure.

In the cotton grown at Chillicothe in the 1931 season there were no significant differences in the strength between weeks, as shown in Table 11. The tests on this cotton were made previous to refinement in the method (8). The data for this cotton include the results obtained from the 15 bundles which most nearly met the requirements of the improved method, but not all of the 15 bundles were within the limits set for size. Had a sufficient quantity of the cotton been available for further testing, it is thought the improved technique would probably have revealed significant differences in the strength for various exposure periods.

In 4 of the remaining 6 lots of cotton for the two seasons at the three locations there is no doubt that significant losses in strength had occurred after 4 and 5 weeks of exposure in the field. Highly significant losses had occurred in each of the six lots after 14 or 15 weeks of exposure, with the exception of the cotton from Temple in 1932, in which 23 weeks of exposure elapsed before the loss was significant.

The breaking strength of the cotton from Lubbock in 1932 exposed for 20 weeks was found to be significantly greater than that after 10 and 14 weeks of exposure. Tests using the same and two other methods were repeated with the same results. Strength tests for other exposure periods between the tenth and twentieth weeks showed the same trend. No satisfactory explanation has been found for this difference.

The cotton which opened after frost at Lubbock in 1932 was stronger than the cotton which opened before frost (Table 8). It showed a significant loss in strength after 10 weeks of exposure and a highly significant loss after 15 weeks (Table 11).

No strength tests were made on the cotton which opened after frost at Chillicothe, in 1931. It was somewhat longer and more uniform than the cotton which opened before frost, no doubt because of more favorable growing conditions, as it was from a June 30 planting which received more rainfall than did the cotton in the earlier planting (8).

From a comparison of the curves for strength, precipitation, and grade in Figures 2 to 7 inclusive, it seems that there is somewhat closer correlation between precipitation and grade than between precipitation and strength. Rainfall during exposure evidently lowers other qualities included in grade, color among them, more than it does the strength.

A comparison of the strength of the various cottons with their corresponding grades shows that there were wide variations in strength within each grade (Figure 1). The range of variation within a grade was approximately 12 to 19 thousand pounds per square inch of cellulose. It is evident that strength was only one of the qualities considered of importance in determining the grade.

The losses in strength which occurred after four and five weeks of exposure in the field extended from less than one per cent to approximately 7 per cent, as shown in Table 12. The maximum loss for the

TABLE 12. Grade, cumulative precipitation, and loss in strength at various periods of exposure.

Weeks of exposure	Grade Number			Loss in strength expressed in percentage			Cumulative precipitation in inches		
	Lubbock	Chillicothe	Temple	Lubbock	Chillicothe	Temple	Lubbock	Chillicothe	Temple
1931									
0	4	4	5	.....	.....	.....	.....	.....	.....
4 - 6	6	6	5	0.31	2.68	4.42	3.46	2.63	0.38
8 - 10	7	6	6	1.92	0.72	3.98	5.10	5.49	1.16
13 - 15	7	8	8	8.47	5.72	7.95	7.12	10.36	3.72
18 - 20	8	7	8	12.62	3.76	4.71	7.25	12.46	8.51
1932									
0	4	4	4	.....	.....	.....	.....	.....	.....
4 - 6	5	4½	5½	8.53	6.72	3.65	0.95	0.89	3.97
8 - 10	6	5½	—	14.21	5.92	.....	1.78	1.79	.....
13 - 15	7	7	6	12.79	8.07	2.34	3.77	5.50	4.60
18 - 20	8	7	7	5.68	9.41	2.34	4.75	5.65	8.48
23	—	7	8	.....	13.45	7.16	.....	6.84	10.88
28 - 29	—	8	9	.....	13.45	7.16	.....	7.36	13.07
33	—	—	8	.....	.....	10.67	.....	.....	13.51

total exposure period was approximately 14 per cent of the original strength. The loss after 13 to 14 weeks was approximately 2 to 13 per cent and after 23 to 33 weeks approximately 7 to 13 per cent.

The cotton exposed at Lubbock suffered in most cases greater loss than that exposed for the same periods at Temple or Chillicothe. The average loss in strength, including four exposure periods from the first through the 18th to 20th weeks, was approximately 4 per cent for Temple, 5 per cent for Chillicothe, and 8 per cent for Lubbock. After 23 and 29 weeks of exposure the cotton grown the second season at Chillicothe had lost a higher percentage of the original strength than had that at Temple. These regional differences cannot be attributed to differences in precipitation, for it is apparent that the greatest loss in percentage of strength did not occur at those stations where the rainfall during the exposure periods was greatest. Comparisons of figures for loss and precipitation, given in Table 12, show that the reverse is more nearly true. For example, as regards increasing loss in strength for the first season after from 4 to 6 weeks of exposure, Lubbock, Chillicothe, and Temple appear in order, but as regards precipitation during the corresponding periods the stations are in exactly the reverse order. This same relationship occurred in three of four cases for the first season. During the second season, for the three periods when comparisons may be made, the least loss in strength occurred at the station where there was the greatest precipitation. In each exposure period where cotton from Temple appears, the loss in strength was less and the precipitation greater than for the one or two other stations recorded for the same periods. These data suggest that the greater loss of strength of the cotton from Lubbock, as compared with that from Temple, was not due to greater rainfall during exposure.

Two explanations of the somewhat greater rate and extent of the loss in the strength of the cotton from Lubbock, as compared with that from Temple or Chillicothe, are suggested. It may be that there were differences inherent in the cotton itself. It seems possible that the greater ultra-violet in the sunlight to be expected at Lubbock where the altitude is greater and the atmosphere more arid than at Temple or Chillicothe, may have increased the degradation of the cellulose with a corresponding decrease in the strength of the fibers. These findings suggest that early harvesting may be more imperative at Lubbock and similar regions than it is at lower altitudes such as at Temple, even though the rainfall may be greater at the lower altitudes. The data indicate that if a loss in strength is to be avoided cotton should be harvested within the first four or five weeks after opening.

THE EFFECT OF EXPOSURE ON THE COLOR OF COTTON

The color of the unexposed and exposed cotton, as determined with a spectrophotometer, are given in terms of percentage reflectance and wave length in Figures 8 to 11 inclusive. These data have been con-

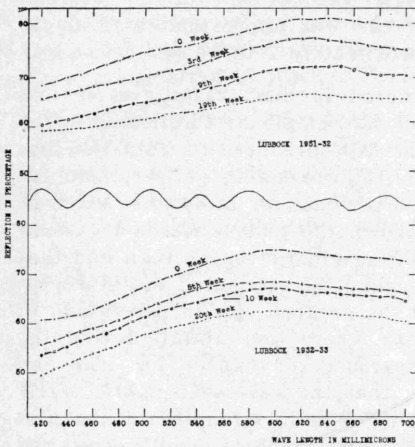


Figure 8. Color curves for cotton grown at Lubbock for two seasons and exposed for various periods.

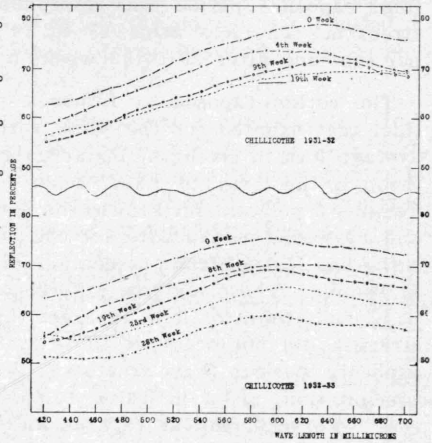


Figure 9. Color curves for cotton grown at Chillicothe for two seasons and exposed for various periods.

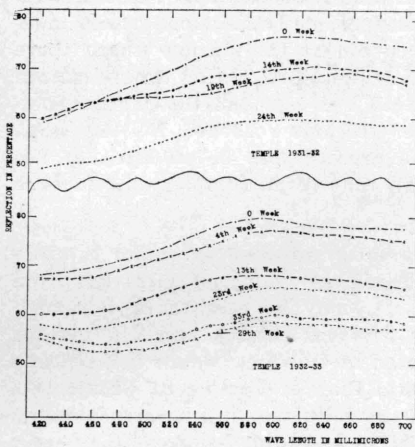


Figure 10. Color curves for cotton grown at Temple for two seasons and exposed for various periods.

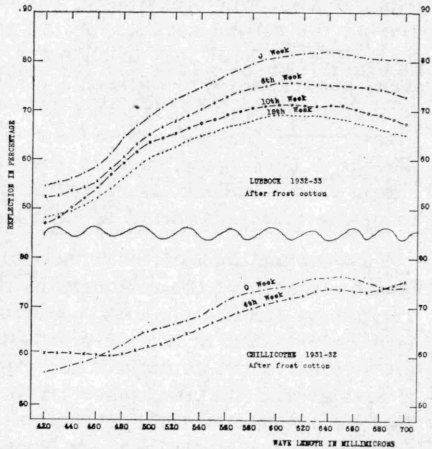


Figure 11. Color curves for cotton opened after frost at Lubbock and Chillicothe and exposed for various periods.

verted into terms of dominant wave length, colorimetric purity, and luminosity by the method described by Judd (4), using illuminant B; they are given in Table 13 and in Figures 12 to 17 inclusive.

The term purity is used to denote the creaminess, and the term luminosity the light-to-dark quality of the cotton. The dominant wave length designates the hue or color name.

Since the dominant wave lengths are all within the relatively narrow range of approximately 570 to 585 millimicrons, they have been omitted

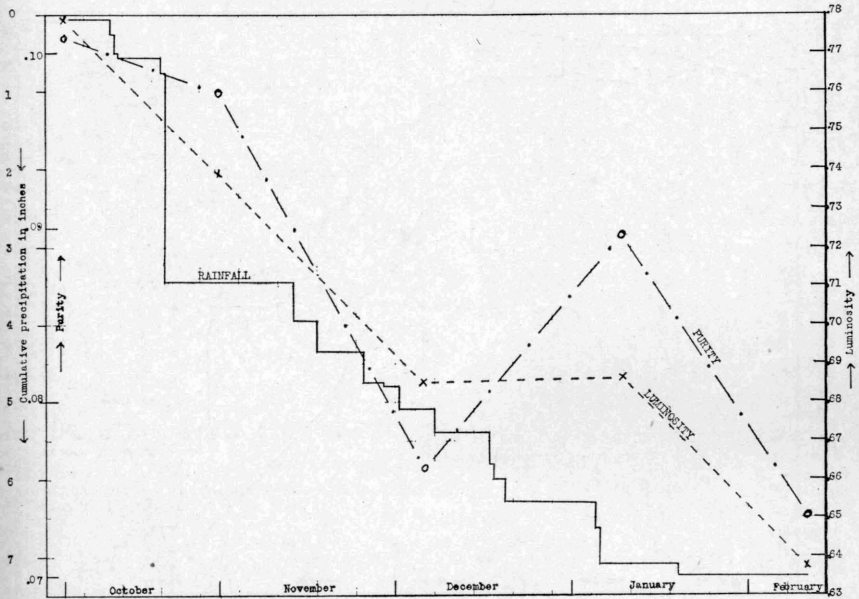


Figure 12. Lubbock 1931-32. The color of cotton expressed in terms of purity and luminosity with the accompanying cumulative precipitation (shown on an inverted scale) at various periods of exposure.

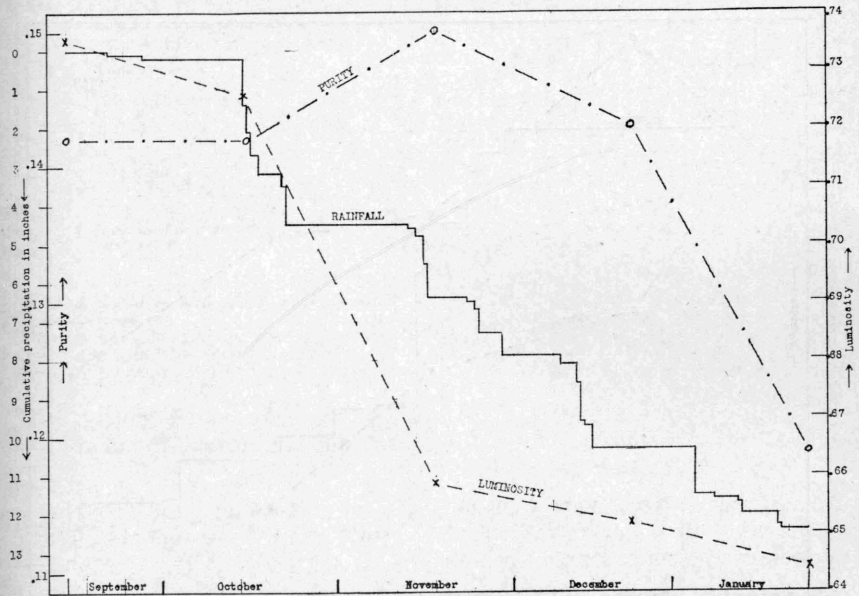


Figure 13. Chillicothe 1931-32. The color of cotton expressed in terms of purity and luminosity with the accompanying cumulative precipitation (shown on an inverted scale) at various periods of exposure.

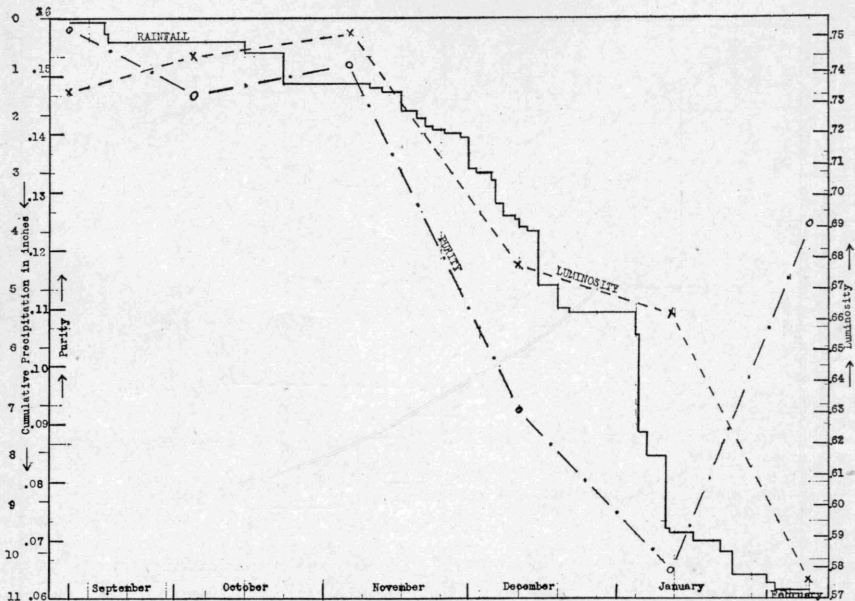


Figure 14. Temple 1931-32. The color of cotton expressed in terms of purity and luminosity with the accompanying cumulative precipitation (shown on an inverted scale) at various periods of exposure.

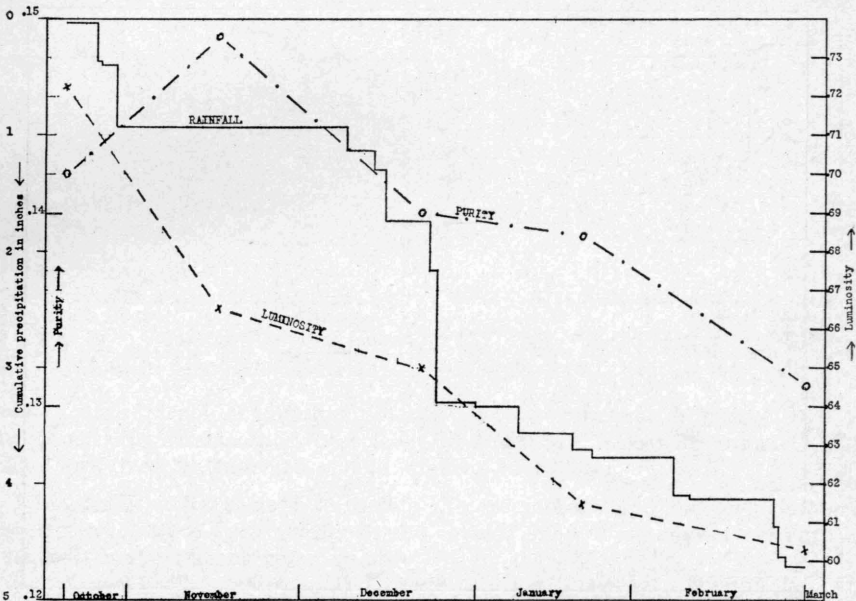


Figure 15. Lubbock 1932-33. The color of cotton expressed in terms of purity and luminosity with the accompanying cumulative precipitation (shown on an inverted scale) at various periods of exposure.

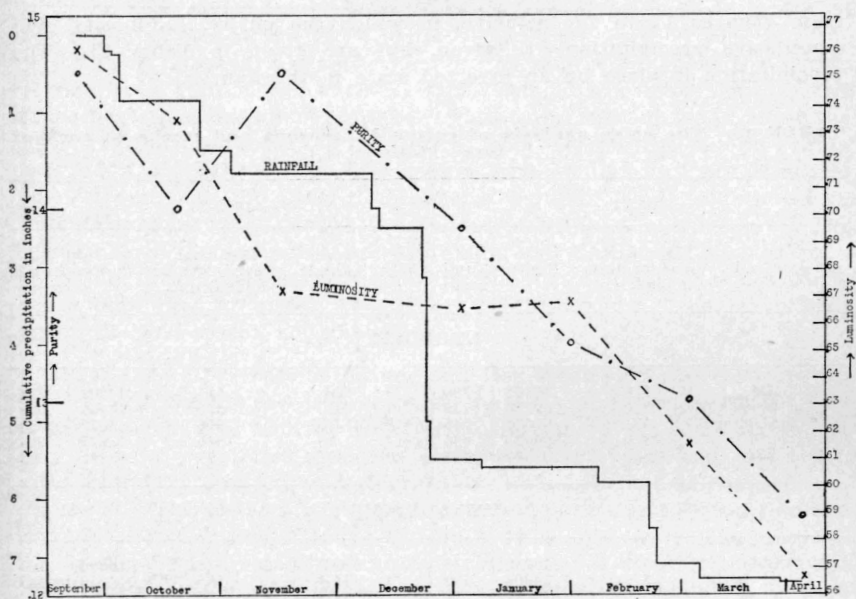


Figure 16. Chillicothe 1932-33. The color of cotton expressed in terms of purity and luminosity with the accompanying cumulative precipitation (shown on an inverted scale) at various periods of exposure.

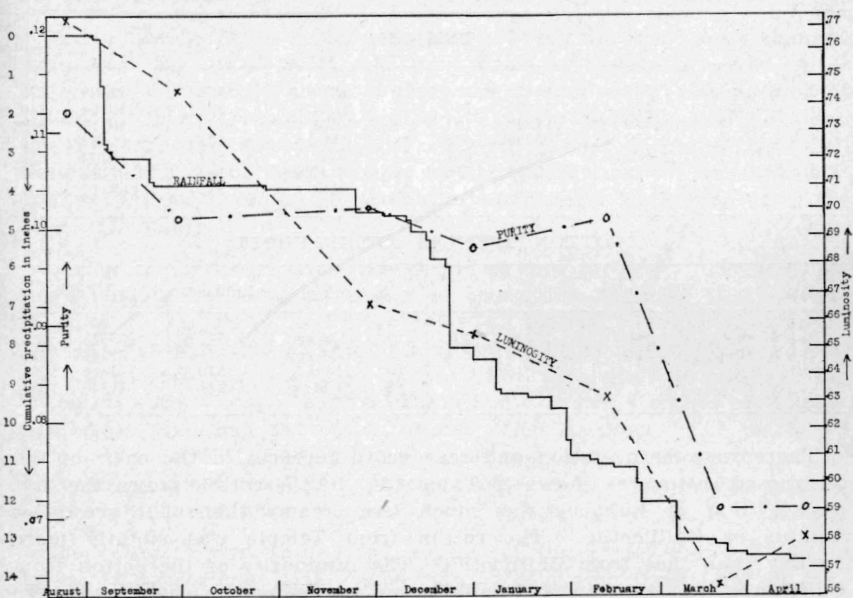


Figure 17. Temple 1932-33. The color of cotton expressed in terms of purity and luminosity with the accompanying cumulative precipitation (shown on an inverted scale) at various periods of exposure.

from Figures 12 to 17 inclusive, in which the purity, luminosity, and cumulative precipitation are given, but are given in Table 13. The precipitation is given on an inverted scale in the figures.

TABLE 13. The color analysis of cotton by seasons and weeks at each of three stations.

1931-32					1932-33				
Wks.	Grade	Dominant wave length in millimicrons	Purity	Lumi-nosity	Wks.	Grade	Dominant wave length in millimicrons	Purity	Lumi-nosity
LUBBOCK									
0	SM	579	.10105	.780	0	SM	577	.14282	.722
4	M sp	580	.09768	.739	5	M	576	.14936	.665
9	SLM sp	581	.07620	.685	10	SLM	576	.14029	.650
14	LM	579	.08973	.686	14	LM	576	.13897	.615
19	SGO	580	.07380	.637	20	SGO	577	.13121	.603
CHILLICOTHE									
0	SM	579	.14212	.735	0	SM	575	.14684	.762
4	M sp	577	.14204	.703	4	M +	580	.14043	.735
9	SLM	579	.14989	.659	8	SLM +	577	.14743	.673
14	SGO	580	.14336	.652	14	LM	580	.13856	.666
19	LM	580	.11905	.644	18	LM	577	.13285	.668
					23	LM	580	.13032	.617
					28	SGO	578	.12387	.567
TEMPLE									
0	SM sp	577	.15873	.734	0	SM	577	.11208	.773
4	SM sp	575	.14655	.746	5	SLM +	579	.10154	.746
9	SLM	570	.15244	.751	13	SLM	576	.10212	.668
14	LM sp	579	.09259	.678	18	LM	578	.09783	.653
19	SGO	582	.06570	.661	23	SGO	577	.10102	.632
23	SGO	578	.12655	.576	29	M Bl st	583	.07112	.564
					33	SGO	581	.07141	.581
COTTON OPENING AFTER FROST									
Chillicothe					Lubbock				
0	M sp	580	.17212	.707	0	GM sp	571	.23523	.764
4	SLM sp	583	.12079	.678	6	GM sp	577	.22584	.717
					10	M sp	576	.22416	.684
					15	SLM sp	577	.21848	.658

There were both station and seasonal differences in the color of the unexposed cottons as shown in Table 13. Of the cotton grown the first season, that at Lubbock was much less creamy than that grown at Temple or Chillicothe. The cotton from Temple was slightly more creamy than that from Chillicothe. The luminosity of the cotton from Chillicothe and that from Temple were approximately equal and were slightly lower than that from Lubbock.

There were marked differences between the creaminess or purity of the cotton grown at the three stations during the second season. The cotton from Lubbock was approximately the same throughout the season as that from Chillicothe, but that from Temple was much less creamy than that from the other stations. This is in marked contrast to the cotton of the first season. The cotton from Temple the second season and that from Lubbock the first season were similar in creaminess and much lower than the other four lots of cotton. These differences in creaminess were great enough to be detected with the unaided eye. The cotton grown the second season at Temple and Chillicothe showed comparatively little difference in luminosity, but that at Lubbock was slightly lower than that at either Temple or Chillicothe and lower than that grown the first season at Lubbock.

All of the cotton became darker and less creamy as the exposure increased, but there were differences in the time of exposure required to initiate the change. During the first season the cotton at Lubbock lost very little in creaminess until the ninth week, when the loss was great, after which the creaminess was probably fairly constant as suggested in Figure 12. The cotton at Chillicothe and Temple the first season retained creaminess equally well through the ninth week, after which time the cotton at Temple lost creaminess more rapidly; however, after the twenty-third week some of the creaminess of the cotton at Temple had been regained (Figures 13 and 14). The cotton at Chillicothe retained its creaminess after fourteen weeks of exposure, but after nineteen weeks the loss was great.

The luminosity of the cotton grown at Lubbock the first season changed little until the ninth week, when the greatest change occurred, after which there was little change. The loss in luminosity was greater at Chillicothe than at Temple after nine weeks of exposure. After nineteen weeks of exposure the luminosity was approximately the same at all stations. The cotton from Temple which was exposed for an additional four weeks was much darker after the twenty-third week than after the nineteenth week.

During the second season the cotton at the three stations had lost approximately the same percentage of creaminess after 20 to 23 weeks of exposure, as shown in Figures 15, 16, and 17. However, after 29 weeks of exposure that at Temple had lost twice as high a percentage of the original creaminess as had that at Chillicothe after 28 weeks. The cotton grown at Temple the first season had also lost a higher percentage creaminess than had the cotton at the other stations. The cotton at Temple remained in the field later in the season than the cotton at the other stations and continued to become darker and less creamy during these additional periods.

The cotton grown the second season at the three stations became darker at approximately the same rate. The cotton from Lubbock was darker than that from Chillicothe or Temple throughout the season.

The cotton which opened after frost at Chillicothe during the first season and at Lubbock during the second season was spotted and much more creamy than any cotton opening before frost. The cotton from Lubbock had much more yellow color than did that from Chillicothe. This difference does not agree with the record of the cotton opening before frost, as that from Chillicothe was yellower than that from Lubbock the first season and they were approximately equal the second season. Of the two crops opened after frost the cotton at Lubbock had retained a higher percentage of creaminess after six weeks than that at Chillicothe after four weeks of exposure. The cotton from Lubbock also had a higher luminosity than that from Chillicothe, but its loss during exposure was approximately the same as that of the Chillicothe cotton.

There was a decrease in the purity and luminosity as the rainfall increased, as shown in Figures 12 to 17 inclusive. In most instances the curves for luminosity follow those for rainfall more closely than do those for purity. This suggests that rainfall may have more effect in darkening the cotton than it does in reducing creaminess.

In all the cotton there was a decrease either in purity or in luminosity or in both after 3 to 5 weeks of exposure. This indicates that early harvesting is desirable to secure creamy, bright cotton.

That qualities other than color were given weight in the classification of the cottons is evident. There were wide variations in both purity and luminosity of the cottons classed in the same grade. For example, of the five first pickings classed as strict middling, two (that from Lubbock the first season and that from Temple the second season) were of much lower purity but slightly higher luminosity than the other three. The lack of creaminess in these two lots of cotton was perhaps compensated for in part by greater brightness. Cotton which opened before frost, and which was classed as strict middling, ranged in purity from approximately 0.101 to 0.146, an average of 0.131. The average purity of the middling cotton was 0.141, of the strict low middling 0.136, of the low middling 0.116, and of the strict good ordinary 0.103. The average luminosity of the cotton classed as strict middling was 0.750, of the middling 0.711, of the strict low middling 0.693, of the low middling 0.654, and of the strict good ordinary 0.620. From these averages it is seen that the decrease in luminosity follows more closely the lowering in grade than does the purity. This suggests that the light-to-dark quality of cotton was given more weight than creaminess in determining the grade. To assure avoidance of this darkening, cotton should be harvested within the first three weeks after opening.

THE EFFECT OF STORAGE ON THE STRENGTH OF COTTON

To determine the effect of storage upon the strength of lint cotton, tests were made of a portion of the cotton before and after one and two years of storage. The cotton had been kept between tests in paper bags

stored in a vault free from light. Two years elapsed between tests of the 1931 cotton and one year between tests of the 1932 cotton. Although the quantity of cotton available for the second test was smaller than desirable for the best sampling, it is believed it was adequate to justify the conclusions drawn.

All of the cotton lost strength after storage. However, the cotton grown at the three stations did not lose strength equally, as may be seen in Table 14. After one year of storage of the 1932 crop the cotton

TABLE 14. The effect of storage on the strength of cotton.

Cotton	Storage period in years	Breaking strength in 1000 lbs. per sq. in.		Loss in percentage
		Before storage	After storage	
Temple 1932.....	1	68.5	63.5	7.3
Chillicothe 1932.....	1	59.5	50.7	14.8
Lubbock 1932.....	1	56.0	45.8	18.2
Lubbock 1931.....	2	62.6	46.6	25.6
Temple 1931.....	2	68.0	45.4	33.2

from Temple had lost only 7 per cent of the original strength, that from Chillicothe 15, and that from Lubbock 18 per cent. These differences between stations are similar to those found during exposure of the same crop in the field, and the stations occupy the same relative positions in loss in strength for exposure and storage. However, after two years of storage of the 1931 crop the cotton from Temple had lost 33 and that from Lubbock 26 per cent. Since the same crop was not tested in each of the two storage periods it is not known how much of this difference was due to qualities inherent in the cotton and how much to the length of the storage period.

The results suggest that the strength of cotton decreases in storage and that the rate of decrease increases as the storage period is extended.

This loss in strength is contrary to the findings of Ahmad (1), who found that storage of baled cotton in India increased the strength of the yarn although not all varieties of cotton responded equally. In the Indian experiment it was found that storage in the open resulted in a weaker yarn than storage in a shed. The exposure periods were for 6, 12, and 18 months. The strength after 12 months, although greater than that of the unstored, was less than after 6 months. The author attributed this difference to difference in humidity, the 6 and 18 months periods having coincided with the rainy season while the 12 months period marked the end of the dry season. The conclusion was reached that the changes in yarn strength are related to the atmospheric conditions of humidity and temperature prevailing in Karachi during the entire period of storage.

From another study made in India (5) on the influence of storage on the length, weight, and strength of Dharwar cotton it was concluded that

storage for as long as three and one-half years had no significant effect on these properties although the color changed slightly. This report from India refers to the controlled conditions of storage in a laboratory where most of the harmful effects of micro-organisms were said to have been eliminated.

Although no record was kept of the temperature and humidity of the vault at College Station, it is believed that the range was not great. It is not known what effect if any the composition of the paper bags may have had upon the cotton. It is hoped that work now under way will furnish explanations for some of the differences in strength which occur during storage.

SUMMARY AND CONCLUSIONS

It is the practice in some sections of the cotton belt to use methods of harvesting which encourage the postponement of picking until most of the bolls are open. As a result of such practices the cotton which opened early is exposed to weather conditions in the field for several weeks or even months.

This study was undertaken to determine the effect of such exposure on the grade, staple, strength, and color of the cotton, with the hope that such information would serve as a basis for recommendations concerning the time of harvesting.

Ferguson Triumph 406, grown two seasons, 1931 and 1932, at substations Temple, Chillicothe, and Lubbock, was the variety used in this study. These three regions were chosen because of wide variations in soil and climatic conditions.

A large number of bolls was tagged at each station when the bolls were opening freely. A portion was picked at once and at weekly and bi-weekly intervals thereafter until no more remained in the field. There were included also cotton which had opened after frost at Chillicothe in 1931 and at Lubbock in 1932. Each picking was sent immediately to College Station where it was ginned, classed, and analyzed for strength and color.

The first picking of each lot of cotton was classed as strict middling, with the exception of the cotton grown at Temple the first season, which was strict middling spotted. Although the cotton from each region was lowered in grade upon exposure, the extent and rate of the decrease were not equal. The time of exposure required to lower one grade from that of the first picking was as short as one week in two cases, 3 weeks in two cases, and an average of less than 4 weeks for all stations and seasons. After an average of 6 weeks of exposure the cotton had dropped two grades, after 12 weeks three grades, after 18 weeks four grades, and after 25 weeks five grades.

Precipitation was apparently an important factor in lowering the quality of the cotton, as in two-thirds of the cases the grade was lowered earlier when the precipitation was greater. However, precipitation is not the only factor, as evidenced in several cases, particularly at Lubbock where the grade was lowered early with little or no accompanying precipitation. The staple, upon classing, was found to be shorter as the exposure was prolonged, the decrease in length being $1/16$ to $3/16$ inches.

The quotations for middling $7/8$ cotton at Houston on the picking dates were used to determine the monetary value of the cotton. The unexposed cotton was entitled to premiums of 45 to 100 points, with an average of 65 points. One week of exposure resulted in an average decrease of 5 points. The decrease continued as the exposure increased until after 31 weeks there was a drop of 185 points. In general the decrease in price due to exposure was approximately 26 per cent but in some cases was more than 40 per cent. Even at the extremely low price of cotton during the 1931 and 1932 seasons (approximately 6 cents), the loss due to exposure was as much as \$13.00 per 500-pound bale. From one to four weeks of exposure may materially reduce the market value of cotton.

Strength analyses were made by the Chandler bundle method. The cotton grown in the three regions varied in strength. That grown at Temple was stronger than that at Chillicothe or Lubbock. There were also seasonal variations which may have been due to differences in precipitation. All of the cotton lost strength upon exposure, the loss in general increasing with the exposure period and precipitation. Losses extending from less than 1 per cent to 7 per cent had occurred in most cases after 4 or 5 weeks of exposure. The average loss after 13 weeks was approximately 8 per cent, after 23 weeks 9 per cent, and after 29 to 33 weeks 11 per cent. The maximum loss throughout the exposure periods was 14 per cent of the original strength. The loss in the strength of the cotton from Chillicothe was slightly greater, and that from Lubbock nearly twice as great, as the loss of that from Temple for the same periods. Differences in precipitation in the three regions during exposure do not account for these differences. It may be that the greater ultra-violet to be expected at Chillicothe and Lubbock may have caused greater degradation of the cotton cellulose in these two regions than occurred at Temple. If this be true, early harvesting may be more imperative in regions of high altitude. To avoid loss in strength, cotton should be harvested within the first 4 or 5 weeks after opening.

There were wide variations in the strength of cotton of the same grade. It is evident that strength was only one of the factors influencing the determination of grade. There was apparently closer correlation between the precipitation and grade than between precipitation and strength.

The color of the cotton was measured with a spectrophotometer and the data were converted into terms of dominant wave length or hue, purity or creaminess, and luminosity or the light-to-dark quality. There

were both regional and seasonal variations in the color of the unexposed cottons. The cotton grown at Lubbock was much less creamy the first season than that grown the second season. Of the two crops grown at Temple that of the first season was much more creamy than that of the second. The differences in luminosity were not so great as those in purity. However, the cotton from Lubbock the second season and that from Chillicothe the first season were slightly darker than that from the other stations and seasons. All became darker as the exposure increased. In all but one case the cotton was noticeably darker after 3 to 5 weeks of exposure.

Cotton which had opened after frost was stained and was much more yellow than that opened before frost. Cotton which had opened after frost at Lubbock was yellower than that opened after frost at Chillicothe. Both became darkened and less creamy upon an exposure of 4 to 6 weeks.

A study of the relation of rainfall to purity and luminosity indicates that rainfall may have had greater effect in darkening the cotton than in decreasing the creaminess. In all cases there was a decrease in either purity or luminosity, or in both, within the first 3 to 5 weeks after opening. The grades of cotton seem to follow luminosity more closely than they do purity, suggesting that the light-to-dark quality of the cotton was considered of greater importance in classing than creaminess.

The effect of storage on the strength of lint cotton was measured by determining the strength of cotton before storage and after one year and two years of storage. All of the cotton lost strength upon storage, but not equally. After one year of storage of the second season cotton that from Temple had lost 7 per cent of the original strength, that from Chillicothe 15 per cent, and that from Lubbock 18 per cent. After two years of storage of the first season cotton that from Temple had lost 33 per cent and that from Lubbock 26 per cent.

From this study it is concluded that to obtain a product of high quality in grade, strength, and color, commanding the best price, cotton should be harvested not later than four or five weeks, and preferably within the first one or two weeks, after opening.

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