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EFFECT OF SPACING ON SOME AGRONOMIC AND FIBER CHARACTERISTICS OF
PEEBLES, R.H.; DEN HARTOG, G.T.; PRESSLEY, E.H. 1 OF 1

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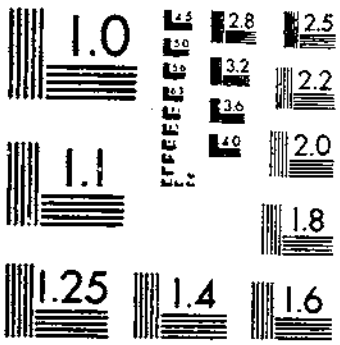

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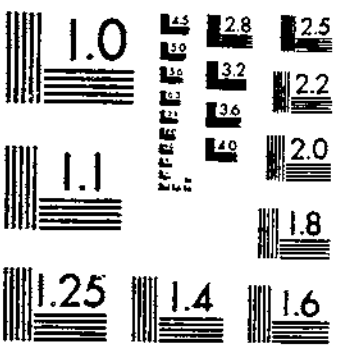

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CONTENTS

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EFFECT of SPACING

ON SOME AGRONOMIC AND FIBER CHARACTERISTICS OF IRRIGATED COTTON[1]

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INTRODUCTION

Density of plant population, which is recognized as an important factor in cotton production, has not heretofore been studied extensively for this crop in Arizona, where large acreages of cotton are grown under irrigation. The phenomenal rise in cotton yield that has taken place in recent years has accompanied the introduction of new varieties and the adoption of improved methods of land preparation, irrigation, fertilization, and insect control. The experiments reported here were designed to determine whether yields could not be raised even further by increasing plant population and to ascertain what influence closer spacing might have on the character of the crop.

Manufacturers are paying ever-increasing attention to the properties of raw cotton according to the intended end use. Consequently, any deviation in culture must be appraised in respect to its effect on fiber properties, as well as on the agronomic characteristics that are of immediate concern to cotton growers.

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[2] Deceased March 25, 1956.

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REVIEW OF LITERATURE

The important effect of spacing on yield of cotton has long been recognized. Some of the earliest findings on this subject were those reported by Stubbs (*37*)[1] and Lee (*24*) in Louisiana in 1889. Stubbs obtained highest yield with 8-inch spacing. In his experiments, however, the plantings exemplifying different spacings were not all of the same variety. Lee found that cotton produced best if 2 plants were left together every 12 inches. In the experimental plantings of these investigators, the distance between rows was 4 feet. Other research workers who reported findings on spacing of cotton before 1900 were Newman (*30*), Redding (*31*), and Duggar (*14*). In 1906 Redding and Kimbrough (*32*) summarized the results of some 15 years of experimentation with the statement that the space between rows should be less than the 4 feet then customary and the space between plants in the row should be more nearly equal to that between rows. For infertile soil they recommended a row spacing of 30 to 36 inches and a within-row spacing of 10 to 12 inches, and for fertile soil they advised a row spacing of 42 to 48 inches and a distance of 12 to 18 inches between plants.

Early in this century, Balls and Holton (*1*) performed their classical experiments on the spacing of long-staple cotton in Egypt. These investigators made a study of spacing with reference to boll weight, seed weight, lint weight, and other components of yield. Daily flowering records were kept, and bolls were harvested at weekly intervals. Spacing intervals within the row ranged from 12 to 72 inches, with both 1 and 2 plants per hill, and the rows were either 30 or 60 inches apart. In their report, published in 1915, the investigators stated that seed and lint weights were unaffected by spacing but that the closest spacing used, the 12-inch, produced considerably more flowers and resulted in the highest yield. They concluded that the Egyptian fellah's practice of leaving 2 plants per hill every 12 inches was a good one. Balls and Holton found evidence that the competition effects of close spacing were due to root rather than aerial interference.

At about the same time Cook (*6*, *7*) advanced his theory of a "new system" of cotton culture, which he termed "single-stalk culture." The theory was based on Cook's observation that the structure of the cotton plant appeared to be modified by spacing. He had observed that where plants were grown in close spacing the fruiting branches were shorter and the vegetative branches were suppressed, so that each plant had a strongly predominant main stalk. He also noted that a crop produced by closely spaced plants tended to mature earlier. In an experiment reported by Cook (*6*), closely spaced plants were not thinned until a rather late date. Higher yields were obtained from the rows of closely spaced, late thinned plants than from comparable rows of widely spaced plants. Close spacing and late thinning were the main features of Cook's proposed system of culture.

The recommendations of Cook created a spirited controversy among cotton agronomists. During the 12 or 13 years following their first publication further experimenting was done, particularly by Brown,

[1] Italic numbers in parentheses refer to Literature Cited, p. 60.

Ricks, and coworkers (*4*, *5*, *34*) in Mississippi and Reynolds (*33*) in Texas. This research proved rather decisively an error in Cook's deductions as to the cause of higher yields; the experimental data showed that close spacing led to increase in yield but that delayed thinning did not result in an increase. When early and late thinning to the same spacing were compared, late thinning almost invariably resulted in lower yield. In 1931 Cook (*8*) attributed the increase in yield and modification of growth habit he had observed in close spaced, late thinned cotton more to close spacing than to delayed thinning.

Among workers reporting superior yields of close spaced cotton during the twenties were Blackwell and Buie (*3*) and Hall and Armstrong (*15*), in South Carolina; King and Leding (*19*), who obtained favorable results from close spacing with both American-Egyptian and Upland cotton in Arizona; McNamara (*28*), in Texas; and McKeever (*27*), in southern California. On the other hand Thompson et al. (*42*), in a combination topping and spacing experiment with Egyptian-type cotton grown in the Salt River Valley of Arizona, obtained maximum yield with a topping treatment in which the plants were spaced 18 inches apart. Reynolds (*33*), in a very exhaustive study of the effects of spacing on yield of Upland cotton at 9 locations in Texas over a period of some 12 years, showed that no single spacing was best in all years and that yield did not vary significantly according to spacing unless the comparisons were between very narrow and very wide intervals.

When the boll weevil had spread menacingly over the entire Cotton Belt, anything that promoted earliness of cotton was eagerly grasped. Blackwell and Buie (*3*), McNamara (*28*), and Stansel (*36*) all found that close spacing generally promoted earlier maturity. Stansel noted, however, that the first open boll appeared very late in cotton grown in 3-inch spacing.

Martin, Ballard, and Simpson (*29*), in a study of earliness of cotton as induced by close spacing, observed that the interval of square, flower, or boll appearance for first nodes on successive fruiting branches was approximately 3 days, compared with 6 days for successive nodes on the same branch.

The period 1927–40 was characterized by increased interest of cotton research workers in the effects of spacing on properties other than yield and earliness. Derevitskiy and Starosel'skiy (*13*), Sankaran (*35*), Ware (*44*, *45*), and Cotton and Brown (*9*) all studied spacing with reference to boll size, seed weight, or both. Generally, the investigators reported little effect of spacing on boll size. Tisdale (*43*), however, obtained an increase in boll size with wider spacings. Results for seed weight appeared to be rather inconclusive. Leding and Lytton (*22*) found that average number of locks per boll was influenced by plant population, close spacing reducing the proportion of 5-lock bolls. In studies on flowering and fruiting, Ware (*44*) and Ludwig (*26*) noted that a thick stand resulted in a greater number of flowers early in the season. Ludwig found that time of initiation of squaring, length of squaring period, and length of boll period were unaffected by spacing, so that proportion of early squares could be used as a criterion of earliness.

Considerable research on cotton spacing was being carried on in Egypt during this period. Templeton (*40*) reported maximum yield

with a spacing of 17,000 plants per acre. Crowther and coworkers (*10, 11, 12*) performed an intensive series of experiments in which the effects of variation in spacing, irrigation, and fertilizer application, respectively, were measured on several varieties. Treatments were replicated, and the data were subjected to analysis of variance. The experiments included spacing as close as 4 inches. In general, 8-inch spacing produced the highest yield. No differential response of varieties to spacing was observed. Gin turnout proved to be highest for close spacing.

Hawkins (*17*) in the Salt River Valley of Arizona, and Cotton and Brown (*9*) in Louisiana, found either no effect of spacing on yield or highest yield at a medium spacing of about 12 inches. Leding and Lytton (*23*), reporting on experiments with Acala cotton in Mesilla Valley, N. Mex., concluded that a spacing of 1 or 2 plants per 12 inches of row was most favorable for earliness and for yield. Ware (*45*), on the basis of 6 years of experimentation in Arkansas, came to the following conclusion:

> A thick stand . . . is advisable any year on any land. A good recommendation to follow is two to three plants a hoe width apart on all lands, the rows 3½ to 4 feet wide on rich land, 3 to 3½ feet apart on land of medium fertility, and less than 3 feet wide on poor land. A thick stand on rich land does not materially reduce yields under any circumstances. In addition, it is a good boll weevil and leaf worm measure, a safer insurance against late season weather unfavorableness, and a better guarantee against long skips in the field. A thick stand is indispensable to best production on poor land.

In recent years, as use of machinery in cotton production has increased, efforts have been made to find what effect, if any, spacing has on the efficiency of machine operations. Experimental results reported by Tavernetti and Ewing (*38*) seem to indicate that no appreciable difference in picker efficiency resulted from the difference between 2- to 4-inch spacing and 16- to 18-inch spacing, although the close spacing resulted in higher trash content. Tavernetti and Miller (*39*) reported essentially the same results, but emphasized the need for stand uniformity with close spacing.

Attention has been given also to the effect of spacing on disease resistance. Leyendecker, Blank, and Nakayama (*25*) found that the incidence of *Verticillium* wilt was much lower where clumps of plants were grown 1 foot apart than where single plants were grown 1 foot apart. This confirmed the finding of Leding (*20*) that significantly higher yields were obtained in unthinned cotton.

In yield experiments by Beckett (*2*) in Lower California, higher yield and monetary income were obtained from unthinned Upland cotton averaging from 3.0 to 4.9 inches between plants. Kanniyan and Balasubramanian (*18*) reported similarly greater yield for close spacing in India. Thomas (*41*), in a study with Upland cotton in Arizona, although noting that close spacing hastened maturity, obtained about the same yield with 30-inch as with 4-inch spacing. Leding and Cotton (*21*) found that American-Egyptian varieties grown under New Mexico conditions gave their highest yields when the plants were spaced 12 inches apart in the row.

In a recent investigation of Upland cotton grown under rather exceptional conditions in the loamy sand soil of the Yuma Mesa, in Arizona, Hamilton et al. (*16*) found that increased shedding offset a

gain in flower production observed at the very close spacing of 1.5 inches. Earliness, as measured by percentage of the total crop harvested at the first picking, proved greater for the 1.5-inch than for wider intervals, but the 6- and 12-inch spacings greatly outyielded the 1.5-inch spacing at the second picking. The greater yield of cotton in the 6- and 12-inch spacings at the late picking appeared to be primarily a matter of greater boll size. Ratio of seed-cotton weight to plant weight was greater for these spacings. The response of yield to spacing appeared not to be affected either by application of nitrogen or by variation in soil moisture.

MATERIALS AND METHODS

Effect of within-row spacing was studied with reference to yield and nine other characteristics, in both Upland cotton (*Gossypium hirsutum* L.) and American-Egyptian cotton (*G. barbadense* L.). The study encompassed 14 experiments made in 1950 and 1951, all under irrigation. The work was conducted at the United States Field Station, Sacaton, Ariz., and the Mesa Experimental Farm of the University of Arizona, Mesa, Ariz. The soil at Sacaton is an alluvium known as Gila silty clay loam. At Mesa the soil is Laveen clay loam.

Spacing

Spacing intervals varied among the experiments (table 1). From 2 to 8 were compared in each experiment. Spacing in the American-Egyptian series of experiments ranged from 2 to 36 inches. Spacing of the Upland varieties was studied over the more limited range of 2 to 16 inches. Except for slight discrepancies in experiments 51–6a and 51–6b, spacing intervals in every experiment varied by equal increments.

In the Sacaton experiments the rows were spaced 36 inches apart. At Mesa they were 38 inches apart.

Varieties

In order to provide a broad base on which to evaluate effects of spacing, several varieties were included in every experiment. The entries included a number of experimental strains as well as commercial varieties, but for the most part the material represented productive and locally adapted cotton. This made it possible for each experiment to provide useful comparative data on varieties. The number of varieties involved in an experiment varied from 3 to 12, as circumstances dictated (table 1).

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TABLE 1.—*Designs used in 14 spacing-variety experiments with irrigated cotton at Sacaton and Mesa, Ariz., in 1950 and 1951*

AMERICAN-EGYPTIAN

Year and experiment	Design	Intervals between plants in the row [1]	Plot length	Varieties	Table presenting results
1950		*Inches*	*Feet*	*Number*	
50–1	8 × 8 Greco-Latin square.	4, 8, 12, 16, 20, 24, 28, 32.	25	8	4
50–2	Modified Latin square.	6, 12, 18, 24, 30, 36.	38	6	5
50–3	8 × 4 Greco-Latin square with duplication of each spacing.	6, 14, 22, 30	25	8	6
1951					
51–1	Repetition of experiment 50–1.	4, 8, 12, 16, 20, 24, 28, 32.	25	8	9
51–2	4 × 4 × 4 split-plot Latin square.	4, 12, 20, 28	24	4	10
51–3	Repetition of experiment 50–3.	6, 14, 22, 30	25	8	11
51–6a	3 × 3 × 3 × 4 split-split-plot.	2, 6, 10, 16	15	3	15

UPLAND

1950					
50–4a	8 × 8 Greco-Latin square.	2, 4, 6, 8, 10, 12, 14, 16.	24	8	7
50–4b (Mesa)	8 × 8 Greco-Latin square.	2, 4, 6, 8, 10, 12, 14, 16.	33	8	8
1951					
51–4a	Repetition of experiment 50–4a.	2, 4, 6, 8, 10, 12, 14, 16.	25	8	12
51–4b (Mesa)	Repetition of experiment 50–4b.	2, 4, 6, 8, 10, 12, 14, 16.	33	8	13
51–5	4 × 4 × 4 split-plot Latin square.	2, 6, 10, 14	29.5	4	14
51–6b	3 × 3 × 3 × 4 split-split-plot.	2, 6, 10, 16	15	3	16
51–7	12 × 2 × 3 split-plot	2, 12	16.5	12	17

[1] In all experiments the plots were 8 rows in width. Distance between rows was 36 inches except in experiments 50–4b and 51–4b, in which it was 38 inches.

Experimental Designs

Each experiment was laid out in a Greco-Latin square, Latin square, split-plot design, or some modification of one of these basic arrangements (table 1).

The Greco-Latin square seemed admirably adapted for testing main effects of several spacing intervals and several varieties simultaneously and with equal precision. For instance, this design permitted testing 8 intervals and 8 varieties on a 64-plot field without confounding spacings or varieties with each other or with "rows" or "columns." The Greco-Latin design utilized in this study does not, however, afford a measure of interaction between the two main factors, "spacings" and "varieties." If this interaction were large, the F values for varieties and spacings would be underestimated. (Actually, as is mentioned later in connection with the analysis of split-plot experiments, the spacing × variety interaction rarely proved to be significant. It thus appears that in nearly all cases the error term used in the Greco-Latin analyses was free from bias.) A diagram of a Greco-Latin square experiment is shown in figure 1.

G-4"	B-2"	E-12"	H-14"	C-16"	A-10"	F-6"	D-8"
A-6"	C-14"	F-10"	D-2"	B-8"	G-12"	E-4"	H-16"
F-16"	H-10"	A-14"	B-12"	D-4"	E-2"	G-8"	C-6"
C-2"	A-4"	H-8"	E-6"	G-10"	B-16"	D-14"	F-12"
B-14"	G-6"	D-16"	F-4"	A-12"	C-8"	H-2"	E-10"
H-12"	F-8"	C-4"	G-16"	E-14"	D-6"	B-10"	A-2"
E-8"	D-12"	G-2"	C-10"	H-6"	F-14"	A-16"	B-4"
D-10"	E-16"	B-6"	A-8"	F-2"	H-4"	C-12"	G-14"

FIGURE 1.—Diagram of the 8 × 8 Greco-Latin square used in experiment 51–4a. Varieties are indicated by letters, spacings by figures. Each plot comprised eight 25-foot rows of cotton, spaced 3 feet apart. All 64 combinations of variety and spacing are represented in the experiment.

Two experiments were laid out as split-plot Latin squares, each with 4 varieties, 4 spacings, and 4 replications. The 4 varieties were arranged in a Latin square, on main plots. The 4 spacings were assigned to subplots of each variety (fig. 2). The split-plot design provided a means of testing spacing × variety interactions and at the same time obtaining a sensitive test of spacing effects and satisfactory information on varieties.

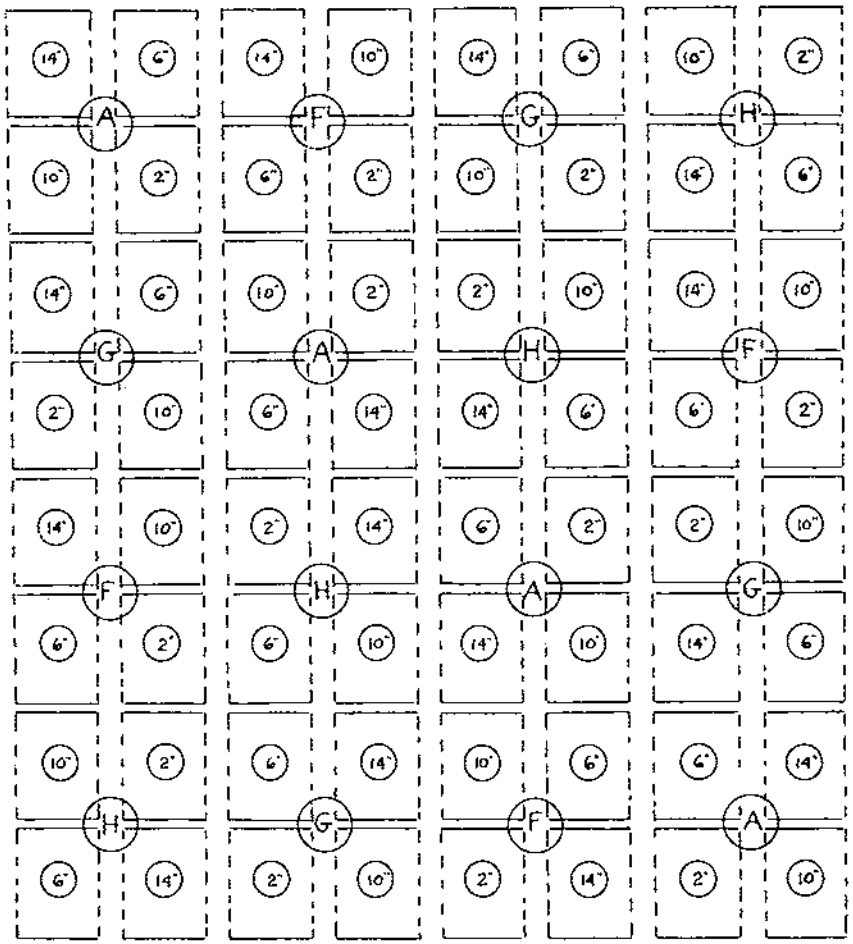

FIGURE 2.—Diagram of the 4 × 4 × 4 split-plot Latin square design used in experiment 51–5. Varieties are indicated by letters, spacings by figures. Each plot comprised eight 29.5-foot rows of cotton, spaced 3 feet apart.

Experiments 50–3 and 51–3 were designed as Greco-Latin squares, but with only 4 spacing intervals for the 8 varieties. Each spacing appeared twice in each row and twice in each column of plots.

Experiment 50–2 involved 6 spacing intervals and 6 varieties. It was laid out in a 36-plot field in such manner that each spacing and each variety occurred once in each row of plots.

The 1950 Greco-Latin experiments 50–1, 50–3, 50–4a, and 50–4b were repeated in 1951. The repetition made it possible to test for spacing × variety interactions.

Experiments 51–2, 51–5, 51–6a, 51–6b, and 51–7 were each laid out in split-plot design. In experiments 51–6a and 51–6b the subplots were divided into sub-subplots and "dates" were assigned to main plots, "varieties" to subplots, and "spacings" to sub-subplots.

Plot Technique

In all experiments the plots were either square or nearly square. Where length of rows was 24 or 25 feet the plots were approximately square, since each plot contained 8 rows spaced 3 feet, or approximately 3 feet, apart. Rows ran in a north-south direction. To eliminate interplot competition, plots were separated at the ends by a 2-foot aisle and laterally by an alley that occupied approximately the same space as a row of cotton.

Since plot yield computations were based on the weight of the seed cotton picked from all 8 rows, some error might have resulted from one variety's being favored by "border row effect." To test this possible source of error, the plots with 12-inch spacing in experiment 51–2 were picked row by row. It was found that the F values for individual rows did not vary appreciably, even though the outer rows invariably yielded at a higher rate. Thus, by harvesting all the rows of each plot added information was obtained on spacings and varieties without introducing any apparent bias into the comparisons.

Long, narrow plots might have given equally reliable results, but square plots had been found satisfactory in previous variety tests. The square shape was utilized in the present study largely for convenience under the method of flood irrigation then employed at the Sacaton and Mesa stations.

Agronomic Practices

Earthen ridges were thrown up lengthwise of the field for the retention of water. The intervening lands, each wide enough for 8 rows of cotton, were flood irrigated before planting and at appropriate intervals during the growing season. Dates of planting ranged from March 25, for experiment 50–2, to April 10, for 51–2. The procedure in experiments 51–6a and 51–6b involved three dates of planting. The crop was handpicked in all experiments.

Sampling and Measurements

Samples of seed cotton were taken from plants selected at random within each plot and at random positions on the plants. The only exception to random sampling was rejection of bolls that were obviously deformed. In the Upland experiments, 25 bolls constituted a sample; in the American-Egyptian experiments, owing to the smaller size of the bolls, 50-boll samples were collected.

The following characteristics were determined for all plot or subplot samples:

Yield—pounds of lint per acre.
Earliness—weight of seed cotton at first picking expressed as a percentage of total seed-cotton yield.
Boll weight—number of bolls per pound of seed cotton.[5]
Lint percentage—lint weight expressed as a percentage of seed-cotton weight.
Seed index—weight, in grams, of 100 ginned seeds.
Lint index—weight, in grams, of the fiber from 100 seeds.
Upper-half mean (U. H. M.) fiber length—determined by means of the Hertel fibrograph.
Mean fiber length—determined by means of the Hertel fibrograph.
Fiber strength—Pressley index, determined by means of the Pressley fiber-strength tester.
Fiber fineness—surface area of a specific mass of fibers, determined by means of the Hertel arealometer or the Sheffield micronaire and expressed in arealometer units.

Fiber fineness was determined with both the arealometer and the micronaire in 9 experiments. In 5 experiments, namely 51–2, 51–5, 51–6a, 51–6b, and 51–7, fineness was determined with the micronaire only. For the sake of uniform presentation, the micronaire values (linear scale) were converted to arealometer units by use of the formula $A=769.7-72.38M$. High arealometer values indicate greater fineness, whereas the reverse is true of the micronaire. To obtain arealometer mean squares for each of the 5 experiments just listed, micronaire mean squares were multiplied by the factor $\left(\frac{\text{derived arealometer mean for the experiment}}{\text{micronaire mean for the experiment}}\right)^2$. The arealometer conversion factors for the 5 experiments were as follows: 51–2, 20,882; 51–5, 13,309; 51–6a, 21,945; 51–6b, 14,400; 51–7, 10,793.

A spinning test was made on composite lint samples of each of 4 varieties grown at each of 4 spacings in experiment 51–5. Data were taken on yarn strength, yarn appearance, neps, and processing waste.

An effort was made in 1951 to obtain some information on the approximate quantity of stalks produced by cotton grown at various spacing intervals. The stalks, minus their leaves and seed cotton and with some burs lost, were cut at ground level several weeks after frost, air-dried, and weighed.

EXPERIMENTAL RESULTS

The effects of spacing in the 14 experiments are presented synoptically in table 2. In this table a plus sign indicates a desirable effect of close spacing, a negative sign denotes an undesirable result, and a zero means that the difference was not statistically significant. It may be seen that some of the characteristics reacted quite differently. For instance, yield and fiber strength often showed a response to close spacing whereas fiber length and seed index seemed to be unaffected.

[5] Often regarded as an estimate of boll size.

Some characteristics were influenced by spacing in certain experiments but not in others. Occasionally, spacing appeared to affect a characteristic oppositely in different experiments. Also presented in table 2 is the average advantage or disadvantage of close spacing for each characteristic, expressed as a percentage of the mean value obtained with 12- to 16-inch spacing. The most outstanding advantage observed was that of 12.9 percent in yield for American-Egyptian cotton.

In 4 of the 7 Upland tests varieties did not differ in fiber length (table 3). Aside from this, varieties exhibited significant differences in nearly every characteristic in all experiments. Tables 2 and 3 serve to compare environmental effects of controlled spacing with genetic effects in the various experiments.

Figure 3 graphically illustrates the effect of spacing on agronomic characteristics of Upland and American-Egyptian cotton. The average value obtained for each spacing interval is plotted as a percentage of the 12-to-16-inch mean. Yield, earliness, and boll weight are the characteristics most influenced by spacing.

Results for individual experiments are given in tables 4 to 17. The mean values for spacings given in various tables represent all the varieties included in the respective experiments. Similarly, the mean values given for varieties represent all the spacing intervals. For example, the acre yield of lint given in table 4 for 4-inch spacing, 783 pounds, is the mean value for all 8 varieties tested at that spacing in experiment 50–1, and the acre yield given in the same table for experimental variety 5–17, 780 pounds, is the mean for that variety at 8 different spacing intervals.

Results of combined analyses, in each case representing two different statistical breakdowns of the sources of variation, are given in tables 18, 19, and 20 for 2 sets of American-Egyptian experiments and 1 set of Upland experiments.

Coefficients of variation for all experiments are given in table 21. Brush weight, lint per acre, and percentage of the total crop obtained in the first picking are the characteristics that exhibited the greatest variability, as indicated by the relatively large coefficients of variation.

Yield

Close spacing increased production in all the Sacaton experiments. In both the American-Egyptian and the Upland experiments there was a strong tendency for yield to increase with each interval of decrease in spacing.

In only 1 of the 7 experiments in which the spacing × variety interaction was tested with respect to yield was the interaction significant. The exception occurred in Upland experiment 51–5 (table 14), in which the larger and later A × D and Acala 28 varieties yielded best at the 6-inch spacing while the smaller and earlier Acala 33 and Acala 44 did so at the 2-inch spacing.

The coefficient of variation for yield ranged from 10.7 to 20.6 percent in the American-Egyptian experiments and from 8.3 to 17.6 percent in the Upland series (table 21).

TABLE 2.—*Advantages (+) and disadvantages (−) of close spacing in comparison with wide spacing in 14 experiments with irrigated cotton in Arizona, 1950 and 1951* [1]

Experiment No.	Yield	Earliness	Boll weight	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength	Fiber fineness
							U. H. M.	Mean		
AMERICAN-EGYPTIAN										
50–1	+	+	−	0	+	0	0	0	0	0
50–2	+	+	0	+	0	0	0	0	0	0
50–3	+	+	0	+	0	+	0	0	−	+
51–1	+	+	+	+	0	+	0	0	0	0
51–2	+	−	0	0	0	−	0	0	0	0
51–3	+	+	0	+	0	+	0	0	−	0
51–6a	+	M	−	+	0	+	0	0	−	+
Percent difference, close and wide means [2]	12.9	9.8	−3.8	0.5	2.1	1.1	0.5	−0.3	−1.3	+1.3
UPLAND										
50–4a	+	−	0	0	+	0	0	0	−	0
50–4b	0	−	−	0	0	0	0	0	0	0
51–4a	+	−	−	0	0	0	0	+	−	0
51–4b	−	−	−	0	0	0	0	0	0	0
51–5	+	−	−	+	0	+	0	0	−	0
51–6b	+	M	−	0	0	0	0	0	−	0
51–7	+	−	−	−	0	−	+	0	−	−
Percent difference, close and wide means [2]	9.5	−7.8	−4.1	0.3	−0.4	0.1	0.4	0.2	−2.6	−0.3

[1] The ranges of within-row spacing classed here as close and wide are 2 to 6 inches and 12 to 16 inches, respectively. For definitions of characteristics named in boxheads, see p. 10. "M" indicates that data were not taken; "0" indicates no advantage.

[2] Difference between mean values for close spacing and wide spacing, respectively, expressed as a percentage of the mean for wide spacing.

366881—56——3

TABLE 3.—*Incidence of significant differences in varietal responses of cotton to close spacing in 14 experiments at Sacaton and Mesa, Ariz., in 1950 and 1951* [1]

Year and experiment No.	Varieties studied	Yield	Earliness	Boll weight	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength	Fiber fineness
								U. H. M.	Mean		
AMERICAN-EGYPTIAN											
1950	*Number*										
50–1	8	**	*	**	**	**	**	**	**	**	**
50–2	6	*	**	**	*	**	**	**	N. S.	**	**
50–3	8	**	**	**	**	**	**	**	**	**	**
1951											
51–1	8	**	**	**	**	**	**	**	**	**	**
51–2	4	N. S.	*	*	**	**	**	**	**	**	**
51–3	8	**	*	**	**	**	**	**	**	**	**
51–6a	3	N. S.	M	**	**	**	**	**	**	**	**
UPLAND											
1950											
50–4a	8	**	**	**	**	**	**	N. S.	N. S.	**	**
50–4b	8	N. S.	N. S.	**	**	**	**	N. S.	N. S.	**	**
1951											
51–4a	8	**	**	**	**	**	**	**	*	**	**
51–4b	8	N. S.	**	**	**	**	**	**	**	**	**
51–5	4	*	N. S.	**	*	N. S.	**	N. S.	N. S.	**	**
51–6b	3	**	M	**	**	**	**	N. S.	N. S.	**	**
51–7	12	**	**	**	**	**	**	**	**	**	**

[1] 1 asterisk indicates significance at the 5-percent level; 2 asterisks, significance at the 1-percent level; "N. S.," no significance; "M," data were not taken.

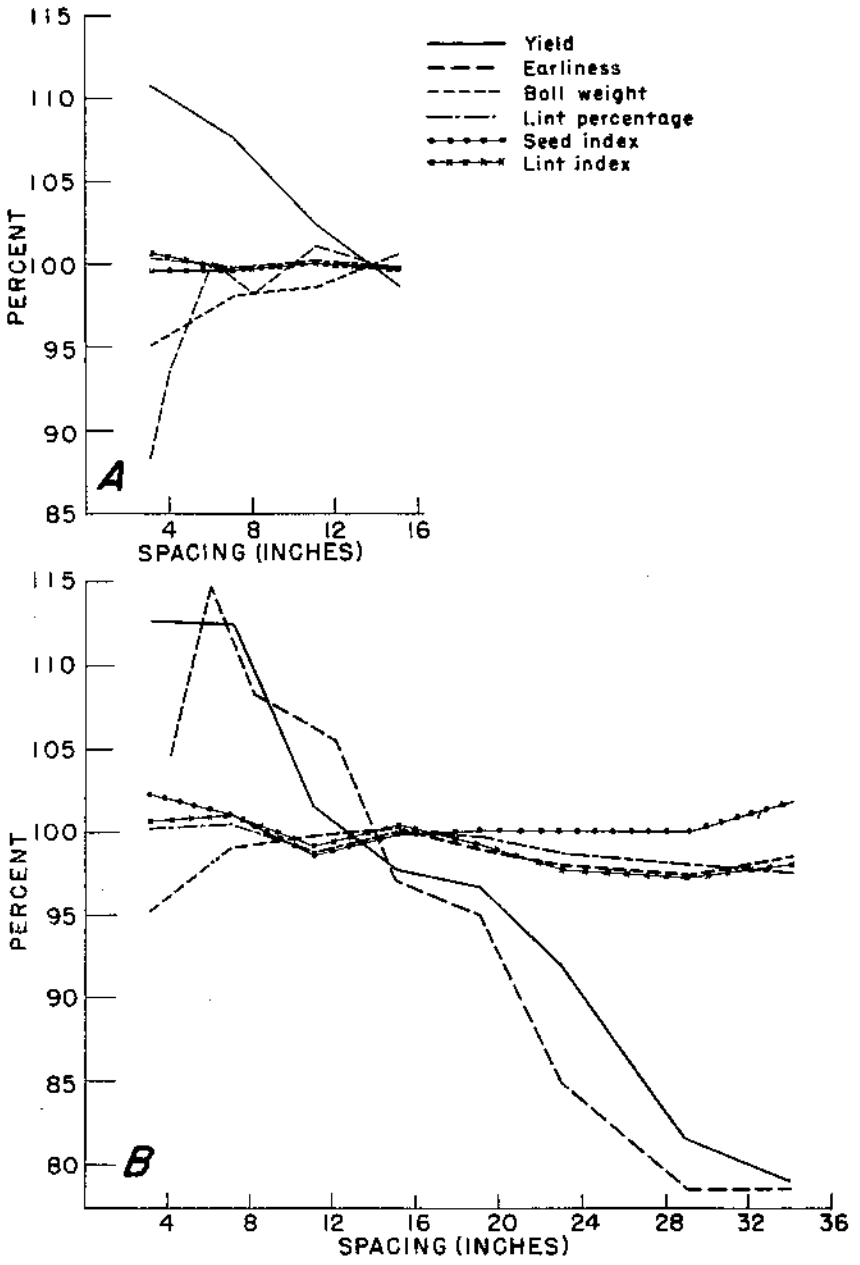

FIGURE 3.—Effect of spacing on 6 agronomic characteristics in (*A*) the Upland and (*B*) the American-Egyptian experiments. For each characteristic, average values are expressed as percentages of that obtained with 12- to 16-inch spacing.

Earliness

In the American-Egyptian series maximum earliness (percentage of the crop harvested in the first picking) occurred at the 6-inch spacing and was nearly 15 percent greater than the average for the 12- to 16-inch range (fig. 3, *B*). However, the advantage in earliness dropped sharply at 4-inch spacing to less than 5 percent. As the spacing interval increased beyond 6 inches, earliness declined continuously until at 28 to 36 inches it averaged less than 80 percent of that obtained with 12- to 16-inch spacing. This trend is demonstrated by data in tables 4, 5, 6, 9, and 11. The only exception occurred in experiment 51–2 (table 10).

In the Upland series, earliness declined markedly at the 2-inch and 4-inch intervals but remained relatively constant through the 6- to 16-inch range of spacing (fig. 3, *A*). In Upland experiments 51–5 and 51–7 a differential response of varieties to spacing occurred with respect to earliness, as shown by significant variety × spacing interactions (tables 14 and 17).

Boll Weight

Results presented in table 2 indicate a strong tendency in the Upland experiments for lower boll weight to accompany close spacing. When data from all experiments are combined and graphed (fig. 3, *A*) it is seen that boll weight declined with considerable regularity from the 16-inch spacing to the closest. Such a continuous trend was not evidenced in the American-Egyptian series, although boll weight dropped appreciably at the close intervals (fig. 3, *B*).

Lint Percentage

The reaction of lint percentage to close spacing contrasted with that of boll weight. Five of the American-Egyptian experiments gave significantly higher lint percentages for close spacing. The Upland cotton displayed no trend.

A significant variety × spacing interaction in respect to this factor occurred only in experiment 51–7 (table 17).

Seed Index

Seed index was not substantially influenced by spacing. In only two experiments, 50–1 (table 4) and 50–4a (table 7), were differences in this characteristic according to spacing found to be statistically significant, and even in these instances the differences were not of sufficient magnitude to warrant serious consideration.

Lint Index

Higher lint index tended to be associated with close spacing in the American-Egyptian series (table 2). The spread between the highest and the lowest index for individual spacings was always less than 3 percent. This contrasts markedly with the range observed for varieties, which in some instances amounted to 20 percent or more.

TABLE 4.—*American-Egyptian spacing-variety experiment No. 50–1, Sacaton, Ariz., 1950*

MEAN SQUARES[a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	7	**30, 343	**253. 2	**130	0. 35	*0. 26	0. 04	0. 0008	0. 0012	0. 02	488
Varieties	7	**31, 921	*64. 6	**147	**14. 73	**4. 00	**1. 22	**. 0073	**. 0159	**. 33	**3, 367
Rows	7	**27, 776	39. 6	**106	. 32	**. 32	**. 11	. 0011	. 0014	. 02	613
Columns	7	4, 540	30. 4	**96	**1. 01	**. 35	*. 08	**. 0030	**. 0054	**. 27	155
Error	35	5, 611	27. 1	25	. 26	. 09	. 03	. 0008	. 0012	. 02	357

MEAN VALUES

Spacing:											
4 inches		783	39. 2	133	30. 3	13. 4	5. 8	1. 43	1. 14	9. 13	476
8 inches		765	35. 7	128	30. 0	13. 3	5. 7	1. 45	1. 15	9. 25	476
12 inches		730	35. 6	126	29. 9	13. 2	5. 6	1. 45	1. 16	9. 29	484
16 inches		730	30. 2	121	30. 0	13. 4	5. 8	1. 44	1. 14	9. 24	490
20 inches		658	32. 1	126	30. 1	13. 2	5. 7	1. 44	1. 13	9. 25	499
24 inches		661	28. 8	122	30. 0	13. 2	5. 6	1. 43	1. 12	9. 29	491
28 inches		638	23. 6	123	29. 6	13. 5	5. 7	1. 45	1. 15	9. 23	486
32 inches		620	23. 9	122	29. 7	13. 7	5. 8	1. 44	1. 15	9. 28	490
Variety:											
5–17		780	33. 3	123	29. 9	13. 1	5. 6	1. 48	1. 15	9. 20	513
3–79		758	36. 2	127	33. 0	13. 1	6. 5	1. 44	1. 16	8. 97	467
Pima 32		748	28. 8	130	28. 8	13. 1	5. 3	1. 39	1. 07	9. 36	502
27–9		719	32. 5	131	30. 0	13. 0	5. 5	1. 46	1. 12	9. 12	501
Mixture[b]		681	29. 4	124	29. 2	13. 3	5. 4	1. 44	1. 14	9. 22	491
Pima 46		668	28. 6	124	30. 4	12. 6	5. 5	1. 42	1. 12	9. 34	491
Amsak		619	28. 2	118	29. 0	13. 9	5. 7	1. 48	1. 23	9. 11	477
16–59		613	32. 0	123	29. 2	14. 9	6. 1	1. 44	1. 15	9. 64	451
Average		698	31. 1	125	29. 9	13. 4	5. 7	1. 44	1. 14	9. 24	487
L. S. D. at 5-percent level		76	5. 3	5	. 5	. 3	. 2	. 03	. 04	. 15	19
L. S. D. at 1-percent level		102	7. 1	7	. 7	. 4	. 3	. 04	. 05	. 20	26

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[b] One-half Pima 32, one-half Amsak.

TABLE 5.—*American-Egyptian spacing-variety experiment No. 50–2, Sacaton, Ariz., 1950*

MEAN SQUARES[a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	5	**51, 214	**269. 6	20	**1. 64	0. 04	0. 08	0. 0008	0. 0015	0. 04	74
Varieties	5	*25, 605	**159. 6	**649	*1. 11	**2. 65	**. 56	**. 0027	. 0017	**. 60	**4, 653
Rows	5	12, 289	**111. 4	63	. 71	**. 58	. 02	. 0008	. 0008	. 02	209
Error	20	6, 830	24. 4	33	. 30	. 12	. 05	. 0004	. 0008	. 05	139

MEAN VALUES

Spacing:											
6 inches		908	57. 2	136	31. 2	13. 0	5. 9	1. 41	1. 16	9. 01	452
12 inches		813	51. 3	134	31. 0	13. 0	5. 8	1. 42	1. 15	9. 12	462
18 inches		819	48. 7	133	31. 0	13. 0	5. 8	1. 43	1. 18	8. 99	460
24 inches		751	41. 6	138	30. 0	13. 0	5. 6	1. 43	1. 18	9. 06	460
30 inches		728	40. 4	136	30. 2	12. 9	5. 6	1. 40	1. 14	9. 02	460
36 inches		638	41. 7	133	30. 2	13. 2	5. 7	1. 42	1. 16	9. 20	459
Variety:											
13–40		864	39. 4	118	30. 6	14. 1	6. 2	1. 39	1. 17	8. 72	420
Pima 32		831	44. 7	146	30. 5	13. 0	5. 7	1. 42	1. 13	9. 51	474
51–14		801	45. 2	138	31. 0	12. 6	5. 7	1. 44	1. 16	9. 19	479
30–65		732	46. 2	144	31. 2	12. 8	5. 8	1. 44	1. 17	9. 22	463
22–3		726	52. 6	128	30. 1	13. 4	5. 8	1. 39	1. 17	8. 68	431
1–71		702	52. 9	134	30. 2	12. 2	5. 3	1. 42	1. 16	9. 08	489
Average		776	46. 8	135	30. 6	13. 0	5. 8	1. 42	1. 16	9. 07	459
L. S. D. at 5-percent level		100	6. 0	7	. 7	. 4	. 3	. 02		. 27	14
L. S. D. at 1-percent level		136	8. 1	9	. 9	. 6	. 4	. 03		. 35	19

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

TABLE 6.—*American-Egyptian spacing-variety experiment No. 50–3, Sacaton, Ariz., 1950*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	3	**150, 734	**698. 7	67	**3. 72	0. 07	**0. 31	0. 0006	0. 0008	**0. 29	**1, 958
Varieties	7	**28, 848	**76. 0	**2, 731	**10. 77	**6. 96	**. 69	**. 0683	**. 0217	**. 31	**4, 697
Rows	7	**30, 300	**104. 4	**122	**1. 34	. 28	*. 13	. 0008	. 0016	. 02	*676
Columns	7	**38, 072	**83. 3	**661	. 70	**. 76	**. 28	**. 0056	**. 0040	**. 48	*653
Error	39	7, 606	22. 0	38	. 38	. 13	. 05	. 0005	. 0008	. 04	224

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MEAN VALUES

Spacing:											
6 inches		709	47.3	125	30.4	13.4	5.8	1.37	1.09	9.05	448
14 inches		656	40.2	121	29.8	13.4	5.7	1.38	1.11	9.16	462
22 inches		574	34.3	125	29.8	13.3	5.6	1.37	1.10	9.37	463
30 inches		487	32.8	125	29.2	13.3	5.5	1.37	1.10	9.25	476
Variety:											
16–55		692	37.5	125	30.7	13.6	6.0	1.44	1.14	9.09	457
Pima 32		664	34.1	135	29.6	12.4	5.2	1.38	1.07	9.25	495
Hopi Acala 50		648	40.6	82	29.3	14.0	5.8	1.16	.99	9.31	414
7–42		626	42.4	136	30.5	12.5	5.5	1.41	1.14	9.34	474
14–29		587	36.2	133	30.3	13.1	5.7	1.42	1.12	8.97	478
10–84		566	36.2	117	27.6	14.2	5.4	1.36	1.08	8.98	456
16–59		551	42.3	128	29.0	14.7	6.0	1.44	1.14	9.56	452
3–76		521	40.0	137	31.2	12.2	5.5	1.38	1.10	9.15	473
Average		607	38.7	124	29.8	13.3	5.6	1.37	1.10	9.21	462
L. S. D. for spacings at 5-percent level		62	3.4		.4		.2			.14	11
L. S. D. for spacings at 1-percent level		84	4.5		.6		.2			.20	14
L. S. D. for varieties at 5-percent level		88	4.7	6	.6	.4	.2	.02	.03	.21	15
L. S. D. for varieties at 1-percent level		118	6.4	8	.8	.5	.3	.03	.04	.28	20

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

TABLE 7.—*Upland spacing-variety experiment No. 50–4a, Sacaton, Ariz., 1950*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	7	**66, 775	**237. 8	8	0. 93	**0. 33	0. 09	0. 0007	0. 0005	**0. 21	84
Varieties	7	**60, 593	**480. 0	**108	**2. 86	**1. 22	**. 81	. 0009	. 0009	**3. 44	**1, 692
Rows	7	**54, 352	**319. 4	**28	*1. 31	**. 62	. 09	**. 0023	*. 0019	. 07	395
Columns	7	13, 975	*50. 2	6	**1. 74	. 04	. 15	. 0012	*. 0019	*. 15	173
Error	35	16, 806	19. 1	6	. 54	. 09	. 08	. 0007	. 0006	. 06	184

MEAN VALUES

Spacing:											
2 inches		1,370	32.0	66	38.8	12.8	8.2	1.10	0.87	7.67	446
4 inches		1,251	44.3	67	38.7	12.9	8.2	1.08	.86	7.69	441
6 inches		1,200	49.3	65	38.4	12.7	7.9	1.08	.86	7.69	445
8 inches		1,185	46.4	64	38.0	13.0	8.0	1.08	.86	7.81	443
10 inches		1,143	48.2	66	38.3	13.0	8.0	1.09	.86	7.75	448
12 inches		1,174	46.4	64	38.1	13.3	8.2	1.10	.87	7.93	439
14 inches		1,117	47.4	64	38.3	13.1	8.2	1.07	.85	8.00	442
16 inches		1,069	46.5	65	37.8	13.3	8.0	1.08	.87	8.10	439
Variety:											
A × D		1,339	35.3	71	38.2	13.0	8.0	1.08	.86	8.12	429
Acala 33		1,260	50.4	69	37.6	12.2	7.4	1.07	.85	8.10	460
Acala 28		1,247	34.2	62	38.0	13.3	8.0	1.10	.87	7.34	460
Acala 1517 RB		1,189	41.1	61	37.5	13.6	8.2	1.09	.86	8.36	428
Mixture [b]		1,158	45.5	64	38.5	12.9	8.1	1.10	.87	7.63	454
Acala 44		1,108	51.5	65	39.0	13.1	8.4	1.08	.85	8.09	445
Acala 4-42		1,107	56.0	68	38.4	13.0	8.2	1.10	.88	8.51	425
Acala P18-C		1,100	46.4	62	39.2	12.9	8.4	1.07	.85	6.50	443
Average		1,188	45.0	65	38.3	13.0	8.1	1.09	.86	7.83	433
L. S. D. at 5-percent level		132	4.4	2	.7	.3	.3			.25	14
L. S. D. at 1-percent level		177	6.0	3	1.0	.4	.4			.33	19

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[b] One-third each Acala 28, Acala 33, and Acala 44.

TABLE 8.—*Upland spacing-variety experiment No. 50–4b, Mesa, Ariz., 1950*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	7	10, 094	**118. 2	**34	0. 70	0. 14	0. 05	0. 0011	0. 0011	0. 06	287
Varieties	7	13, 977	29. 7	**67	**5. 28	**2. 17	**. 74	. 0008	. 0009	**2. 93	**1, 636
Rows	7	**46, 179	40. 1	**13	. 73	*. 34	**. 17	. 0010	. 0012	. 04	337
Columns	7	**172, 996	*52. 6	**28	1. 08	**. 56	. 04	**. 0027	*. 0024	**. 32	191
Error	35	8, 821	22. 7	4	. 63	. 11	. 04	. 0008	. 0010	. 05	240

MEAN VALUES

Spacing:											
2 inches		837	73.4	67	38.2	12.2	7.5	1.08	0.83	8.31	459
4 inches		855	83.0	66	38.7	12.1	7.7	1.07	.83	8.23	465
6 inches		791	82.7	65	38.0	12.3	7.5	1.08	.83	8.46	447
8 inches		818	85.2	64	37.8	12.4	7.7	1.10	.85	8.29	450
10 inches		819	84.5	63	38.3	12.5	7.8	1.08	.84	8.40	451
12 inches		762	84.6	63	38.3	12.3	7.6	1.07	.82	8.25	455
14 inches		762	82.1	61	38.5	12.3	7.7	1.07	.81	8.45	453
16 inches		769	84.7	61	38.1	12.5	7.7	1.05	.82	8.30	460
Variety:											
Acala 33		866	80.7	64	37.5	11.8	7.1	1.08	.82	8.50	446
Mixture [b]		844	80.6	65	38.2	12.0	7.6	1.09	.83	8.10	465
A × D		832	85.4	70	39.2	11.8	7.6	1.05	.81	8.74	444
Acala 28		809	80.4	62	38.4	12.2	7.6	1.08	.83	8.00	471
Acala 44		775	83.2	62	38.0	13.3	8.1	1.07	.84	8.43	467
Acala 4–42		767	82.7	65	38.8	12.5	7.9	1.07	.83	8.99	434
Acala 1517 RB		761	82.5	63	36.8	12.9	7.5	1.08	.85	8.82	445
Acala P18–C		760	84.9	61	39.1	12.3	7.8	1.07	.82	7.10	469
Average		802	82.5	64	38.2	12.3	7.6	1.07	.83	8.33	455
L. S. D. at 5-percent level			4.8	2	.8	.3	.2			0.23	16
L. S. D. at 1-percent level			6.5	3	1.1	.4	.3			.31	21

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[b] One-third each Acala 28, Acala 33, and Acala 44.

TABLE 9.—*American-Egyptian spacing-variety experiment No. 51–1, Sacaton, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	7	**71, 594	**150. 1	*190	**1. 82	0. 07	*0. 12	*0. 0008	0. 0016	0. 08	**1, 674
Varieties	7	**35, 792	**92. 1	**505	**10. 45	**3. 19	**. 71	**. 0064	**. 0133	**. 46	**3, 498
Rows	7	7, 228	*39. 5	111	. 20	. 14	. 06	*. 0007	. 0019	. 03	330
Columns	7	9, 724	**145. 5	**303	**1. 24	. 21	. 08	**. 0012	. 0010	**. 20	340
Error	35	4, 371	13. 6	63	. 26	. 15	. 05	. 0003	. 0009	. 04	266

MEAN VALUES

Spacing:											
4 inches		635	31.8	167	28.4	13.3	5.3	1.47	1.12	9.44	494
8 inches		636	30.2	158	28.3	13.5	5.3	1.46	1.15	9.54	498
12 inches		601	28.7	163	28.1	13.4	5.2	1.44	1.12	9.45	500
16 inches		543	28.2	169	27.9	13.5	5.2	1.45	1.15	9.56	505
20 inches		482	24.2	170	27.5	13.4	5.1	1.47	1.16	9.74	508
24 inches		497	23.6	167	27.7	13.4	5.1	1.45	1.13	9.56	509
28 inches		423	20.6	170	27.5	13.2	5.0	1.45	1.15	9.66	529
32 inches		387	20.6	174	26.9	13.5	5.0	1.46	1.15	9.56	519
Variety:											
Pima 32		609	22.8	170	27.1	13.2	4.9	1.40	1.06	9.61	514
5–17		593	30.7	167	27.6	13.5	5.1	1.50	1.13	9.41	529
Pima 46		543	22.3	165	27.8	12.9	5.0	1.45	1.15	9.75	512
Mixture [b]		537	26.1	161	27.9	13.1	5.1	1.45	1.16	9.46	510
3–79		535	25.6	182	30.3	13.2	5.7	1.43	1.13	9.38	492
27–9		533	26.4	174	26.8	13.2	4.8	1.48	1.13	9.43	535
16–59		536	31.0	158	26.7	14.9	5.4	1.47	1.16	10.07	470
Amsak		419	22.9	161	28.1	13.2	5.2	1.47	1.21	9.40	499
Average		526	26.0	167	27.8	13.4	5.2	1.46	1.14	9.56	508
L. S. D. at 5-percent level		68	3.8	8	.5	.4	.2	.02	.03	.19	16
L. S. D. at 1-percent level		91	5.2	11	.7	.5	.3	.03	.04	.26	22

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[b] One-half Pima 32, one-half Amsak.

TABLE 10.—*American-Egyptian spacing-variety experiment No. 51–2, Sacaton, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Varieties	3	59, 022	*536. 3	*580	**32. 25	**6. 34	**3. 26	**0. 0303	**0. 0451	**2. 62	**41, 151
Rows	3	38, 909	294. 7	110	. 34	*. 85	. 11	. 0033	. 0053	. 10	1, 442
Columns	3	12, 568	153. 2	354	*1. 14	. 72	. 17	. 0011	. 0009	. 23	1, 144
Error (a)	6	16, 809	106. 7	103	. 13	. 16	. 05	. 0019	. 0044	. 05	501
Spacings	3	**95, 357	**539. 6	149	*. 98	. 08	*. 12	. 0015	. 0004	. 04	553
V × S	9	5, 513	30. 4	**182	. 66	. 31	. 02	. 0012	. 0024	. 03	526
Error (b)	36	4, 505	56. 3	60	. 35	. 14	. 03	. 0006	. 0013	. 05	390

366691—56——5

MEAN VALUES

Spacing:											
4 inches		633	40.2	139	27.9	13.8	5.4	1.46	1.14	9.35	514
12 inches		586	54.2	133	28.2	13.8	5.4	1.44	1.13	9.40	508
20 inches		539	46.6	132	28.4	13.8	5.5	1.44	1.13	9.46	514
28 inches		452	44.8	135	28.5	13.9	5.5	1.44	1.14	9.47	516
Variety:											
5–17		631	46.9	137	27.8	13.6	5.3	1.50	1.14	9.57	533
Pima S1		556	42.9	129	30.4	13.8	6.0	1.40	1.15	8.95	504
Pima 32		540	54.4	142	27.4	13.2	5.0	1.42	1.06	9.89	533
13–40		483	41.6	131	27.4	14.7	5.6	1.46	1.19	9.26	481
Average		552	46.5	135	28.3	13.8	5.5	1.44	1.14	9.42	513
L. S. D. for spacings at 5-percent level		34	5.4				.1				
L. S. D. for spacings at 1-percent level		46	7.3								
L. S. D. for varieties at 5-percent level			8.9	9	.3	.3	.2	.04	.06	.20	19
L. S. D. for varieties at 1-percent level					.5	.5	.3	.06	.09	.30	29

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate signifiance at the 1-percent level.

TABLE 11.—*American-Egyptian spacing-variety experiment No. 51–3, Sacaton, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	3	**149, 020	**673. 6	150	**3. 78	0. 03	**0. 33	*0. 0021	0. 0012	*0. 13	**1, 403
Varieties	7	**145, 321	*111. 1	**6, 936	**25. 87	**4. 80	**2. 94	**. 0694	**. 0294	**. 32	**11, 432
Rows	7	10, 783	57. 8	123	. 61	. 17	. 04	. 0003	. 0012	. 07	326
Columns	7	**19, 409	81. 2	**507	. 61	**. 49	**. 10	**. 0032	**. 0039	. 09	361
Error	39	4, 804	37. 4	60	. 53	. 08	. 03	. 0007	. 0007	. 05	283

MEAN VALUES

Spacing:											
6 inches		631	43.7	155	29.4	13.3	5.5	1.37	1.08	9.39	456
14 inches		555	37.2	153	29.3	13.2	5.5	1.35	1.07	9.45	457
22 inches		492	32.8	155	28.7	13.3	5.3	1.37	1.09	9.61	469
30 inches		403	28.5	160	28.3	13.2	5.2	1.38	1.09	9.49	475
Variety:											
Hopi Acala 50		800	28.9	86	32.3	14.1	6.7	1.14	.96	9.76	376
Pima 32		622	33.4	171	28.4	12.8	5.0	1.39	1.03	9.48	504
14–29		523	34.1	170	29.4	13.1	5.5	1.41	1.11	9.32	480
7–42		510	35.7	169	29.2	12.3	5.0	1.40	1.14	9.46	469
10–84		461	37.8	148	26.0	13.6	4.8	1.35	1.07	9.17	478
3–76		438	38.0	178	29.6	12.4	5.2	1.40	1.12	9.51	478
16–55		431	34.8	164	29.0	13.4	5.5	1.42	1.13	9.45	466
16–59		378	41.5	160	27.5	14.4	5.5	1.43	1.12	9.75	463
Average		520	35.5	156	28.9	13.2	5.4	1.37	1.08	9.49	464
L. S. D. for spacings at 5-percent level		50	4.4		.5		.1	.02		.15	12
L. S. D. for spacings at 1-percent level		66	5.8		.7		.2	.03			16
L. S. D. for varieties at 5-percent level		70	6.2	8	.7	.3	.2	.03	.03	.22	17
L. S. D. for varieties at 1-percent level		94		10	1.0	.4	.2	.04	.04	.29	23

* 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

TABLE 12.—*Upland spacing-variety experiment No. 51–4a, Sacaton, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	7	**71, 650	*149. 0	**24	0. 59	0. 10	0. 06	0. 0005	**0. 0013	**0. 34	209
Varieties	7	**42, 957	**384. 1	**105	**6. 52	**1. 55	**. 84	**. 0021	*. 0008	**3. 67	**5, 034
Rows	7	**51, 646	**489. 6	**38	. 10	*. 25	*. 10	*. 0019	**. 0026	**. 15	117
Columns	7	*21, 048	55. 3	11	. 48	. 14	. 03	. 0004	**. 0018	**. 17	106
Error	35	8, 236	48. 6	7	. 40	. 08	. 04	. 0006	. 0003	. 05	124

MEAN VALUES

Spacing:											
2 inches		1,110	37.4	75	38.1	12.8	7.8	1.11	0.91	8.54	426
4 inches		1,128	41.2	72	37.3	13.0	7.7	1.12	.92	8.47	420
6 inches		1,045	47.1	71	37.7	12.7	7.6	1.11	.92	8.68	425
8 inches		1,052	45.1	70	37.4	12.7	7.6	1.09	.88	8.61	427
10 inches		913	48.4	70	37.7	12.7	7.7	1.11	.91	8.83	422
12 inches		913	50.3	72	37.6	12.7	7.6	1.11	.91	8.88	429
14 inches		894	49.0	69	37.6	12.7	7.6	1.11	.90	9.05	422
16 inches		945	44.5	71	37.2	12.6	7.5	1.10	.90	8.95	436
Variety:											
A × D		1,119	35.8	79	37.5	12.9	7.7	1.10	.91	9.08	393
Acala 28		1,095	37.7	68	37.8	12.8	7.7	1.11	.91	8.14	465
Mixture [b]		1,008	44.4	71	37.5	12.4	7.5	1.10	.91	8.55	450
Acala P18–C		1,000	44.4	67	38.7	12.6	7.9	1.09	.90	7.43	417
Acala 4–42		983	53.5	72	38.3	12.7	7.8	1.10	.91	9.34	398
Acala 44		944	48.2	69	38.1	13.1	8.0	1.10	.89	8.93	426
Acala 1517 RB		926	43.3	70	35.7	13.4	7.5	1.14	.93	9.33	416
Acala 33		925	55.7	73	37.0	12.0	7.0	1.12	.91	9.23	442
Average		1,000	45.4	71	37.6	12.7	7.6	1.11	.91	8.75	426
L. S. D. at 5-percent level		93	7.1	3	.6	.3	.2	.02	.02	.22	11
L. S. D. at 1-percent level		125	9.6	4	.9	.4	.3	.03	.02	.30	15

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[b] One-third each Acala 28, Acala 33, and Acala 44.

TABLE 13.—*Upland spacing-variety experiment No. 51–4b, Mesa, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Spacings	7	**41, 520	**44. 0	*26	0. 47	0. 08	0. 08	0. 0011	0. 0013	0. 13	336
Varieties	7	**31, 748	**124. 3	**61	**6. 05	**1. 91	**. 71	**. 0050	**. 0035	**3. 63	**2, 646
Rows	7	**39, 641	**45. 6	**83	*2. 62	*. 50	. 03	. 0009	. 0008	. 08	**624
Columns	7	15, 293	**109. 3	11	1. 97	**. 70	. 07	. 0013	. 0016	*. 18	*480
Error	35	8, 948	13. 6	11	. 87	. 21	. 07	. 0007	. 0010	. 06	182

MEAN VALUES

Spacing:											
2 inches		883	76. 9	76	37. 4	12. 8	7. 5	1. 07	0. 88	8. 80	427
4 inches		947	78. 8	73	37. 7	12. 8	7. 7	1. 06	. 87	8. 88	438
6 inches		971	79. 0	72	37. 7	13. 0	7. 7	1. 07	. 88	8. 92	420
8 inches		1, 073	81. 5	72	38. 1	12. 7	7. 7	1. 08	. 88	8. 82	433
10 inches		1, 045	82. 6	71	38. 0	12. 7	7. 4	1. 06	. 87	8. 64	438
12 inches		1, 063	82. 4	73	37. 9	12. 8	7. 7	1. 07	. 89	9. 07	437
14 inches		976	83. 9	72	37. 9	12. 7	7. 7	1. 07	. 89	8. 99	434
16 inches		1, 086	80. 9	71	38. 1	12. 7	7. 7	1. 09	. 91	8. 86	439
Variety:											
A × D		1, 088	80. 1	75	37. 9	12. 3	7. 5	1. 06	. 87	9. 29	404
Acala 28		1, 084	83. 5	73	39. 0	12. 7	7. 8	1. 08	. 89	8. 18	463
Mixture [b]		1, 037	81. 4	71	38. 0	12. 7	7. 6	1. 07	. 88	8. 78	441
Acala P18–C		1, 019	84. 7	67	38. 5	12. 6	7. 9	1. 04	. 86	7. 59	442
Acala 44		1, 001	84. 3	73	37. 7	13. 5	8. 0	1. 07	. 89	9. 05	436
Acala 1517 RB		947	73. 1	70	36. 4	13. 6	7. 6	1. 12	. 92	9. 50	436
Acala 4–42		937	81. 8	76	38. 5	12. 5	7. 7	1. 05	. 86	9. 49	413
Acala 33		932	77. 1	74	36. 8	12. 3	7. 0	1. 08	. 90	9. 11	432
Average		1, 006	80. 8	72	37. 8	12. 8	7. 6	1. 07	. 88	8. 87	433
L. S. D. at 5-percent level		97	3. 8	3	1. 0	. 5	. 3	. 03	. 03	. 24	14
L. S. D. at 1-percent level		130	5. 1	5	1. 3	. 6	. 4	. 04	. 04	. 33	18

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[b] One-third each Acala 28, Acala 33, and Acala 44.

TABLE 14.—*Upland spacing-variety experiment No. 51–5, Sacaton, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Varieties	3	*219, 286	193. 1	*127	*6. 92	*2. 74	**2. 91	0. 0011	0. 0078	**2. 39	**16, 999
Rows	3	15, 854	151. 4	47	3. 63	. 73	. 06	. 0012	. 0008	. 22	63
Columns	3	*299, 721	80. 0	*133	5. 36	. 28	*. 28	. 0021	. 0015	. 08	*1, 182
Error (a)	6	41, 289	66. 5	15	1. 33	. 54	. 05	. 0050	. 0017	. 18	227
Spacings	3	**84, 960	**1, 156. 6	*41	**5. 13	. 07	**. 81	. 0011	. 0007	**. 43	180
V × S	9	*23, 529	**62. 4	11	. 46	. 16	. 08	. 0012	. 0008	. 07	367
Error (b)	36	10, 132	18. 6	11	. 60	. 13	. 04	. 0008	. 0009	. 07	250

MEAN VALUES

Spacing:										
2 inches		1,296	48.6	73	38.9	12.7	8.1	1.11	0.86	7.80	472
6 inches		1,244	65.1	70	38.3	12.6	7.8	1.11	.86	8.04	471
10 inches		1,187	65.4	70	38.0	12.7	7.8	1.11	.86	8.10	474
14 inches		1,127	66.3	70	37.5	12.6	7.6	1.10	.85	8.18	476
Variety:										
A × D		1,342	59.2	75	37.9	12.9	7.9	1.11	.87	8.25	477
Acala 28		1,266	58.9	68	38.8	12.9	8.2	1.11	.88	7.45	448
Acala 33		1,176	66.4	71	37.4	12.0	7.2	1.10	.84	8.24	498
Acala 44		1,071	60.9	71	38.7	12.7	8.0	1.10	.84	8.17	471
Average		1,214	61.4	71	38.2	12.6	7.8	1.11	.86	8.03	473
L. S. D. for spacings at 5-percent level		72	3.1	2	.6		.1			.20	
L. S. D. for spacings at 1-percent level		97	4.2		.8		.2			.26	
L. S. D. for varieties at 5-percent level		176		3	1.0	.6	.2			.36	13
L. S. D. for varieties at 1-percent level							.3			.55	20

• 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

TABLE 15.—*American-Egyptian spacing-variety experiment No. 51–6a, Sacaton, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
							U. H. M.	Mean		
Source of variation:		*Pounds*	*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Dates	2	*46, 994	460	*12. 90	0. 01	*0. 88	0. 0105	0. 0166	0. 61	*2, 201
Replications	2	8, 583	800	1. 36	. 49	. 31	. 0001	. 0076	3. 54	*1, 926
Error (a)	4	3, 090	349	1. 00	. 51	. 11	. 0041	. 0116	. 71	250
Varieties	2	8, 470	**1, 535	**4. 04	**6. 50	**1. 78	**. 0603	**. 2430	**1. 90	**166, 446
V × D	4	5, 780	*224	. 32	. 40	. 13	. 0022	. 0011	. 28	1, 142
Error (b)	12	16, 080	61	. 42	. 40	. 06	. 0023	. 0052	. 24	1, 421
Spacings	3	**138, 370	**321	**4. 11	. 26	**. 15	. 0003	. 0012	**. 75	**5, 247
S × D	6	11, 440	86	**. 70	. 13	. 02	. 0009	. 0036	. 06	832
S × V	6	5, 561	71	. 40	. 08	. 04	. 0017	. 0040	**. 22	874
S × V × D	12	6, 534	27	. 10	. 12	. 02	. 0016	. 0030	. 05	659
Error (c)	54	6, 199	48	. 18	. 11	. 02	. 0013	. 0024	. 04	404

MEAN VALUES

Spacing:									
2 inches	448	148	29.2	12.9	5.3	1.42	1.07	9.25	508
6 inches	433	143	29.0	12.9	5.3	1.42	1.06	9.58	516
10 inches	365	140	28.5	13.1	5.2	1.42	1.08	9.54	521
16 inches	292	141	28.4	13.0	5.1	1.41	1.07	9.61	523
Variety:									
5–17	402	145	29.1	12.9	5.3	1.45	1.09	9.58	537
13–40	376	136	28.8	13.4	5.4	1.43	1.14	9.23	479
Pima 32	375	148	28.4	12.6	5.0	1.37	.98	9.67	534
Average	384	143	28.8	13.0	5.2	1.42	1.07	9.49	517
L. S. D. for spacings at 5-percent level	43	4	0.2	-------	.1	-------	-------	.13	10
L. S. D. for spacings at 1-percent level	57	5	.3	-------	.1	-------	-------	.17	15
L. S. D. for varieties at 5-percent level	-------	4	.3	.3	.1	.02	.04	.25	19
L. S. D. for varieties at 1-percent level	-------	6	.5	.5	.2	.03	.05	.35	27

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

TABLE 16.—*Upland spacing-variety experiment No. 51–6b, Sacaton, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
							U. H. M.	Mean		
Source of variation:		*Pounds*	*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Dates	2	192, 326	94	8. 84	2. 54	0. 04	0. 0462	0. 0274	1. 23	*7, 743
Replications	2	249, 725	304	1: 19	1. 85	*. 29	. 0138	. 0162	1. 81	776
Error (a)	4	229, 521	97	2. 91	. 53	. 03	. 0096	. 0112	1. 83	671
Varieties	2	**352, 626	**260	**8. 08	**20. 41	**10. 85	. 0006	. 0039	**2. 33	**14, 466
V × D	4	14, 789	6	. 08	. 46	. 12	. 0009	. 0008	. 40	143
Error (b)	12	27, 885	32	. 27	. 48	. 15	. 0014	. 0018	. 13	829
Spacings	3	**319, 490	**59	. 50	. 15	. 02	. 0016	*. 0021	**. 37	325
S × D	6	12, 822	4	. 17	. 03	. 02	. 0006	. 0010	. 07	233
S × V	6	30, 328	8	. 38	. 12	. 06	. 0005	. 0005	. 02	667
S × V × D	12	15, 756	5	. 03	. 10	. 05	. 0012	*. 0016	. 13	228
Error (c)	54	20, 551	9	. 29	. 12	. 05	. 0008	. 0007	. 08	337

MEAN VALUES

Spacing:										
2 inches		930	74	38.0	12.2	7.5	1.09	0.85	7.73	483
6 inches		865	72	37.8	12.3	7.5	1.10	.86	7.75	480
10 inches		768	71	38.1	12.2	7.5	1.08	.84	7.72	478
16 inches		682	70	38.1	12.2	7.5	1.09	.86	7.96	481
Variety:										
Acala 28		911	70	38.5	12.2	7.6	1.09	.85	7.50	492
Acala 44		809	70	38.0	13.0	8.0	1.10	.86	7.94	468
Acala 33		713	75	37.5	11.5	6.9	1.09	.84	7.93	481
Average		811	72	38.0	12.2	7.5	1.09	.85	7.79	480
L. S. D. for spacings at 5-percent level		78	2					.01	.15	
L. S. D. for spacings at 1-percent level		105	2						.20	
L. S. D. for varieties at 5-percent level		86	3	.3	.4	.2			.18	14
L. S. D. for varieties at 1-percent level		120	4	.3	.5	.3			.26	20

* 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

TABLE 17.—*Upland spacing-variety experiment No. 51–7, Sacaton, Ariz., 1951*

MEAN SQUARES [a]

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Varieties	11	**113, 744	**1, 876. 4	**488	**36. 04	**13. 07	**2. 89	**0. 0267	**0. 0190	**3. 85	**7, 967
Replications	2	**316, 386	*721. 7	**308	**2. 66	. 40	**. 87	**. 0118	**. 0143	. 09	553
Error (a)	22	23, 689	151. 7	15	. 28	. 17	. 06	. 0009	. 0005	. 07	418
Spacings	1	*100, 950	**197. 7	**323	**6. 61	. 23	**1. 31	**. 0068	. 0014	**1. 43	**4, 396
V × S	11	30, 330	**67. 7	16	*. 64	. 38	*. 14	. 0006	. 0009	. 04	*748
Error (b)	24	14, 301	17. 7	9	. 26	. 21	. 05	. 0005	. 0007	. 07	284

MEAN VALUES

Spacing:											
2 inches (unthinned)	-------	1,005	62.8	75	36.7	12.5	7.2	1.13	0.91	7.63	459
12 inches (thinned)	-------	930	66.1	71	37.3	12.6	7.4	1.11	.90	7.92	448
Variety:											
A × D	-------	1,218	40.4	72	37.8	12.9	7.8	1.11	.90	7.55	446
Acala 4–42	-------	1,084	57.4	67	38.9	12.3	7.9	1.12	.91	8.09	456
Acala 28	-------	1,054	46.1	67	39.0	12.2	7.7	1.14	.91	7.02	480
Acala 33	-------	1,051	68.9	72	38.2	11.7	7.2	1.09	.86	7.75	469
Acala 44	-------	1,045	65.4	69	38.6	13.0	8.2	1.12	.89	7.67	458
Deltapine Fox	-------	1,019	87.0	85	39.9	9.7	6.5	1.09	.85	7.25	451
Acala 29–16	-------	963	70.1	70	35.5	13.4	7.4	1.14	.93	7.79	459
Acala 1517C	-------	909	82.5	74	36.1	12.8	7.2	1.15	.92	8.60	488
Deltapine 15	-------	890	88.4	92	38.0	10.0	6.1	1.03	.82	7.34	417
Mesilla Acala	-------	839	78.7	72	33.6	13.9	7.0	1.28	1.03	8.67	483
Mebane Watson	-------	825	46.9	58	36.3	14.4	8.2	1.01	.83	6.29	406
Hopi Acala 50	-------	717	42.0	79	31.6	14.0	6.4	1.12	.95	9.26	431
Average	-------	967	64.5	73	37.0	12.5	7.3	1.12	.90	7.77	454
L. S. D. for spacings at 5-percent level	-------	58	2.1	1	.2	-------	.1	.01	-------	0.13	8
L. S. D. for spacings at 1-percent level	-------	-------	2.8	2	.3	-------	.1	.01	-------	.18	11
L. S. D. for varieties at 5-percent level	-------	184	14.7	5	.6	.5	.3	.04	.03	.32	25
L. S. D. for varieties at 1-percent level	-------	250	20.0	6	.9	.7	.4	.05	.04	.44	33

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

TABLE 18.—*American-Egyptian spacing-variety experiment No. 1, combined analyses, Sacaton, Ariz., 1950 and 1951*

MEAN SQUARES,[a] ANALYSIS A

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Years	1	**953, 753	**851. 8	**56, 827	**146. 85	0. 01	**9. 73	*0. 0067	0. 0001	**3. 23	**14, 280
Spacings	7	**96, 166	**384. 4	93	1. 63	. 17	. 08	. 0006	. 0017	. 06	1, 111
S × Y, Error (a)	7	5, 771	18. 9	**226	. 54	. 16	*. 09	. 0010	. 0011	. 04	451
Varieties	7	**63, 251	123. 1	497	**22. 81	**6. 70	**1. 84	**. 0130	**. 0277	**. 76	**6, 697
V × Y, Error (b)	7	4, 462	33. 6	**154	**2. 37	**. 49	*. 09	. 0007	. 0015	. 03	168
Rows in years	14	**17, 502	*39. 5	**108	. 26	*. 23	*. 08	. 0009	. 0016	. 02	471
Columns in years	14	7, 132	**88. 0	**200	**1. 13	*. 28	*. 08	**. 0021	**. 0032	**. 24	248
Error (c)	70	4, 991	20. 4	44	. 26	. 12	. 04	. 0006	. 0010	. 03	311

MEAN VALUES, ANALYSIS A

Spacing:											
4 inches		709	35. 5	150	29. 3	13. 3	5. 5	1. 45	1. 13	9. 28	485
8 inches		701	33. 0	143	29. 2	13. 4	5. 5	1. 46	1. 15	9. 39	487
12 inches		666	32. 1	144	29. 0	13. 3	5. 4	1. 45	1. 14	9. 37	492
16 inches		637	29. 2	145	28. 9	13. 4	5. 5	1. 44	1. 14	9. 40	498
20 inches		570	28. 1	148	28. 8	13. 3	5. 4	1. 46	1. 14	9. 50	504
24 inches		579	26. 2	144	28. 8	13. 3	5. 4	1. 44	1. 12	9. 42	500
28 inches		530	22. 1	146	28. 6	13. 4	5. 4	1. 45	1. 15	9. 45	508
32 inches		503	22. 2	148	28. 3	13. 6	5. 4	1. 45	1. 15	9. 42	504

Variety:											
5-17		686	32. 0	145	28. 8	13. 3	5. 4	1. 49	1. 14	9. 30	521
Pima 32		678	25. 8	150	28. 0	13. 2	5. 1	1. 40	1. 06	9. 48	508
3-79		647	30. 9	154	31. 7	13. 1	6. 1	1. 44	1. 14	9. 17	480
27-9		626	29. 5	152	28. 4	13. 1	5. 2	1. 47	1. 13	9. 27	518
Mixture [b]		608	27. 8	143	28. 5	13. 2	5. 3	1. 44	1. 15	9. 34	500
Pima 46		606	25. 4	144	29. 1	12. 7	5. 2	1. 44	1. 14	9. 54	502
16-59		524	31. 5	141	28. 0	14. 9	5. 8	1. 46	1. 15	9. 85	460
Amsak		519	25. 6	140	28. 6	13. 5	5. 4	1. 47	1. 22	9. 26	488
Average		612	28. 6	146	28. 9	13. 4	5. 4	1. 45	1. 14	9. 40	497
L. S. D. for spacings at 5-percent level		64	3. 6								
L. S. D. for spacings at 1-percent level		94	5. 4								
L. S. D. for varieties at 5-percent level		56			1. 3	. 6	. 2	. 02	. 03	. 15	11
L. S. D. for varieties at 1-percent level		83			1. 9	. 9	. 4	. 03	. 05	. 22	16

MEAN SQUARES,[a] ANALYSIS B

Source of variation:											
Years	1	**953, 753	**851. 8	**56, 827	**146. 85	0. 01	**9. 73	**0. 0067	0. 0001	**3. 23	**14, 280
Spacings	7	**96, 166	**384. 4	93	**1. 63	. 17	. 08	. 0006	. 0017	. 06	**1, 111
Varieties	7	**63, 251	**123. 1	**497	**22. 81	**6. 70	**1. 84	**. 0130	**. 0277	**. 76	**6, 697
V × S	49	5, 559	**44. 6	57	. 46	. 13	. 05	. 0008	. 0017	. 06	325
V × Y	7	4, 462	33. 6	154	**2. 37	*. 49	. 09	. 0007	. 0015	. 03	168
S × Y	7	5, 771	18. 9	*226	. 54	. 16	. 09	. 0010	. 0011	. 04	451
Error	49	8, 609	21. 0	94	. 30	. 18	. 05	. 0008	. 0012	. 06	326

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[b] One-half Pima 32, one-half Amsak.

TABLE 19.—*American-Egyptian spacing-variety experiment No. 3, combined analyses, Sacaton, Ariz., 1950 and 1951*

MEAN SQUARES,[a] ANALYSIS A

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
Source of variation:		*Pounds*		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Years	1	*238, 915	*312. 2	**32, 163	**22. 96	0. 26	**1. 97	0. 0013	0. 0053	**2. 52	118
Spacings	3	**298, 971	**1, 361. 8	179	*7. 04	. 05	*. 61	. 0002	. 0004	*. 41	*3, 103
S × Y, Error (a)	3	783	10. 4	39	. 47	. 04	. 03	**. 0025	. 0017	. 02	258
Varieties	7	117, 840	117. 9	**9, 150	26. 75	**11. 36	2. 60	**. 1370	**. 0497	**. 58	**14, 908
V × Y, Error (b)	7	**56, 329	*69. 3	**518	**9. 89	**. 40	**1. 04	. 0007	. 0014	. 05	1, 221
Rows in years	14	**20, 542	**81. 1	**122	*. 98	*. 22	*. 08	. 0005	. 0014	. 04	*501
Columns in years	14	**28, 740	**82. 3	**584	. 65	**. 63	**. 19	**. 0044	**. 0039	**. 28	*507
Error (c)	78	6, 205	29. 7	49	. 46	. 10	. 04	. 0006	. 0008	. 04	254

MEAN VALUES, ANALYSIS A

Spacing:											
6 inches		670	45. 5	140	29. 9	13. 3	5. 7	1. 37	1. 09	9. 22	452
14 inches		606	38. 7	137	29. 5	13. 3	5. 6	1. 36	1. 09	9. 30	460
22 inches		533	33. 5	140	29. 2	13. 3	5. 5	1. 37	1. 10	9. 49	466
30 inches		445	30. 6	143	28. 8	13. 2	5. 4	1. 37	1. 09	9. 37	475
Variety:											
Hopi Acala 50		724	34. 8	84	30. 8	14. 1	6. 3	1. 15	. 98	9. 53	395
Pima 32		643	33. 8	153	29. 0	12. 6	5. 1	1. 39	1. 05	9. 37	500
7–42		568	39. 1	152	29. 9	12. 4	5. 2	1. 40	1. 14	9. 40	476
16–55		561	36. 2	144	29. 9	13. 5	5. 8	1. 43	1. 14	9. 27	462
14–29		555	35. 1	152	29. 8	13. 1	5. 6	1. 41	1. 12	9. 14	479
10–84		513	37. 0	132	26. 8	13. 9	5. 1	1. 35	1. 07	9. 07	467

3–76		479	39. 0	157	30. 4	12. 3	5. 4	1. 39	1. 11	9. 33	471
16–59		464	41. 9	144	28. 3	14. 5	5. 7	1. 43	1. 13	9. 65	458
Average		564	37. 1	140	29. 3	13. 3	5. 5	1. 37	1. 09	9. 34	463
L. S. D. for spacings at 5-percent level		22	2. 6		. 5		. 1			. 11	13
L. S. D. for spacings at 1-percent level		41	4. 7								
L. S. D. for varieties at 5-percent level				19		. 5		. 02	. 03	. 18	29
L. S. D. for varieties at 1-percent level				28		. 8		. 03	. 05	. 27	43

MEAN SQUARES,[a] ANALYSIS B

Source of variation:											
Years	1	**238, 913	**312. 2	**32, 163	**22. 96	0. 26	**1. 97	0. 0013	0. 0053	**2. 52	118
Spacings	3	**298, 971	**1, 361. 8	179	**7. 04	. 05	**. 61	. 0002	. 0004	**. 41	**3, 103
Varieties	7	**117, 840	*117. 9	**9, 150	**26. 75	**11. 36	**2. 60	**. 1370	**. 0497	**. 58	**14, 908
V × S	21	10, 278	55. 3	182	. 91	. 16	. 07	. 0009	. 0014	. 10	279
V × Y	7	**56, 329	69. 3	**518	**9. 89	*. 40	**1. 04	. 0007	. 0014	. 05	**1, 221
S × Y	3	783	10. 4	39	. 47	. 04	. 03	. 0025	. 0017	. 02	258
V × S × Y, Error (a)	21	11, 921	36. 6	90	. 46	. 13	. 06	. 0015	. 0017	. 05	238
Within V × S × Y, Error (b)	64	11, 058	41. 8	124	. 46	. 22	. 06	. 0010	. 0011	. 07	360

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

TABLE 20.—*Upland spacing-variety experiment No. 4, combined analyses, Sacaton and Mesa, Ariz., 1950 and 1951*

MEAN SQUARES,[a] ANALYSIS A

Source of variation, spacing interval, or variety	Degrees of freedom	Lint per acre	Percentage of crop in first picking	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness
								U. H. M.	Mean		
		Pounds		*Number*				*Inches*	*Inches*		*Mm.²/mm.³*
Source of variation:											
Experiments [b]	3	**1,597,446	**28,349.3	**1,164	**7.34	**5.10	**3.03	**0.0176	**0.0736	**14.25	**10,056
Spacings	7	52,321	**431.3	**69	.49	.05	.04	.0004	.0004	*.39	218
S × E, Error (a)	21	**45,906	39.2	8	.74	*.20	.08	.0010	*.0012	*.12	232
Varieties	7	**91,046	442.4	**280	**16.72	**5.57	**2.91	**.0051	.0027	**13.46	**8,725
V × E, Error (b)	21	*19,410	**191.9	**21	**1.33	**.43	.07	.0012	.0011	.07	**761
Rows in experiments	28	**47,955	**223.7	**40	**1.19	**.43	*.10	**.0015	**.0016	*.08	**368
Columns in experiments	28	**55,828	**66.8	**14	**1.32	**.36	.07	**.0014	**.0019	**.20	237
Error (c)	140	10,703	26.0	7	.61	.12	.06	.0007	.0007	.05	182

MEAN VALUES, ANALYSIS A

Spacing:											
2 inches		1,050	55.0	72	38.1	12.6	7.8	1.09	0.87	8.33	440
4 inches		1,045	61.8	69	38.1	12.7	7.8	1.08	.87	8.32	441
6 inches		1,002	64.5	68	37.9	12.7	7.7	1.08	.87	8.44	434
8 inches		1,032	64.6	68	37.8	12.7	7.7	1.09	.87	8.38	438
10 inches		980	65.9	67	38.1	12.7	7.7	1.08	.87	8.40	440
12 inches		978	65.9	68	38.0	12.8	7.8	1.09	.87	8.54	440
14 inches		937	65.6	66	38.1	12.7	7.8	1.08	.86	8.62	438
16 inches		967	64.2	67	37.8	12.8	7.7	1.08	.88	8.55	443
Variety:											
A × D		1,094	59.1	74	38.2	12.5	7.7	1.08	.86	8.81	417
Acala 28		1,059	59.0	66	38.3	12.7	7.8	1.09	.88	7.92	465

Mixture [c]		1,012	63.0	68	38.1	12.5	7.7	1.09	.87	8.26	452
Acala 33		996	66.0	70	37.2	12.1	7.1	1.09	.87	8.74	445
Acala P18–C		970	65.1	64	38.8	12.6	8.0	1.07	.86	7.15	443
Acala 44		957	66.8	67	38.2	13.2	8.1	1.08	.87	8.62	444
Acala 1517 RB		956	60.0	66	36.6	13.4	7.7	1.11	.89	9.00	431
Acala 4–42		948	68.5	70	38.5	12.6	7.9	1.08	.87	9.08	418
Average		999	63.4	68	38.0	12.7	7.8	1.09	.87	8.45	439
L. S. D. for spacings at 5-percent level			3.2	1						.18	
L. S. D. for spacings at 1-percent level			4.4	2							
L. S. D. for varieties at 5-percent level		72		2	.6	.3	.1	.02		.14	14
L. S. D. for varieties at 1-percent level		99		3	.8	.5	.2	.02		.19	20

MEAN SQUARES,[a] ANALYSIS B

Source of variation:											
Experiments [b]	3	**1,597,446	**28,349.3	**1,164	**7.34	**5.10	**3.03	**0.0176	**0.0736	**14.25	**10,056
Spacings	7	*52,321	**431.3	**68	.49	.05	.04	.0004	.0004	**.39	218
Varieties	7	**91,046	**442.4	**280	**16.72	**5.57	**2.91	**.0051	*.0027	**13.46	**8,725
V × S	49	24,780	56.6	14	.80	*.27	.06	.0009	.0010	.07	205
V × E	21	19,410	**191.9	*21	*1.33	**.43	.07	.0012	.0011	.07	**761
S × E	21	**45,906	39.2	8	.74	.20	.08	.0010	.0012	.12	232
Error	147	21,701	61.2	12	.79	.18	.07	.0009	.0010	.08	221

[a] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[b] 2 locations × 2 years.
[c] One-third each Acala 28, Acala 33, and Acala 44.

TABLE 21.—*Coefficients of variation for 11 characteristics in 14 individual experiments and 3 combined experiments, Sacaton and Mesa, Ariz., 1950–51*

Experiment No.	Lint per acre	Percentage of crop in first picking[1]	Bolls per pound	Lint percentage	Seed index	Lint index	Fiber length		Fiber strength index	Fiber fineness	Brush weight
							U. H. M.	Mean			
Individual experiments:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
50–1	10.7	16.7	4.0	1.7	2.3	3.2	1.9	3.1	1.6	3.9	----
50–2	10.7	10.5	4.2	1.8	2.6	3.8	1.3	2.5	2.3	2.6	----
50–3	14.3	12.1	5.0	2.0	2.7	4.1	1.6	2.6	2.2	3.2	----
50–4a	10.9	9.8	3.8	1.9	2.3	3.5	2.4	2.8	3.1	3.2	----
50–4b	11.7	5.8	3.1	2.1	2.7	2.6	2.6	3.9	2.6	3.5	----
51–1	12.5	14.2	4.8	1.8	2.8	4.2	1.3	2.5	2.0	3.1	16.5
51–2	12.1	15.9	5.7	2.1	2.7	3.1	1.7	3.2	2.3	3.9	31.9
51–3	13.3	17.2	4.9	2.5	2.1	3.0	1.9	2.5	2.2	3.7	13.3
51–4a	9.1	15.4	3.8	1.7	2.3	2.8	2.2	1.9	2.5	2.6	15.8
51–4b	9.3	4.5	4.6	2.4	3.5	3.4	2.4	3.5	2.6	3.0	----
51–5	8.3	7.0	4.6	2.0	2.9	2.6	2.5	3.5	3.2	3.4	11.7
51–6a	20.6	M	4.8	1.5	2.5	3.1	2.5	4.6	2.1	3.9	----
51–6b	17.6	M	4.2	1.4	2.9	2.9	2.6	3.1	3.6	3.8	----
51–7	12.4	6.4	4.2	1.4	3.7	3.0	2.0	2.9	3.3	3.7	----
Average	12.4	11.3	4.4	1.9	2.7	3.2	2.1	3.0	2.5	3.4	17.8
Combined experiments (1950–1951):											
1 (50–1 and 51–1)	11.6	15.7	4.6	1.8	2.6	3.7	1.7	2.8	1.8	3.6	----
3 (50–3 and 51–3)	14.0	14.8	5.0	2.3	2.4	3.5	1.8	2.6	2.2	3.5	----
4 (50–4a, 50–4b, 51–4a, and 51–4b)	10.3	8.0	4.0	2.1	2.8	3.1	2.4	3.0	2.7	3.2	----

[1] "M" indicates that data were not taken.

In the Upland experiments, lint index appeared to be little affected by spacing.

Fiber Length

Fiber length was not affected by spacing.

Fiber Strength

Somewhat weaker fiber was produced at close spacing in 8 of the experiments (table 2), and in no experiment did close spacing result in stronger fiber.

Maximum strength of American-Egyptian cotton occurred at spacing of 20 to 28 inches. In the Upland series, also, greatest strength occurred in the upper spacing range, namely, 12 to 16 inches.

A significant interaction between spacings and varieties appeared only in experiment 51–6a (table 15).

Fiber Fineness

The American-Egyptians proved to be somewhat sensitive to spacing with respect to fineness. In 2 experiments close spacing resulted in slightly coarser fiber, and in no instance did it induce significantly finer fiber (table 2). Only 1 Upland experiment revealed an effect of spacing on fiber fineness. In that experiment, 51–7, the fiber from plants spaced 2 inches apart proved to be finer (table 17).

Spinning Performance

In the spinning test, made on lint samples of 4 Upland varieties grown at 4 spacing intervals in experiment 51–5, yarn strength increased as spacing interval lengthened (table 22). This result is in agreement with the trend observed in that experiment in respect to raw fiber strength (table 14). Other effects are not so clear, but yarn appearance was significantly better for the cotton from plants spaced 14 inches apart.

Brush Weight

In the 5 experiments in which brush was weighed, close spacing resulted in greater production of brush (table 23). Brush weight averaged from 2,914 to 3,562 pounds per acre in the 3 American-Egyptian experiments and 3,185 and 5,408 pounds per acre in the 2 Upland experiments.

In these particular experiments, brush production varied with spacing in much the same manner as lint yield.

TABLE 22.—*Spinning properties of carded yarns, Upland spacing-variety experiment No. 51–5, Sacaton, Ariz., 1951*

MEAN SQUARES [1]

Source of variation, spacing interval, or variety	Degrees of freedom	Yarn skein strength			Yarn appearance [2]	Neps in 100 square inches of card web	Picker and card waste
		22s	36s	50s			
Source of variation:		*Pounds*	*Pounds*	*Pounds*	*Grade*	*Number*	*Percent*
Spacings	3	**73. 6	*23. 5	**7. 4	*1. 34	3. 0	**0. 40
Varieties	3	*53. 4	*16. 6	*5. 0	. 87	4. 7	**. 31
Error	9	8. 3	4. 1	1. 0	. 27	2. 9	. 01

MEAN VALUES

Spacing:							
2 inches		112. 4	62. 6	40. 4	7. 6	14	6. 22
4 inches		116. 5	64. 4	41. 1	7. 4	13	5. 53
10 inches		118. 5	66. 9	42. 3	7. 4	13	5. 88
14 inches		122. 7	68. 0	43. 4	6. 3	13	6. 18
Variety:							
Acala 33		122. 8	68. 3	43. 4	7. 4	15	5. 97
A × D		116. 6	65. 7	41. 6	6. 5	13	5. 68
Acala 44		116. 3	64. 2	40. 8	7. 5	12	6. 33
Acala 28		114. 4	63. 8	41. 3	7. 4	13	5. 84
Average		117. 5	65. 5	41. 8	7. 2	13	5. 95
L. S. D. at 5-percent level		4. 6	3. 2	1. 6	. 8		. 56
L. S. D. at 1-percent level		6. 6		2. 4			. 81

[1] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[2] Lower values indicate better appearance.

TABLE 23.—*Brush weight per acre in 3 American-Egyptian and 2 Upland experiments, Sacaton, Ariz., 1951*

AMERICAN-EGYPTIAN

Experiment 51–1			Experiment 51–2			Experiment 51–3		
Source of variation, spacing interval, or variety	D. F.	Mean squares [1] or mean values	Source of variation, spacing interval, or variety	D. F.	Mean squares [1] or mean values	Source of variation, spacing interval, or variety	D. F.	Mean squares [1] or mean values
Source of variation:			Source of variation:			Source of variation:		
Spacings	7	**1, 308, 653	Varieties	3	1, 412, 516	Spacings	3	**2, 534, 395
Varieties	7	*718, 246	Rows	3	1, 541, 558	Varieties	7	*461, 796
Rows	7	463, 803	Columns	3	*5, 823, 460	Rows	7	**493, 910
Columns	7	347, 698	Error (a)	6	643, 792	Columns	7	**777, 997
Error	35	300, 762	Spacings	3	**6, 542, 744	Error	39	151, 169
			V × S	9	874, 475			
			Error (b)	36	1, 290, 894			
		Pounds	Spacing:		*Pounds*	Spacing:		*Pounds*
Spacing:			4 inches		4, 417	6 inches		3, 403
4 inches		3, 781	12 inches		3, 681	14 inches		3, 024
8 inches		3, 682	20 inches		3, 031	22 inches		2, 762
12 inches		3, 682	28 inches		3, 116	30 inches		2, 466
16 inches		3, 386						
20 inches		3, 156						
24 inches		3, 222						
28 inches		2, 992						
32 inches		2, 597						
Variety:			Variety:			Variety:		
Mixture [2]		3, 583	13–40		3, 835	Pima 32		3, 287
Amsak		3, 518	Pima S1		3, 801	Hopi Acala 50		3, 189
5–17		3, 518	Pima 32		3, 322	7–42		2, 893
Pima 32		3, 518	5–17		3, 288	14–29		2, 893
Pima 46		3, 419				16–55		2, 893
27–9		3, 222				10–84		2, 827
16–59		2, 860				3–76		2, 827

See footnotes at end of table, p. 55.

TABLE 23.—*Brush weight per acre in 3 American-Egyptian and 2 Upland experiments, Sacaton, Ariz., 1951*—Continued

AMERICAN-EGYPTIAN—Continued

Experiment 51–1			Experiment 51–2			Experiment 51–3		
Source of variation, spacing interval, or variety	D. F.	Mean squares [1] or mean values	Source of variation, spacing interval, or variety	D. F.	Mean squares [1] or mean values	Source of variation, spacing interval, or variety	D. F.	Mean squares [1] or mean values
Variety—Continued			Variety—Continued			Variety—Continued		
3–79	------	2, 860				16–59	------	2, 499
Average	------	3, 312	----------	------	3, 562	----------	------	2, 914
L. S. D. for spacings at 5-percent level	------	560	----------	------	820	----------	------	278
L. S. D. for spacings at 1-percent level	------	754	----------	------	1, 105	----------	------	372
L. S. D. for varieties at 5-percent level	------	560	----------	------	----------	----------	------	393
L. S. D. for varieties at 1-percent level	------	----------	----------	------	----------	----------	------	----------

UPLAND

Experiment 51–4			Experiment 51–5		
Source of variation, spacing interval, or variety	D. F.	Mean squares [1] or mean values	Source of variation, spacing interval, or variety	D. F.	Mean squares [1] or mean values
Source of variation:			Source of variation:		
Spacings	7	**1, 251, 063	Varieties	3	*10, 458, 929
Varieties	7	**924, 981	Rows	3	**20, 592, 188
Rows	7	**880, 515	Columns	3	*9, 519, 384

Columns	7	*811, 788	Error (a)	6	1, 206, 134
Error	35	254, 448	Spacings	3	**3, 772, 593
			V × S	9	610, 993
			Error (b)	36	400, 364
Spacing:		*Pounds*	Spacing:		*Pounds*
2 inches	------	3, 748	2 inches	------	6, 098
4 inches	------	3, 748	6 inches	------	5, 391
6 inches	------	3, 255	10 inches	------	5, 030
8 inches	------	3, 222	14 inches	------	5, 112
10 inches	------	2, 992			
12 inches	------	2, 794			
14 inches	------	2, 696			
16 inches	------	3, 024			
Variety:			Variety:		
A × D	------	3, 551	Acala 28	------	6, 115
Acala 4–42	------	3, 550	A × D	------	6, 033
Acala 28	------	3, 485	Acala 33	------	5, 046
Acala 1517 RB	------	3, 288	Acala 44	------	4, 438
Acala P18–C	------	3, 123			
Mixture [3]	------	2, 992			
Acala 44	------	2, 827			
Acala 33	------	2, 663			
Average	------	3, 185		------	5, 408
L. S. D. for spacings at 5-percent level	------	515		------	454
L. S. D. for spacings at 1-percent level	------	694		------	608
L. S. D. for varieties at 5-percent level	------	515		------	672
L. S. D. for varieties at 1-percent level	------	694		------	------

[1] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.
[2] One-half Pima 32, one-half Amsak.
[3] One-third each Acala 28, Acala 33, and Acala 44.

DISCUSSION

The present study emphasizes the difficulties encountered in trying to evaluate the effects of a cultural practice such as spacing on a long-season crop such as cotton. Nevertheless the overall results for all experiments, as summarized in table 2 and illustrated in figure 3, reveal certain trends.

The closest spacing interval gave higher yield than the widest or the two widest in almost all experiments, but in no instance was it possible to demonstrate statistically that the closest spacing interval resulted in higher yield than the next closest. As a rule, a spacing difference of at least 10 inches was required to produce a statistically significant yield difference in a given experiment. Nevertheless, in many of the experiments an almost perfect yield-spacing relationship was observed. This relationship is illustrated in figure 3.

Three yield components that were determined in the present study were (1) number of bolls per unit area, (2) number of seeds per boll, and (3) weight of lint per seed. Mensural data were obtained on weight of lint per seed and on weight of individual seeds and bolls. Number of seeds per boll was derived from averages of weight per boll, weight of lint per seed, and weight of individual seeds. These averages were based on data from small plot samples, whereas lint yield averages were based on the weight of all the cotton. Nevertheless, the error variances of each of the components indicate that the estimates based on samples are reasonably accurate. Number of bolls per unit area (B) was derived from averages of lint yield per acre (Y), number of seeds per boll (S), and weight of lint per seed (L) by applying the equation $B=\frac{Y}{S\times L}$.

Average values for these three yield components according to spacing are graphically presented in figure 4. It appears evident that the 12.9-percent advantage of the American-Egyptian yield and the 9.5-percent advantage of the Upland yield associated with close spacing (table 2) can be attributed mainly to greater production of bolls per unit area.

Differences existed between varieties with respect to each of the three yield components determined. The high yielding varieties were not all high in the same components. For example, in American-Egyptian experiment 50–1 (table 4) the high yield of Pima 32 evidently was derived from its high boll production, that of variety 3–79 from high weight of lint per seed, and that of variety 5–17 from both high number of bolls per unit area and high number of seeds per boll. A similar situation existed in Upland experiment 50–4a (table 7), in which A × D, the highest yielding variety, was not the highest in all yield components.

In the present study the Upland cotton displayed little difference in earliness between the 6-inch and the 16-inch spacing, differing in that respect from the American-Egyptian. Somewhat different results were obtained in a previous experiment with Acala 44 Upland cotton in which spacing covered a wider range. In that experiment, percentage of the crop taken in the first picking decreased through the entire range of the spacing intervals, as follows: 3.5 inches, 38 percent; 12

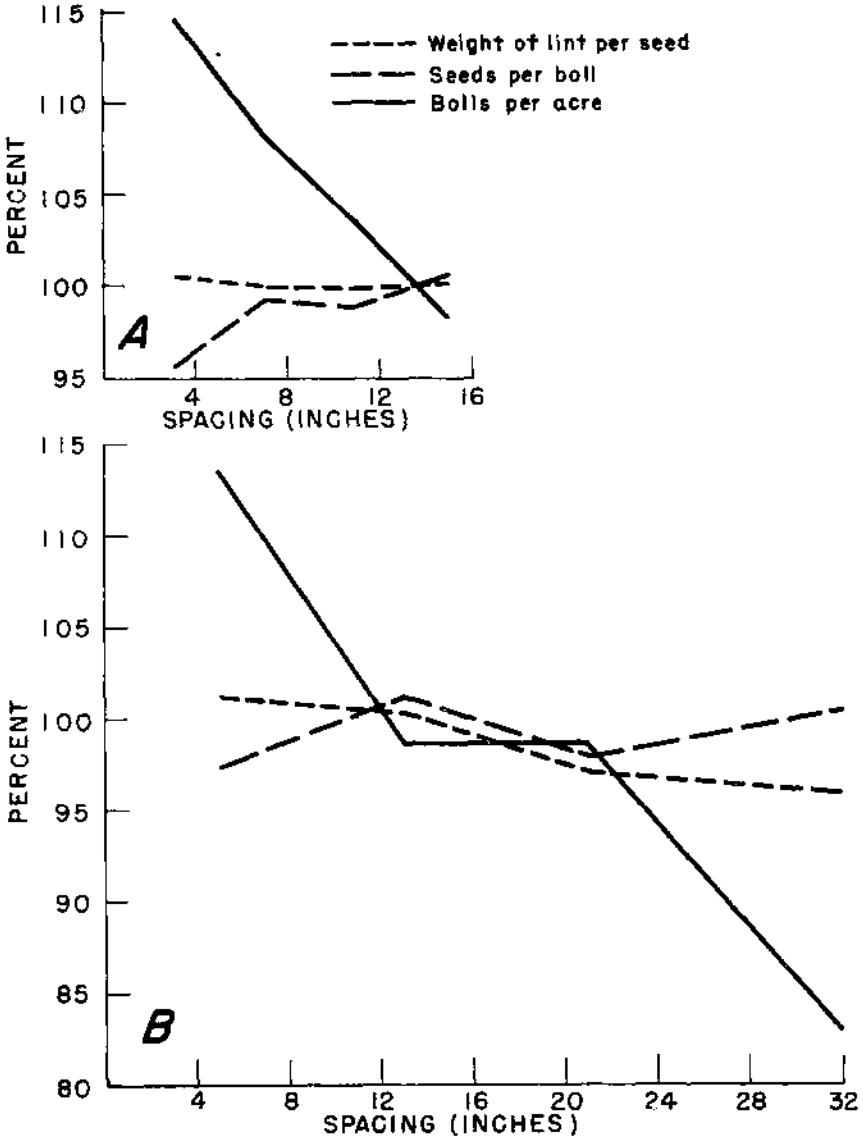

FIGURE 4.—Effect of spacing on 3 components of yield in (*A*) the Upland and (*B*) the American-Egyptian experiments. For each component, average values are expressed as percentages of that obtained with 12- to 16-inch spacing.

inches, 36 percent; 24 inches, 28 percent; 42 inches, 25 percent. Although the present study indicates a different earliness-spacing response on the part of the Upland and American-Egyptian types of cotton, one cannot but wonder how much of the divergence may be due to the dissimilarity of the spacing intervals that were employed to test the two types.

Close spacing exerts two opposite influences on crop maturity. On close spaced plants only a few fruiting branches develop beyond the first node, with the result that the crop consists largely of bolls located in the immediate region of the axis, or main stalk. On plants having few-noded fruiting branches the crop matures early, because the interval of flower appearance is much shorter between first nodes of successive fruiting branches than between successive nodes on a particular fruiting branch. On the other hand, in closely spaced cotton low fruiting branches usually do not develop and the first boll, consequently, appears higher on the plant and later, a circumstance that retards maturity of the crop. Furthermore, extremely close spacing forces the first boll to appear so high on the plant that yield is appreciably reduced. An experiment with Pima 32 American-Egyptian cotton on the Sacaton station's seed farm, where the soil is Mohave sandy loam, illustrates this situation. In the unthinned plots, with an average spacing interval of 4.5 inches, few bolls were produced on the lower half of the plants and scarcely any on the lower third. Yields for the unthinned plots averaged only 391 pounds of lint per acre, whereas the 12-inch and 24-inch spacings produced at the rates of 445 and 467 pounds, respectively.

Close spacing suppresses development of the monopodial branches or limbs. Since limbs are secondary to the main stalk of the plant, their fruiting branches develop later. Consequently the crop produced on limbs matures somewhat later than that on the main stalk. Cook (*8*) observed that--

> thick spacing restricts the formation of vegetative branches and effects a substitution of several small single-stalk plants for one of the large plants with spreading side stalks. The smaller individual plants growing on their own roots have advantages over the side stalks of the large plants in maturing larger crops of bolls early in the season . . .

Cook's comments refer mainly to rain-grown cotton, but the effects of close spacing on the conformation of the cotton plant are essentially the same under irrigation.

Closely spaced cotton casts a dense shadow and shades the ground to such an extent that the surface remains damp for a long time after irrigation, although the more numerous plants actually withdraw a little more moisture from beneath the surface of the soil. This differential shading occurs from the time the plants are large enough to cast an appreciable shadow until sometime in July, when even normally spaced plants attain sufficient size to shade the ground effectively. The implications of early shading are not understood, except for the beneficial effect of suppressing weeds. Even such troublesome shade-tolerant weeds as those the farmer calls "water grasses" are less numerous and more easily controlled in dense stands of cotton. The weeds of this type most common in Arizona cotton-fields are *Leptochloa filiformis* (Lam.) Beauv., *Echinochloa colonum* (L.) Link, and *E. crusgalli* (L.) Beauv. Shading has no suppressive effect on Johnson grass (*Sorghum halepense* (L.) Pers.) or the purple morning-glory (*Ipomoea hirsutula* Jacq. f.).

One of the important findings in this project was the absence of any deleterious effect of close spacing on fiber length. This should reassure growers and merchants that closely spaced irrigated cotton will not be marketed at a discount because of inferiority in staple length. A

deficiency in fiber strength amounting to about 1 percent in the American-Egyptian experiments and about 3 percent in the Uplands was observed in closely spaced cotton. Such a deficiency is not to be regarded lightly, but from the standpoint of the grower it seems to be more than offset by the relatively large gain in yield.

Previous investigators have often noted the advantages of close spacing. Certain objectionable features should also be mentioned. Changes in the growth habit of cotton induced by density of population can result in lateness and even loss in production. Under some conditions the plants in dense stands of irrigated cotton become tall, topheavy, and disposed to lodge. The exclusion of sunlight from rank, badly lodged cotton invites boll rotting, and the tangle of stems and foliage interferes with chemical defoliation and mechanical harvesting. These unfavorable aspects of close spacing should be considered, along with yield, in determining the best spacing for a particular situation.

This study has established a spacing of 4 to 6 inches as the optimum interval between plants for the Sacaton experiment station. Optimum spacing is the spacing that gives the highest yield obtainable without the deleterious side effects mentioned above. It may or may not coincide with the spacing that produces the highest absolute yield, depending on circumstances. Optimum spacing deserves priority over the simple goal of spacing for maximum yield. It is suggested that farmers growing cotton under irrigation make an effort to determine the spacing best adapted to their particular farms and cultural practices.

SUMMARY

Fourteen spacing experiments with Upland and American-Egyptian cotton were conducted under irrigation at Sacaton and Mesa, Ariz., in 1950 and 1951. Effects of within-row spacing of plants were determined for each of these types of cotton with respect to yield, earliness, boll weight, lint percentage, seed index, lint index, fiber length, fiber strength, and fiber fineness. Each experiment included 3 to 12 varieties, and the data were analyzed for varietal differences as well as for effects of spacing. Summarized data and analyses are tabulated.

Yield.—Close spacing of 2 to 6 inches, versus wide spacing of 12 to 16 inches, increased lint yield by 9.5 and 12.9 percent, respectively, in the Upland and American-Egyptian series of experiments. Analysis of three yield components indicates that the yield advantage associated with close spacing was primarily a matter of greater boll production.

Earliness.—In the American-Egyptian experiments, earliness was nearly 15 percent greater at the 6-inch than at 12- to 16-inch spacing, but at the 4-inch spacing it was less than 5 percent above the mean for the 12- to 16-inch range. In the Upland experiments, crop maturity was greatly retarded at the 2-inch and 4-inch intervals but varied little among spacings of 6 to 16 inches.

Boll weight.—Boll weight varied with spacing in the Upland experiments, declining regularly as interval lessened. In both the American-Egyptian and the Upland experiments the sharpest decrease occurred when the plants were spaced closer than 6 inches.

Lint percentage.—In 5 of the American-Egyptian experiments lint percentage declined as interval increased, but the average advantage for close spacing amounted to only 0.5 percent. No relation between spacing and lint percentage was detected in the Upland series.

Seed index.—Spacing did not materially affect seed index in either type of cotton.

Lint index.—Lint index followed the same trend as lint percentage.

Fiber length.—Fiber length was not affected by spacing.

Fiber strength.—Weaker fiber was associated with close spacing in 8 of the 14 experiments. The mean deficiency induced by close spacing amounted to about 1 percent and 3 percent, respectively, in the American-Egyptian and Upland series of experiments.

Fiber fineness.—Spacing had no effect on fineness of fiber in the Upland series, with the exception of one experiment in which greater fineness was associated with close spacing. A tendency toward slight coarsening of fiber was observed in closely spaced American-Egyptian cotton.

Yarn strength.—Skein strength diminished with decrease in spacing in an Upland cotton experiment.

Brush weight.—Greater production of brush was associated with close spacing.

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