COMPARATIVE EFFECTS of Mechanical Picking Spindles and Handpicking on Cotton Quality and Spinning Performance in Mississippi, 1960–63

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SUMMARY AND CONCLUSIONS

Studies were conducted in the Mississippi Delta in 1960, 1961, and 1963 to evaluate the effects of handpicking and of various types of picker spindles used in mechanical picking on the quality and spinning performance of cotton. Mechanical harvesters were equipped with 9/16-inch tapered barbed, 1/4-inch straight barbed, and 3/16-inch straight smooth picker spindles.

Enough seed cotton was harvested from high-yielding fields of a standard variety of cotton to provide lint for four 300-pound replications the first 2 years and for five 300-pound replications the last year of the study. The cotton harvested by each of the four methods was ginned in a commercial gin that had moderate overhead cleaning equipment and two stages of lint cleaning.

Grade of lint harvested by use of all three types of spindles was about the same, but because of higher content of foreign matter, spindle-picked cotton averaged almost one grade lower than handpicked cotton. Neither classers' call of staple length, fibrograph measurements, nor fiber length distribution were significantly affected by the type of picker spindles used in mechanical harvesting. However, lint from handpicked cotton was less uniform in length than that from the mechanically picked cottons. This was evident in the coefficient of length variation, uniformity ratio, and proportion of short fibers. Short fibers were more abundant in handpicked cotton than in spindle-picked cotton, probably because hand harvesters tended to pick more immature locks and partly opened bolls than did the machines.

The 3-year average fiber strength of handpicked cotton measured with the zero gage was lower than that of spindle-picked cotton. However, when measured with the 1/8-inch gage, this average was higher than that of spindle-picked cotton. Thus, there appears to be little real difference in fiber strength of lint picked by hand or by any of the three types of spindles.

Lint from handpicked cotton had less foreign matter than that from any of the three spindle-picked cottons. The differences in amount of foreign matter in lint from the three spindle-picked cottons were small. Differences in fiber fineness of lint from the three spindle-picked cottons also were small. Handpicked lint had a lower 3-year average Micronaire reading than spindle-picked lint. Again, this difference was probably due to the selective harvesting by mechanical pickers.

The lower content of foreign matter in handpicked lint than in machine-picked lint was reflected in lower picker and card waste in manufacturing. Except in strength and ends down, there was very little difference in spinning performance among handpicked and machine-picked cottons or among cottons picked by any of the spindle types.

Yarn strength expressed in average break factor was highest in cotton harvested by the 1/4-inch spindle. The difference in break factors between yarn spun from cotton picked by this spindle and that spun from cotton picked by the 9/16-inch spindle or by hand was highly significant. However, the highest average ends-down count was also associated with the 1/4-inch spindle. Yarn breakage during spinning was higher at the 10-percent significance level for cotton harvested by the 9/16-inch tapered and the 1/4-inch straight spindles than for cotton harvested by hand or by the 9/16-inch straight spindle. At the 5-percent significance level, difference in ends down between lints harvested by only the 1/4- and the 3/16-inch spindles was significant. At the 1-percent significance level, differences in ends down among lints harvested by all three types of spindles were not significant.

In some respects, lint from handpicked cotton may be superior to that from machine-picked cotton, but the differences are small and of no consequence compared to the economic advantages of havesting cotton by use of machinery. In addition, differences among lints harvested by the different types of spindles are somewhat erratic and are not consistent. Other considerations such as durability and serviceability of the harvesters are probably more important than differences in lint harvested by the various types of spindles.

Comparative Effects of Mechanical Picking Spindles and Handpicking on Cotton Quality and Spinning Performance in Mississippi, 1960–63

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INTRODUCTION

During the past two decades, the production, harvesting, and ginning of cotton have undergone revolutionary changes. Much research has been done on problems associated with reducing costs of producing and harvesting cotton and of maintaining its quality during harvesting and ginning. One of the most important cost-cutting practices that has been developed is the mechanical harvesting of cotton. Twenty years ago, only a small percentage of the crop was harvested mechanically. At present, more than 70 percent of the cotton grown in the United States is harvested in this manner. In some States nearly all cotton is harvested mechanically.

Early research in mechanized cotton harvesting dealt almost entirely with mechanical efficiency and with the effects on cotton quality as measured by grade and staple. This was expanded to include fiber testing and small-scale spinning tests to measure the effects on yarn appearance and strength. More recently, comparisons between handpicking and machine harvesting by spindle pickers have been made a part of pilot plant, or large-scale, study of the effects of various ginning practices on fiber quality and spinning performance.

In two of these pilot-plant spinning studies, handpicked and machine-picked lots of a single well-adapted variety of cotton grown in the Midsouth were ginned for comparison by the two extreme gin treatments in three replications.

In one of these studies, the spinning samples were ginned in a commercial gin (*8*).[1] Ginning consisted of various combinations of high and low lint moisture; moderate and elaborate overhead cleaning; and zero, one, and two stages of lint cleaning. The handpicked lots were ginned with the moderate overhead setup, no lint cleaning, and high moisture; and with the elaborate overhead setup, two lint cleaners, and low moisture.

In this experiment, quality of lint was about one-half grade higher in handpicked cotton than in machine-picked cotton. There was little or no difference in staple. When processed through the same gin setup, fiber properties were practically no different in hand- and machine-picked cottons. Nep counts were low and were about the same for all combinations of machinery through which the cotton was passed. There was also very little difference in break factor or in yarn appearance. Manufacturing waste was higher for machine-picked cotton than for handpicked cotton. Ends-down counts were also higher for machine-picked cotton in all comparisons. However, the ends-down counts were extremely low for 30s yarn spun from both handpicked and machine-picked cottons and were moderately low for 40s yarn.

[1] Italicized numbers in parentheses refer to Selected References at the end of this publication. The list contains some of the other publications issued by the U.S. Department of Agriculture on studies related to the research reported in this publication.

In the other large-scale spinning tests, machine-picked cotton was processed through three levels of overhead cleaning, three levels of lint moisture, and three stages of lint cleaning. Handpicked lots were ginned in three replications by the two extreme methods, consisting of the simple overhead setup, in combination with high lint moisture, and no lint cleaning; and by the elaborate overhead setup, with low lint moisture, and two stages of lint cleaning. These cottons were ginned in an experimental gin (*4*).

The processing of spinning samples was similar to that described in the first study, except that 40s and 50s yarn counts were spun. Comparison of yarns spun from machine-harvested and hand-harvested cottons resulted in about the same conclusions as those derived from the first test, except for ends-down counts. Machine-picked cotton had lower counts than handpicked cotton in both comparisons involving the elaborate overhead setup. The overall average ends-down counts were higher for the handpicked lots than for the machine-picked lots in comparable gin treatment.

All machine-picked cotton used in the foregoing tests was harvested by machines equipped with the same type of spindle, and a comparison of the effects of various types of spindles with that of handpicking could yield useful information.

OBJECTIVES AND METHODS

This study was made to determine through pilot spinning-plant tests the effects of handpicking and three types of spindle picking (mechanical picking) on fiber properties and spinning performance of cotton. After measuring fiber properties and spinning performance, the data were analyzed statistically and comparisons were made among the four methods of harvest.

One of the following types of spindles was installed in each of several currently available makes of mechanical cotton harvesters: The $\frac{5}{16}$-inch tapered barbed spindle, with three equally spaced straight rows of barbs running lengthwise of the picking surface; the $\frac{1}{4}$-inch straight barbed spindle, with only one row of barbs running lengthwise of the picking surface; and the $\frac{3}{16}$-inch straight smooth spindle, with no barbs on its picking surface. These three types of spindles are the ones used most commonly in the Midsouth.

Prior to harvesting, all machines were inspected, were properly serviced and adjusted, and were put in good mechanical condition. Uniform, high-yielding fields of mature cotton were selected for harvesting. In 1960 and 1961, four replications of Stoneville 7, a standard Delta variety, were harvested; in 1963 five replications of an improved selection (Stoneville 7–A), of the same variety, were harvested. The field layout was a randomized block design.

Plots were large enough to provide 300 pounds of ginned lint for the spinning tests. All samples got the same gin treatment. Ginning equipment consisted of a tower drier, one six-cylinder cleaner, a stick machine, extractor feeders, and gin stands followed by two saw-cylinder lint cleaners in tandem.

CONDITION OF SEED COTTON

The test cotton was picked from high-yielding, chemically defoliated fields. Consequently, foreign-matter content of seed cotton was low in all 3 years (table 1 in the Appendix). In the 1960 and 1963 experiments, the weight of foreign matter averaged more in handpicked cotton than in machine-picked cotton. For the 3 years combined, the percent of foreign matter in wagon samples was higher in handpicked cotton than in machine-picked cotton, and it was more variable from year to year than in machine-picked cotton. Burs in seed cotton vary greatly in amount with the condition of the bolls when picking is done by hand but vary only slightly when harvesting is done by machine. There was practically no difference in foreign matter between methods of harvest after the seed cotton had been cleaned and dried.

Moisture content of seed cotton, both before and after drying, was higher in 1960 than in the other 2 years. In mechanical harvesting, mois-

ture is normally added to seed cotton as an aid to doffing the spindles. Consequently, machine-picked cotton often has a higher moisture content than handpicked cotton. However, in this test, there was very little difference in moisture content of cotton picked by either type spindle or by hand. As a result of controlled drying of seed cotton in the gin, the average moisture content of lint ranged only from 4.5 percent to 4.9 percent among the four methods of harvest.

GRADE AND STAPLE

Research has shown that, on the average, grade of machine-picked cotton is usually lower than that of handpicked cotton. However, if the plants are well defoliated at time of harvest and the field is free of excessive grass and weeds, lint obtained from machine-picked cotton may be as good in grade as that from handpicked cotton. This would result if the seed cotton were relatively free of green leaves or other extraneous material.

In 1960, the grade of lint obtained from handpicked cotton used in these tests was only slightly better than that from machine-picked cotton (table 2). In 1961, the handpicked cotton averaged one and one-half grades better than machine-picked cotton but less than one grade better in 1963. As a result, the average grade index for all 3 years was about one grade better for the lint of handpicked cotton. The grade of lint from cotton picked by the three types of spindles was approximately the same for all 3 years.

As a rule, staple length was not affected by method of harvest or by the type of spindle used in mechanical harvesters. Any difference in fiber distribution, or in average length, resulting from method of harvest or in the type of picker spindle was not discernible to the cotton classers.

FIBER LENGTH MEASUREMENTS

Fiber length measurements were made by mechanical sorting (Suter-Webb Sorter [2] array) and electronic scanning (Fibrograph).

Upper quartile length (determined by the array method) and upper-half mean length (determined by the Fibrograph method) correlate closely with the classers' staple length designation. In 1960, there appeared to be no significant differences in upper quartile length for the different methods of harvest (table 3). However, in 1961, differences among the values were significant and ranged from 1.250 inches for lint picked by the ¼-inch spindle to 1.278 inches for that picked by the $\frac{9}{16}$-inch spindle. This difference is almost the equivalent of one thirty-second of an inch in staple length. In 1963 differences were significant but were of less magnitude. Comparison of the 3-year means also indicates that at the 5-percent significance level, the upper quartile length of lint harvested by the ¼-inch spindle is significantly less than that harvested by the other two types of spindles.

In contrast to the upper quartile length, there is practically no difference in upper-half mean fiber length as measured by the Fibrograph (table 4). Only in 1960 were any of the values significantly different. The differences among values were not significant for either of the other years or for the 3-year averages. This indicates that very little importance can be attached to the significant differences in upper quartile length.

Another indication of the effects of the various harvests on fiber length and length distribution is the mean length of all fibers computed from the fiber array (table 5). There were no significant differences among mean lengths at the 10-percent level in 1961, but at this same level some differences were indicated in 1960 and 1963 and at the 5-percent level in the overall averages. More explicitly, at the 5-percent level the mean length of cotton harvested by hand can be distinquished from that harvested by the ¼-inch spindle, but that harvested by the three types of spindles cannot be separated, even at the 10-percent level of significance.

In 1961, when mean fiber lengths were not significantly different, the lint in cotton harvested by the ¼-inch spindle had the lowest value. However, when the averages of all 3 years are

[2] Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee or warranty and does not signify that the product is approved to the exclusion of other comparable products.

arranged in ascending order, lint picked by hand had the lowest mean fiber length and that picked by the ¼-inch spindle had the highest. This contrasts with upper quartile length, which showed that lint picked by the ¼-inch spindle was lowest in value.

Indications of the length uniformity of lint are given by coefficients of length variation (array) and uniformity ratios (Fibrograph). The coefficient of length variation from the Suter-Webb Sorter array is the standard error of the mean length divided by the mean length and expressed as a percentage. Therefore, low coefficients mean more uniform fiber length. The uniformity ratio obtained from the Fibrograph is the ratio of the mean length to the upper half mean expressed as a percentage. Therefore, the higher ratios mean more uniform fiber length. High uniformity in fiber length is desirable because this usually means less fiber breakage in ginning or in some other stage of processing.

The mean coefficient of variation of fiber length of handpicked cotton was significantly higher than that picked by all spindles in 1960 and for all years combined (table 6). The lowest coefficient of variation of fiber length was in cotton picked by the ¼-inch spindle in 1960 and in the 3-year average. However, the means for all three types of spindles were not significantly different. This is probably due to some selectivity in the cotton that had been picked by machine compared to that picked by hand. As a rule, the hand harvesters pick more of the immature, or partly opened bolls, than do the machines. This results in more weak, wasty, and immature fibers in handpicked cotton.

Uniformity ratio (Fibrograph) was not affected significantly by different methods of harvest except in 1963 (table 7). In 1963 the highest uniformity ratio, indicating more uniform fiber length, occurred in fiber picked by the $\frac{9}{16}$-inch spindle. The highest uniformity ratio for the 3-year average also was in fiber picked by the $\frac{9}{16}$-inch spindle. However, the differences were not significant even at the 10-percent significance level.

Another indication of fiber damage, or breakage, is the percentage of fibers shorter than one-half inch. Excessive short fibers cause increased yarn breakage in spinning. Breakage adds to processing costs, and it may also lower yarn quality.

In this study, the percent of short fibers (shorter than one-half inch) was higher in handpicked cotton than in machine-picked cotton in 1960 and 1963, and in the overall averages (table 8). The differences were significant in 1960 and in all years combined. However, there appeared to be little difference between means for different types of spindles. Because all lots of cotton were ginned alike, the higher percent of short fibers in a handpicked cotton is probably due to more selective picking by the machines. As has been mentioned earlier, hand harvesters tend to pick more immature locks and bolls not fully opened than do the machines. From this standpoint, therefore, cotton harvested by machine is likely to be of better quality than that picked by hand.

Other fiber measurements that give some indication of fiber-length uniformity are the percentage of fibers by weight that are one-half inch to 1 inch in length and those that are longer than 1 inch. Handpicked cotton had the highest percent of fibers one-half inch to 1 inch in length (table 9).

Handpicked cotton had a high percentage of fibers shorter than one-half inch and in lengths ranging from one-half inch to 1 inch. This would necessarily give handpicked cotton a lower percentage of fibers in lengths longer than 1 inch than occur in machine-picked cotton (table 10). On the average, this difference is about 2 percent in favor of machine-picked cotton, and it is highly significant. The differences among means for fibers longer than 1 inch for the three types of spindles are not significant.

In general, it appears that the differences in fiber length and in length distribution of lint harvested by the three different types of spindles are of little importance. The differences between handpicked and machine-picked cotton appear to be due to the selective action of the mechanical picker. These differences occur in the cotton that is actually being harvested and are not due to any breakage during harvest.

FIBER STRENGTH

Strength of fibers is measured by the Pressley strength test in which two gages are used—the zero gage and the ⅛-inch gage. Results obtained by use of the zero gage are expressed in thousand pounds per square inch; those by the ⅛-inch gage, in grams per tex.

Differences in 3-year average breaking strength of fibers in handpicked cotton and in those of cotton picked by the three spindles were not significant when measured by the zero gage, even at the 10-percent significance level (table 11). However, when measured by the ⅛-inch gage, fibers of handpicked cotton were stronger than those of cotton picked by the 3/16-inch spindle at both the 10- and 5-percent significance levels. Measurements by the ⅛-inch gage also showed there were significant interactions among methods of harvest and the year of harvest, indicating that the effects from year to year were not the same.

Because the overall averages for handpicked cotton were lowest when measured by the zero gage and highest when measured by the ⅛-inch gage, there appears to be little real difference in fiber strength among cottons picked by hand and by any of the three types of mechanical picker spindles.

FOREIGN MATTER IN LINT

Previous research has shown that lint of machine-picked cotton generally contains more foreign matter than the lint of handpicked cotton. However, under some conditions this is not true. In the 1960 picker-spindle test, the nonlint content of ginned lint from handpicked cotton was practically the same as that of cotton picked by the three types of spindles (table 12). In 1961 and 1963 and in the 3-year averages, the nonlint content of ginned lint from cotton picked by hand was significantly lower than that from cotton picked by the three types of picker spindles. In addition, at the 10- and 5-percent significance levels, foreign matter in lint ginned from cotton picked by the ¼-inch spindle appears to be higher than that in lint picked by the 3/16-inch spindle. These differences are small, but they are significant.

FIBER FINENESS

The actual fineness of a fiber should not be affected by method of harvest. However, if in one method of harvest more immature locks or bolls are picked than in another method, the average fineness of the fibers could be affected. In 1960 and 1963, fineness of lint was lower in cotton picked by hand than in cotton picked by any of the three types of spindles (table 13). In 1961 fineness of lint in handpicked cotton also averaged lower than it did in cotton picked by the ¼- and 5/16-inch picker spindles. Average fiber fineness for all 3 years was lower at the 1-percent significance level in cotton picked by hand than it was in cotton picked by any of the three types of picker spindles. The lower fineness of handpicked cotton could affect processing performance.

PROCESSING PERFORMANCE

There are many possible criteria for assessing the processing performance of cotton. The most important among these are manufacturing waste, neppiness, yarn strength, yarn appearance, and yarn breakage during spinning.

Manufacturing Waste

Foreign matter in lint is reflected as picker and card waste in manufaeturing. In 1960 the differences between means of total picker and card waste were not significant (table 14). However, in 1961 and 1963 and in the 3-year averages, the differences were highly significant. There was very little difference in amount of waste in cotton picked by the three types of spindles, but hand-harvested cotton had significantly lower processing waste. These results parallel those for foreign matter in ginned lint shown previously in table 12.

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Neps in Card Web

This and other tests indicate that method of harvest has little influence on neps in card web. Although the differences in mean nep count were significant in 1960, all counts were low (table 15). Differences were not significant in 1961 or 1963. The lowest overall average nep count occurred in handpicked cotton, but for all methods, the count ranged from 17.3 to 19.3 per hundred square inches of card web.

Yarn Properties

Some differences in yarn appearance were associated with the method of harvest. However, the differences in the 3-year average yarn appearance index were not significant even at the 10-percent significance level (table 16).

Differences in mean break factor were not significant in 1960 and 1961, but they were significant at the 10-percent significance level in 1963 (table 17). Differences in the 3-year average break factors were significant at the 1-percent level. Highest 3-year average break factor occurred in yarn spun from cotton picked by the ¼-inch spindle; the lowest, in that picked by the 5/16-inch tapered spindle. At all levels of significance, the mean break factor was significantly higher in yarn spun from cotton picked by the ¼-inch spindle than in yarn from cotton picked by the 5/16-inch spindle or in that picked by hand. The magnitudes of the differences were relatively small, but there seems to be some indication that break factor is affected by the type of spindle used in mechanical harvesters.

Yarn Breakage

The cost and quality of yarn and of the fabric made from it can be adversely affected by yarn breakage, or ends down, in spinning. The average ends-down count of yarn spun from cotton harvested by hand and by the 3/16-inch spindle was lower than that of lint harvested by the 5/16- and ¼-inch spindles in all 3 years of the study (table 18).

At the 10-percent level of significance, the 3-year average ends-down counts were greater in yarn spun from lint that had been harvested by the 5/16- and ¼-inch spindles than in lint harvested by the 3/16-inch straight smooth spindle or by hand. At the 5-percent level, ends down were greater in yarn spun from lint harvested by the ¼-inch spindle than in lint harvested by the 3/16-inch spindle. At the 1-percent level, differences in ends down were not significant among yarn spun from lints picked by any of the three types of spindles. It should be pointed out that the higher ends-down counts occurred in spinning cotton that had been harvested by the ¼-inch straight spindle, even though this cotton also produced the highest yarn break factor.

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APPENDIX

TABLE 1.—*Foreign matter and moisture content of seed cotton harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked				Machine-picked with spindle type—											
					9/16-in. tapered barbed				1/4-in. straight barbed				3/16-in. straight smooth			
	Foreign matter		Moisture content		Foreign matter		Moisture content		Foreign matter		Moisture content		Foreign matter		Moisture content	
	Wagon sample	Feeder sample	Wagon sample	Feeder sample	Wagon sample	Feeder sample	Wagon sample	Feeder sample	Wagon sample	Feeder sample	Wagon sample	Feeder sample	Wagon sample	Feeder sample	Wagon sample	Feeder sample
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1960	6.1	2.4	12.4	10.5	4.6	1.6	10.1	9.9	4.6	1.9	10.4	8.7	3.1	1.5	10.3	9.5
1961	1.9	.8	8.2	8.4	5.1	2.2	9.7	8.1	5.2	2.5	9.7	9.3	3.4	2.0	8.8	8.4
1963	7.5	1.5	6.7	6.7	4.8	1.4	8.5	7.2	3.7	1.3	8.2	7.2	3.7	1.3	8.6	7.5
Average	5.2	1.6	9.1	8.5	4.8	1.7	9.4	8.4	4.5	1.9	9.4	8.4	3.4	1.6	9.2	8.5

TABLE 2.—*Grade and staple of ginned lint harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked		Machine-picked with spindle type—					
			9/16-in. tapered barbed		1/4-in. straight barbed		3/16-in. straight smooth	
	Grade [1]	Staple	Grade [1]	Staple	Grade [1]	Staple	Grade [1]	Staple
	Index	*32ds in.*	*Index*	*32ds in.*	*Index*	*32ds in.*	*Index*	*32ds in.*
1960	94.8	34.2	94.0	34.2	94.0	34.5	94.0	34.2
1961	100.0	35.0	91.8	35.0	90.6	35.0	91.8	35.0
1963	99.8	36.1	94.2	36.1	93.5	36.1	94.0	36.1
Average	98.2	35.1	93.3	35.1	92.7	35.2	93.3	35.1

[1] Grade index: SLM=94; M=100

TABLE 3.—*Upper quartile length of ginned lint harvested by stated methods in the Mississippi Delta, 1960–63*

[Length by the array method]

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	Machine-picked using spindle type— 1/4-inch straight barbed (3)	Machine-picked using spindle type— 3/16-inch straight smooth (4)	Significant treatment differences [1]
	Inches	*Inches*	*Inches*	*Inches*	
1960	1.245	1.235	1.242	1.240	NS
1961	1.265	1.278	1.250	1.272	2, 4, 1>3
1963	1.270	1.274	1.270	1.276	4>1, 3
Average	1.260	1.262	1.254	1.263	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(3)	(1)	(2)	(4)
	Inches	*Inches*	*Inches*	*Inches*
10 percent	1.254	1.260	1.262	1.263
5 percent	1.254	1.260	1.262	1.263
1 percent	1.254	1.260	1.262	1.263

[1] Based on Duncan's multiple range test at the 10-percent level of siguificance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 4.—*Upper half mean length of ginned lint harvested by stated methods in the Mississippi Delta, 1960–63*

[Length by Fibrograph]

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	Machine-picked using spindle type— 1/4-inch straight barbed (3)	Machine-picked using spindle type— 3/16-inch straight smooth (4)	Significant treatment differences [1]
	Inches	*Inches*	*Inches*	*Inches*	
1960	1.110	1.120	1.128	1.118	3>1
1961	1.110	1.110	1.110	1.125	NS
1963	1.130	1.128	1.132	1.130	NS
Average	1.117	1.119	1.123	1.124	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(2)	(3)	(4)
	Inches	*Inches*	*Inches*	*Inches*
10 percent	1.117	1.119	1.123	1.124

[1] Based on Duncan's multiple rauge test at the 10-percent level of significance for individual years.' NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 5.—*Mean length of ginned lint harvested by stated methods in the Mississippi Delta, 1960–63*

[Length by the array method]

Season	Handpicked (1)	Machine-picked using spindle type—			Significant treatment differences [1]
		9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	
	Inches	*Inches*	*Inches*	*Inches*	
1960	0.995	1.008	1.030	1.010	3>1
1961	1.042	1.050	1.040	1.052	NS
1963	1.022	1.030	1.032	1.030	3>1
Average	1.020	1.029	1.034	1.031	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(2)	(4)	(3)
	Inches	*Inches*	*Inches*	*Inches*
10 percent	1.020	1.029	1.031	1.034
5 percent	1.020	1.029	1.031	1.034
1 percent	1.020	1.029	1.031	1.034

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 6.—*Coefficient of variation in fiber length of cotton harvested by stated methods in the Mississippi Delta, 1960–63*

[Length by array method]

Season	Handpicked (1)	Machine-picked using spindle type—			Significant treatment differences [1]
		9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	
	Pct.	*Pct.*	*Pct.*	*Pct.*	
1960	33.8	31.0	30.0	31.0	1>2, 3, 4
1961	30.5	30.5	29.5	29.2	NS
1963	32.0	31.8	32.2	32.2	1>2
Average	32.3	31.1	30.6	30.8	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(3)	(4)	(2)	(1)
	Pct.	*Pct.*	*Pct.*	*Pct.*
10 percent	30.6	30.8	31.1	32.3
5 percent [3]	30.6	30.8	31.1	32.3
1 percent	30.6	30.8	31.1	32.3

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

[3] *F* ratio for treatment × years interaction is significant at the 5-percent significance level.

TABLE 7.—*Fiber length uniformity ratio of ginned lint harvested by stated methods in the Mississippi Delta, 1960–63*

[Length by Fibrograph]

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	Pct.	*Pct.*	*Pct.*	*Pct.*	
1960	80.8	80.5	80.5	80.8	NS
1961	79.2	79.2	79.0	78.8	NS
1963	74.2	76.0	75.0	74.8	2>1, 4
Average	78.1	78.6	78.2	78.1	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(4)	(3)	(2)
	Pct.	*Pct.*	*Pct.*	*Pct.*
10 percent	78.1	78.1	78.2	78.6

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 8.—*Fibers shorter than ½ inch in cotton picked by stated methods in the Mississippi Delta, 1960–63*

[Length by the array method]

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straigbt barbed (3)	3/16-inch straigbt smooth (4)	Significant treatment differences [1]
	Pct.	*Pct.*	*Pct.*	*Pct.*	
1960	11.65	9.68	8.65	9.60	1>2, 4, 3; 2>3
1961	8.68	8.75	8.50	7.95	NS
1963	10.68	10.12	10.44	10.40	1>2
Average	10.34	9.52	9.20	9.32	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(3)	(4)	(2)	(1)
	Pct.	*Pct.*	*Pct.*	*Pct.*
10 percent	9.20	9.32	9.52	10.34
5 percent	9.20	9.32	9.52	10.34
1 percent [3]	9.20	9.32	9.52	10.34

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

[3] *F* ratio for treatment × years interaction is significant at the 1-percent level of significance.

TABLE 9.—*Fibers ½ inch to 1 inch long in lint harvested by stated methods in the Mississippi Delta, 1960–63*

[Length by the array method]

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	Pct.	*Pct.*	*Pct.*	*Pct.*	
1960	28.28	27.58	26.32	27.70	NS
1961	25.20	23.42	24.70	23.45	1>2
1963	25.32	24.62	24.08	24.04	1>3, 4
Average	26.27	25.21	25.03	25.06	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(3)	(4)	(2)	(1)
	Pct.	*Pct.*	*Pct.*	*Pct.*
10 percent	25.03	25.06	25.21	26.27
5 percent	25.03	25.06	25.21	26.27
1 percent	25.03	25.06	25.21	26.27

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 10.—*Fibers longer than 1 inch in lint harvested by stated methods in the Mississippi Delta, 1960–63*

[Length by the array method]

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	Pct.	*Pct.*	*Pct.*	*Pct.*	
1960	60.08	62.75	65.00	62.60	3>1
1961	66.12	67.78	66.82	68.60	4>1
1963	64.00	65.22	65.42	65.46	NS
Average	63.40	65.25	65.77	65.55	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(2)	(4)	(3)
	Pct.	*Pct.*	*Pct.*	*Pct.*
10 percent	63.40	65.25	65.55	65.77
5 percent	63.40	65.25	65.55	65.77
1 percent	63.40	65.25	65.55	65.77

[1] Based on Ducan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 11.—*Fiber strength of ginned lint harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked (1)		Machine-picked using spindle type— 9/16-inch tapered barbed (2)		1/4-inch straight barbed (3)		3/16-inch straight smooth (4)		Significant treatment differences[1]	
	Zero gage	1/8-in. gage	Zero gage	1/8-in. gage	Zero gage	1/8-in. gage	Zero gage	1/8-in. gage	Zero gage	1/8-in. gage
	M p.s.i.	*Grams per tex*	*M p.s.i.*	*Grams per tex*	*M p.s.i.*	*Grams per tex*	*M p.s.i.*	*Grams per tex*		
1960	78.5	19.99	81.0	19.45	79.5	19.58	79.0	18.97	2>1, 4	1>2, 4; 3>4
1961	82.2	23.50	83.2	23.25	84.5	23.20	83.2	23.38	NS	NS
1963	86.2	21.36	85.4	21.54	85.6	21.48	85.8	21.58	NS	NS
Average	82.3	21.65	83.2	21.41	83.2	21.42	82.7	21.31	See data below.	

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order[2]

Significance level	Methods of harvest are shown in columns opposite the zero and 1/8-inch gages			
Zero gage:	(1)	(4)	(2)	(3)
10 percent	82.3	82.7	83.2	83.2
1/8-inch gage:	(4)	(2)	(3)	(1)
10 percent	21.31	21.41	21.42	21.65
5 percent[3]	21.31	21.41	21.42	21.65
1 percent	21.31	21.41	21.42	21.65

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

[3] *F* ratio for treatment × years interaction is significant at the 5-percent significance level.

TABLE 12.—*Foreign matter in ginned lint harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	Pct.	*Pct.*	*Pct.*	*Pct.*	
1960	2.52	2.68	2.65	2.52	NS
1961	2.23	3.48	3.79	3.48	2, 3, 4>1
1963	1.91	2.74	2.64	2.34	2, 3>4>1
Average	2.22	2.97	3.03	2.78	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(4)	(2)	(3)
	Pct.	*Pct.*	*Pct.*	*Pct.*
10 percent	2.22	2.78	2.97	3.03
5 percent	2.22	2.78	2.97	3.03
1 percent	2.22	2.78	2.97	3.03

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 13.—*Fiber fineness of ginned lint of cotton harvested by stated methods in the Mississippi Delta, 1960–63*

[Fineness measured by Micronaire]

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	μg./in.	*μg./in.*	*μg./in.*	*μg./in.*	
1960	4.78	4.98	5.08	5.00	2, 3, 4>1
1961	3.98	4.05	4.12	3.95	3>1, 4
1963	4.34	4.50	4.42	4.42	2>3; 4>1
Average	4.37	4.51	4.54	4.46	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(4)	(2)	(3)
	μg./in.	*μg./in.*	*μg./in.*	*μg./in.*
10 percent	4.37	4.46	4.51	4.54
5 percent	4.37	4.46	4.51	4.54
1 percent [3]	4.37	4.46	4.51	4.54

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

[3] *F* ratio for treatment × years interaction is significant at the 1-percent significance level.

TABLE 14.—*Picker and card waste in lint of cotton harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked (1)	Machine-picked using spindle type—			Significant treatment differences [1]
		9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	
	Pct.	*Pct.*	*Pct.*	*Pct.*	
1960	7.75	7.66	7.53	7.55	NS
1961	5.76	7.37	7.08	6.75	2, 3, 4>1; 2>4
1963	4.18	4.92	4.94	4.68	2, 3>4>1
Average	5.90	6.65	6.52	6.33	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(4)	(3)	(2)
	Pct.	*Pct.*	*Pct.*	*Pct.*
10 percent	5.90	6.33	6.52	6.65
5 percent	5.90	6.33	6.52	6.65
1 percent [3]	5.90	6.33	6.52	6.65

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

[3] *F* ratio for treatment × years interaction is significant at the 1-percent significance level.

TABLE 15.—*Neps per hundred square inches of card web in lint harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	Number	*Number*	*Number*	*Number*	
1960	7	10	8	9	2>3, 1
1961	26	28	27	26	NS
1963	19	20	20	19	NS
Average	17.3	19.3	18.3	18.0	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(4)	(3)	(2)
	Number	*Number*	*Number*	*Number*
10 percent	17.3	18.0	18.3	19.3
5 percent	17.3	18.0	18.3	19.3
1 percent	17.3	18.0	18.3	19.3

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 16.—*Appearance index of yarn spun from cotton harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	Index	*Index*	*Index*	*Index*	
1960	104	108	106	109	4>1, 3; 3, 2>1
1961	80	72	72	72	NS
1963	105	102	102	103	NS
Average	96	94	93	94	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(3)	(2)	(4)	(1)
	Index	*Index*	*Index*	*Index*
10 percent	93	94	94	96

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 17.—*Break factor of yarn spun from cotton harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	Index	*Index*	*Index*	*Index*	
1960	1400	1414	1467	1416	NS
1961	1901	1879	1969	1969	NS
1963	1864	1868	1906	1874	3>1, 2, 4
Average	1722	1720	1780	1753	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(2)	(1)	(4)	(3)
	Index	*Index*	*Index*	*Index*
10 percent	1720	1722	1753	1780
5 percent	1720	1722	1753	1780
1 percent	1720	1722	1753	1780

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

TABLE 18.—*Ends down per thousand spindle hours for 40s yarn spun from cotton harvested by stated methods in the Mississippi Delta, 1960–63*

Season	Handpicked (1)	Machine-picked using spindle type— 9/16-inch tapered barbed (2)	1/4-inch straight barbed (3)	3/16-inch straight smooth (4)	Significant treatment differences [1]
	Number	*Number*	*Number*	*Number*	
1960	73.8	95.3	90.7	71.8	2>4
1961	64.0	79.2	93.8	64.5	3>1
1963	46.6	53.6	56.2	51.2	2, 3>1
Average	61.4	76.0	80.2	62.5	See data below.

Duncan's multiple range test applied to the 3-year averages is shown below. Values are arranged in ascending order [2]

Significance level	(1)	(4)	(2)	(3)
	Number	*Number*	*Number*	*Number*
10 percent	61.4	62.5	76.0	80.2
5 percent	61.4	62.5	76.0	80.2
1 percent	61.4	62.5	76.0	80.2

[1] Based on Duncan's multiple range test at the 10-percent level of significance for individual years. NS means not significant. The symbol > means greater than. Numerals refer to method of harvest.

[2] Values not underscored by the same solid line are different at the indicated levels of significance. The same type of information is indicated in the column headed "Significant treatment differences." Numerals in parentheses refer to method of harvest.

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