

April 6, 1970

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I am submitting herewith a thesis written by Aurelio Lorenzo Infante entitled "Cotton Harvesting Effects on Fiber and Yarn Properties." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Engineering.

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COTTON HARVESTING EFFECTS ON
FIBER AND YARN PROPERTIES

A Thesis

Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Aurelio Lorenzo Infante

June 1970

ACKNOWLEDGMENTS

The author is deeply indebted to his major professor, Dr. James A. Mullins, and the other members of his committee, Dr. John J. McDow, Dr. Zachary A. Henry, Dr. Smith Worley, and Dr. Kermit E. Duckett, for their invaluable assistance in the preparation of this thesis.

The author wishes also to express his appreciation to the following for their valuable cooperation: Mrs. Elsie Newman, Mr. Gary Puckett, Mr. Ronnie Parker, Mr. Richard Shadden, Mr. J. R. Overton, Mr. P. E. Hoskinson, the USDA Spinning Laboratory personnel, and the Board of Cotton Examiners of the USDA Memphis Classing Office.

Appreciation is also expressed to the Agricultural Experiment Station for their financial support under the Cooperative States Research Service Research Grant No. 816-15-06.

ABSTRACT

Twelve cotton varieties, selected for their maturity date from the 1968 and 1969 crops, were spindle picked and stripped and ginned with a laboratory gin. In 1969, one variety ('Auburn M') was hand-picked, and six trash treatments (leaves, sticks, stems, bracts, grass, and burrs) were added individually by hand to simulate the trash content of stripped cotton. Classer's grade and staple length, length by the Fibrograph, micronaire index, lint color, tenacity, elongation, and yarn strength were determined from the lint samples.

Spindle-picked cotton had significantly higher tenacity, micronaire index, 50 percent span length, 2.5 percent span length, and yarn strength than stripped cotton for the combined analysis. Stripped cotton had similar elongation values and significantly higher reflectance values than spindle-picked cotton for the combined analysis. Grades were lower for stripped cotton for both years. These results indicated that stripped cotton was a lower quality product than spindle-picked cotton.

The addition of sticks to the hand-picked cotton tended to significantly lower elongation, 2.5 percent span length, and yarn strength values. The added burr fragments tended to significantly lower 2.5 percent span length and yarn strength values. The presence of stems resulted in samples having significantly lower yarn strength. Grass resulted in significantly lower 2.5 percent span length values. Bracts and leaves had no effect on the fiber properties and yarn strength. However, the leaf-treated cotton had the lowest grade. No apparent relationships

were found among the different trash treatments for micronaire index index, reflectance, and 50 percent span length. The wood fibers from the sticks, burrs, and stems seemed to be a contributing factor for the reduced yarn strength.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
The Problem.	1
Objectives of the Investigation.	2
II. REVIEW OF LITERATURE	3
Mechanical Harvesting.	3
The Ginning Process.	7
Fiber and Yarn Properties.	7
Types of Trash in Machine Harvested Cotton	10
III. PROCEDURE.	13
Cotton Varieties Selected for the Study.	13
Plot Arrangement	13
Harvesting	14
Ginning.	15
Sampling Techniques.	21
Testing Fiber and Yarn Properties.	21
Samples of Hand-Picked Cotton with Added Increments of Trash.	24
IV. RESULTS AND DISCUSSION	26
Fiber and Yarn Properties of Spindle-Picked and Stripped Cotton.	26
Fiber and Yarn Properties of Hand-Picked Cotton Having Added Increments of Trash	37

CHAPTER	PAGE
V. SUMMARY AND CONCLUSIONS.	40
BIBLIOGRAPHY.	44
APPENDIX.	48
VITA.	51

LIST OF TABLES

TABLE	PAGE
I. Foreign Matter Content of Stripped Seed Cotton	25
II. Means for Fiber and Yarn Properties for Twelve 1968 Varieties of Machine Harvested Cotton.	27
III. Means for Fiber and Yarn Properties for Twelve 1969 Varieties of Machine Harvested Cotton.	30
IV. Mean Fiber and Yarn Properties for Spindle-Picked and Stripped Cotton 1968 and 1969 Crop	32
V. Means for Fiber and Yarn Properties of 1969 Hand- Picked 'Auburn M' With Six Trash Treatments.	39
VI. Grades for Twelve Varieties of Machine Harvested Cotton 1968 and 1969 Crop.	49

LIST OF FIGURES

FIGURE	PAGE
1. Machine Stripped Cotton.	16
2. Spindle-picked Cotton.	17
3. Seed Cotton and Lint from Spindle-picked and Stripped Cotton.	18
4. Seed Cotton and Lint from Spindle-picked and Hand-picked Cotton	19
5. Final Stages of the Ginning Process.	20
6. Lint Sample of Stripped Cotton	22
7. Lint Sample of Spindle-picked Cotton	23

CHAPTER I

INTRODUCTION

I. THE PROBLEM

Machines harvested 72 percent of the United States' cotton crop in 1963. In 1953 this figure was only 22 percent, and prior to that the figure was negligible (15). In Tennessee, mechanical harvesting increased from 23 percent in 1953 to 72 percent in 1966 (21).

Mechanical cotton harvesters are of two basic types: spindle pickers and strippers. Spindle pickers remove the seed cotton from the open bolls on the plant, while stripper-type harvesters remove both open and unopened bolls along with the burrs and some leaves and stems. Almost all the mechanical harvesters in Tennessee are of the spindle picker type. More than one picking is usually necessary to harvest all the cotton from the plant when using a spindle picker. On the other hand, stripping is a once-over operation.

The cost of a spindle picker is about twice that of the stripper, and this cost has been steadily increasing in recent years. This increase in cost is forcing cotton farmers to seek new ways to reduce production cost. Stripper harvesting may be a way to achieve a reduction in cost of production, even though it often results in lower grades in cotton.

A complete evaluation of the performance of a stripper with respect to end use value of stripped cotton would reveal its full potential. In

order to make a realistic evaluation of the performance of a stripper, it is necessary to compare it with a standard method such as the performance of a spindle picker. This would permit an objective comparison of the two harvesting methods.

Cotton is priced by the grade, staple length, and fineness as determined by the classing office. Additional properties must be considered in evaluating mill performance and end use value. Some of the properties often measured are strength (tenacity), elongation, length, fineness, color of fiber, and yarn strength. Trash content, both amount and type, play a part in determining the final quality of cotton (25). The composition of the trash present in mechanically harvested cotton is also a factor affecting quality. The most important types of trash found in machine harvested cotton are sticks, leaves, stems, bracts, grass, and burrs (3).

II. OBJECTIVES OF THE INVESTIGATION

The objectives of this investigation were: (1) to evaluate cotton stripper harvesting for open-boll varieties by measuring fiber properties and yarn strength, and (2) to determine the effects of the various types of trash, representative of that introduced by the stripper, on cotton fiber properties and yarn strength.

CHAPTER II

REVIEW OF LITERATURE

Several studies have been made on the performance of stripped cotton from open-boll varieties. Graves et al. (7), Tupper (26), Overton et al. (17), and Garner et al. (6) have reported on the performance of stripped cotton as compared to spindle-picked cotton. Several others, including Corley (4) and Taylor et al. (24) have studied the performance of stripped cotton from storm-resistant varieties.

I. MECHANICAL HARVESTING

Mechanical cotton pickers are selective; that is, they harvest only the seed cotton of open cotton bolls and leave unopened bolls, "tight lock" bolls, and empty burrs on the plant. The picking is done by means of revolving spindles which move into and out of the plant as the machine moves forward. The performance is influenced by the uniformity of spacing in the row and between rows, and by the uniformity of bed shape and spacing (15).

Stripper-type harvesters are nonselective; that is, they strip the entire plant of open and unopened bolls. Field losses are normally lower than those of spindle pickers, and the normal range of field efficiency can be expected to be from 95 to 98 percent. However, since stripping is a once-over operation, harvest must be delayed until a high percentage of the bolls are open. Because green leaves on the plant make stripping impractical, effective defoliation or desiccation of the leaves

is necessary. Defoliants and desiccants are applied before the normal frost date (15).

In 1964 Graves et al. (7) conducted a study in West Tennessee using four varieties (two open-boll and two storm-resistant) to evaluate the performance of stripped and spindle-picked cotton. They reported that stripped cotton gave a higher gross return per acre but had lower grade and shorter 2.5 percent span length. The storm-resistant varieties had shorter 2.5 percent span length regardless of harvesting method. It was also reported that ginning on a commercial gin reduced length, strength, and fineness as compared to a laboratory gin.

A study on mechanical methods of harvesting irrigated cotton in Oklahoma, conducted for five years (1959-1963) by the Oklahoma Agricultural Experiment Station, concluded that spindle-picked lint was usually higher in grade, staple length, and value than lint from once-over stripping. In seasons of high yields, once-over stripping of a picker variety was more profitable, but in seasons of low yields once-over stripping of a stripper variety was far more profitable than any method of harvesting. These results suggested that the farmer growing irrigated cotton in Oklahoma could expect the highest average annual returns by growing a stripper variety and harvesting it in a once-over operation. A second choice would be to once-over strip a picker variety if it had storm resistance comparable to those of stripper varieties (24).

A comparative study of stripping and spindle picking of open-boll and experimental stripper varieties was conducted by Tupper (26) in Arkansas from 1962 to 1964. He reported that overall harvesting efficiencies

were higher for the stripper than for the spindle picker in stormproof cotton. Small differences occurred in open-boll varieties between stripper and spindle picker overall harvesting efficiencies. There were no significant differences between yields of stormproof varieties and open-boll varieties when stripped. More seed cotton was harvested with the stripper than with the picker in all six varieties in the three years the tests were conducted.

A two-year study of a spindle picker versus stripper harvesting was conducted by Corley (4) in 1965 and 1966 with 'Auburn 56.' He reported that the gross lint and seed value of the stripper cotton was greater than for once-over spindle-picked cotton. The results suggested that although strippers were shown to have potential for lowering costs, stripping was not likely to gain wide acceptance in Alabama because of the greater demand for quality cotton and larger discounts for lower grades.

Overton et al. (17) conducted a study on the performance of cotton varieties stripped and spindle picked in West Tennessee (1964-1966) at two locations. He reported that more lint cotton was harvested from each variety with the stripper than with the spindle picker on both locations each year. The average increase in harvested cotton by stripping over spindle picking was about twice as great with the stormproof varieties as with the open-boll varieties with the exception of 1965 at Ames Plantation. Lint from stripped cotton yielded lower grades than that from spindle-picked cotton in all tests. Fiber strength was slightly higher for the spindle-picked cotton, and yarn strength was also greater for spindle-picked cotton.

Garner et al. (6) conducted a three year study with the 'Auburn 56' variety to compare the ginning performance, fiber quality, and spinning performance of cotton harvested with a spindle picker and with a brush-type stripper. Cotton conditioning and cleaning treatments for ginning cotton by the two methods were evaluated. It was reported that stripped cotton had a higher yield of lint and seed cotton per acre than spindle-picked cotton. However, spindle-picked cotton ginned about 24 percent faster than stripped cotton. Stripper harvesting produced cotton which was slightly shorter, weaker, and finer than spindle-picked cotton. Spindle-picked cotton processed, through spinning, significantly better than stripped cotton. Spindle-picked cotton also had less total manufacturing waste, greater break and yarn appearance index, lower yarn irregularity coefficient of variation, and fewer ends down per 1000 spindle hours. Stripped cotton had a gross return of \$9.00 per acre more than spindle-picked cotton when the returns were averaged for the three years and between the two locations. It was noted, however, that this average was subject to a wide margin of error due to variations in factors such as field conditions, harvester efficiencies and other uncontrolled factors. No adjustments were made for differences in harvesting and ginning costs which greatly influence the meaningfulness of the average gross return. The results suggested that stripped cotton had a lower performance as compared to that for spindle-picked cotton when handled in the conventional manner. This indicated that in spite of the apparent higher gross return for stripped cotton, stripping would not be advantageous to producers in the long run or to the

manufacturers until improvements in processing stripped cotton could be made. Garner finally concluded that the opportunity of a gain for the producer with the stripper in the short run is small as compared to differences in the end use values.

II. THE GINNING PROCESS

Cotton fiber is removed from the seed and much of the foreign material is removed in the ginning process. Ginning equipment usually consists of a feed control unit, driers, cleaning and extracting units, a gin stand, lint cleaners, and a packaging unit. The feed control unit is designed to minimize chokages in the seed cotton cleaners, to provide an even flow of cotton, to minimize fiber damage, and to decrease time loss between bales. The driers control the moisture content of the seed cotton at the desired level to provide for an efficient operation. Cleaners are used primarily for removing fine trash and leaf. The extracting units are more effective in removing burrs, sticks, and other large foreign material. The gin stand is the heart of the gin plant. The function of the gin stand is to separate the lint from the seed. Lint cleaners are used to remove small leaf particles and grass left in the lint cotton by the seed cotton cleaners and extractors. Finally, the packaging system is designed to deliver the lint in properly packaged bales ready for the market (8).

III. FIBER AND YARN PROPERTIES

Once the cotton has been ginned, tests can be performed to measure the different fiber and yarn properties. Some of the most significant

fiber properties are grade, length, color, fineness, and strength. Yarn strength is one of the most often measured yarn properties. The quality of cotton is traditionally designated in terms of grade and staple length as determined by skilled cotton classers. However, instrument test measurements of the most significant fiber and yarn properties have been developed to provide additional information to supplement the usual classification results (22).

Grade is composed of three factors: color, trash content, and gin preparation of a sample of cotton. Staple length is the length of a typical portion of the fibers in the sample as determined by the classer in comparison with official standards (22).

Color by the colorimeter is measured in terms of reflectance (R_d) values and degree of yellowness ($+b$). Increasing reflectance values indicate increasing whiteness of the cotton. Fiber length by the Fibrograph is usually reported in terms of 2.5 percent span length and 50 percent span length. The 2.5 percent span length is the length of the test specimen spanned by 2.5 percent of the fibers scanned at the initial starting point. The 2.5 percent span length values in inches have been described as follows: (1) short for values below 1.00, (2) medium for values between 1.00 and 1.14, (3) long for values between 1.15 and 1.29, and extra long for values above 1.29. The 50 percent span length is a similar measurement but the length is spanned by 50 percent of the fibers scanned at the initial starting point (22).

Fiber strength is expressed in terms of tenacity, and it is a measure of the strength of a bundle of fibers. Tenacity is expressed in

either grams per tex or in pounds per square inch. A tex unit is equal to the weight in grams of one thousand meters of the material (19). Tenacity in grams per tex values for medium staple cottons as adjusted to the Stelometer level has been described as follows: (1) low strength for values between 14.9 and 16.4, (2) average strength for values between 16.5 and 18.1, and (3) high strength for values between 18.2 and 19.6 (22). Elongation is the percentage elongation at break of the center 1/8 inch of the fiber bundle measured for tenacity on the Stelometer (19). Elongation values in percentage units as adjusted to the Stelometer level are described as follows: (1) very high for values above 9.2, (2) high for values between 8.1 and 9.2, (3) average for values between 6.9 and 8.0, (4) low for values between 5.7 and 6.8, and (5) very low for values below 5.7 (22).

The micronaire index is a measure of the fineness of the sample taken from the ginned lint measured by the Micronaire and expressed in standard micronaire units (19). Micronaire units for medium staple cottons have been described as very fine for values below 3.0, fine for values between 3.0 and 3.9, average for values between 4.0 and 4.9, and coarse for values between 5.0 and 5.9 (22).

Yarn strength is perhaps the most important and reliable test of yarn quality. Yarn strength not only determines the range of usefulness of a given cotton, but is also an indication of spinning performance. Yarn strength is reported in terms of skein strength. Studies have shown that skein strength values are more closely related to fabric strength as well as to fiber properties than single strand yarn strength. Yarn strength is usually reported in pounds (22).

IV. TYPES OF TRASH IN MACHINE-HARVESTED COTTON

Excessive foreign material in cotton increases the costs of processing and results in a lower quality of the finished product. Grass and other foreign matter such as leaves, stems, sticks, bracts, and burrs included with the seed cotton are very objectionable and cannot be removed completely at the gin. Cotton which is classed grassy or barky is penalized severely when sold (7).

Grass particles in cotton lint increase the difficulty in manufacturing processes. Grass removal by excessive machining results in damage to the cotton fibers, and the particles that are not removed may cause yarn breakages during spinning (ends down). Grass that is mixed with cotton by mechanical harvesters may impair the appearance of cotton fibers by staining the fibers and by their physical presence in the end product. Garner (5) reported in 1962 that the reduction in grade, of lint cotton due to grass, increased as the percentage of grass in the seed cotton increased. Also, the non-lint content of lint cotton increased with increasing percentage of grass in the seed cotton. Seed cotton which contained high percentages of grass resulted in lint samples which produced increased mill picker and card waste, and decreased yarn strength and appearance indexes in spinning performance tests.

The presence of sticks or plant limbs in the harvested cotton is one of the greatest problems associated with the development of the stripper. Limbs may be broken at harvest time by the rollers and deposited in the wagon along with the seed cotton. When this material

enters the gin, small particles of bark may be torn from the sticks and contaminate the lint. Lint which contains bark is subject to severe discounts in price. However, the new stick machines which have been installed in the gin plants remove most of the stick particles in all except extremely severe conditions (23).

Leaf and bract particles of different sizes are usually collected, along with the seed cotton, by mechanical harvesters. The removal of these two types of trash in the gin plant is usually accomplished by screen cleaners. In these machines, spike-tooth cylinders rotate above screen concaves. Leaf and bract trash fall through the screen while the cotton is being agitated and conveyed over it by the toothed cylinders. Further cleaning is done by the lint cleaners which try to eliminate all traces of leaf and bract content (23).

Corley (3), in studying the basic factors affecting the performance of mechanical cotton pickers in 1964, identified the sources of trash contamination in cotton harvesting. It was reported that leaves, bracts, burrs, and ground trash (soil particles, insect parts, and foreign seeds) were the sources of large trash. The fine trash content was isolated and found to be composed of stems, cotton fibers, flakes from burrs and some unidentified trash.

Benedict and Berriman (2) of the Stanford Research Institute conducted an investigation to determine the major components of trash in samples of 1961 raw cotton, card sliver, and cotton yarn, and to find any possible relationships between raw cotton and yarn appearance index for various trash contents. The trash particles found in the cotton were

classified as seed-coat fragments, leaf particles, and miscellaneous. It was reported that in general the lower the grade class, the greater the number of leaf blades, leaf fragments and miscellaneous particles present. Also, it was determined that the greater the number of seed-coat particles the higher the grade classification. These relationships were found to be true for both raw cotton and card sliver, and they indicate that the seed-coat content appears to be more or less ignored in determining grade. For yarn, no clear relationship between yarn appearance index and the number of seed-coat fragments was found. However, it was found that as the yarn appearance index increased the number of trash particles other than seed-coat fragments decreased. The results suggested that most of the trash content which affects the grade of raw cotton is removed in the cleaning process, and that most of the trash which affects the yarn appearance index is not removed. Grade and yarn appearance do not appear to be related to the seed-coat content but to the smaller trash fragments.

A study of the foreign matter content of stripped cotton from Ames Plantation in West Tennessee in 1967 made by the USDA Cotton Ginning Research Laboratory at Leland, Mississippi, identified the different types of trash present. Moore (16) reported burrs, stems, sticks, leaves, grass, bracts, and motes as the foreign matter present in stripped cotton of this area.

CHAPTER III

PROCEDURE

Twelve varieties with two harvesting methods replicated four times were used in comparing the performance of stripped cotton to spindle-picked cotton for 1968 and 1969.

Hand-picked 'Auburn M' cotton was treated with six types of trash to simulate the foreign matter content of stripped cotton and evaluate individual trash effects on the end use value of stripped cotton. The treatments were replicated six times.

I. COTTON VARIETIES SELECTED FOR THE STUDY

The twelve varieties selected varied in maturity date and were chosen because of their adaptability to Tennessee conditions (11). The varieties included in the early maturing group were: (1) 'Auburn M,' (2) 'Rex Smooth Leaf,' (3) Arkansas Experimental Stripper, (4) 'Hancock,' and (5) Experimental T-59-538. Those included in the mid-season group were 'Deltapine 45A' and 'Dixie King II.' The late maturing group consisted of: (1) 'Deltapine 16,' (2) 'Deltapine Smooth Leaf,' (3) 'Stoneville 213,' (4) 'Coker 413,' and (5) 'McNair 1032.'

II. PLOT ARRANGEMENT

In 1968 and 1969 the twelve cotton varieties were field planted during the first week of May at Ames Plantation, Grand Junction,

Tennessee.¹ Each plot consisted of four 40-inch rows, 65 feet long. Each variety was replicated four times. Replications were separated by 15 foot alleyways. Cotton was flat planted to give 60,000 to 80,000 plants per acre.

All varieties received three early insecticide spray applications for overwintering weevils and seven insecticide applications for mid- and late-season insect control. The cotton plants were defoliated during the first week in October. In 1968, a phosphate defoliant was used alone, but in 1969 a phosphate defoliant with Paraquat was used. Desiccation was accomplished two weeks after defoliation. In 1968, the cotton was spindle picked on October 9 and stripped on October 16. In 1969, the cotton was spindle picked on November 4 and stripped on November 16.

III. HARVESTING

Two types of mechanical harvesters, a spindle picker and a stripper, were used in harvesting the twelve cotton varieties for both 1968 and 1969. A two-row Hesston SP-50 brush-type stripper, equipped with a green boll separator and a saw type seed cotton cleaner, was used both years. The Hesston stripper used nylon brushes and rubber paddles to strip the cotton plant. Spindle picking was accomplished with a two-row John Deere picker in 1968, and with a one-row high drum International Harvester spindle picker in 1969. The one-row spindle

¹Ames Plantation is an activity of the University of Tennessee Agricultural Experiment Station.

picker was equipped with a sacking attachment designed to facilitate the sacking of cotton from small plots.

The two center rows of each plot were harvested by stripping and the two outside rows by the spindle picker (Figures 1 and 2). The stripped cotton was collected from the basket and put into previously coded sacks by hand. The spindle-picked cotton was collected in sacks at the sacking station inside the basket. These sacks were dumped to the ground at intervals, and the cotton was transferred to previously coded sacks. Only one picking was made in order to more adequately compare once-over picking to stripping. The seed cotton contained in the sacks collected from both types of harvesting weighed approximately eight pounds.

IV. GINNING

Samples for the 1968 plots were stored at the West Tennessee Experiment Station in Jackson for one year and ginned along with the 1969 harvest at the laboratory gin located at the station (Figures 3 and 4). Before the 1968 seed cotton was ginned, it was necessary to let it stand in the gin building overnight to restore moisture. The laboratory gin used in the study was a cut-down version of a regular size gin. The ginning equipment consisted of two incline cleaners, one stick machine, one feeder, one 20-saw 16-inch gin, two laboratory size lint cleaners, and one laboratory size condenser (Figure 5).



Figure 1. Machine stripped cotton.



Figure 2. Spindle-picked cotton.

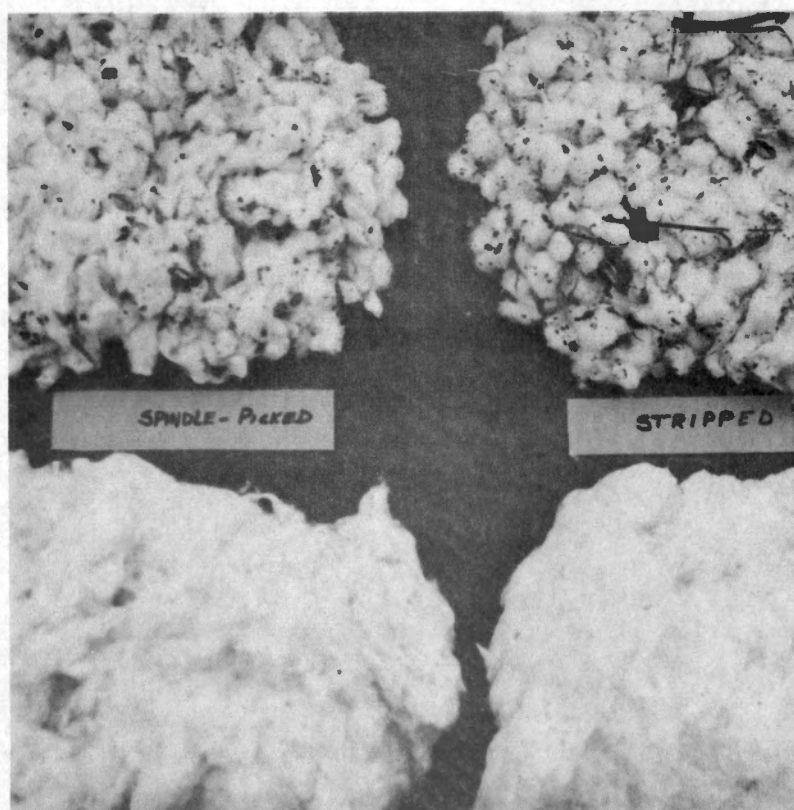


Figure 3. Seed cotton and lint from spindle-picked and stripped cotton.

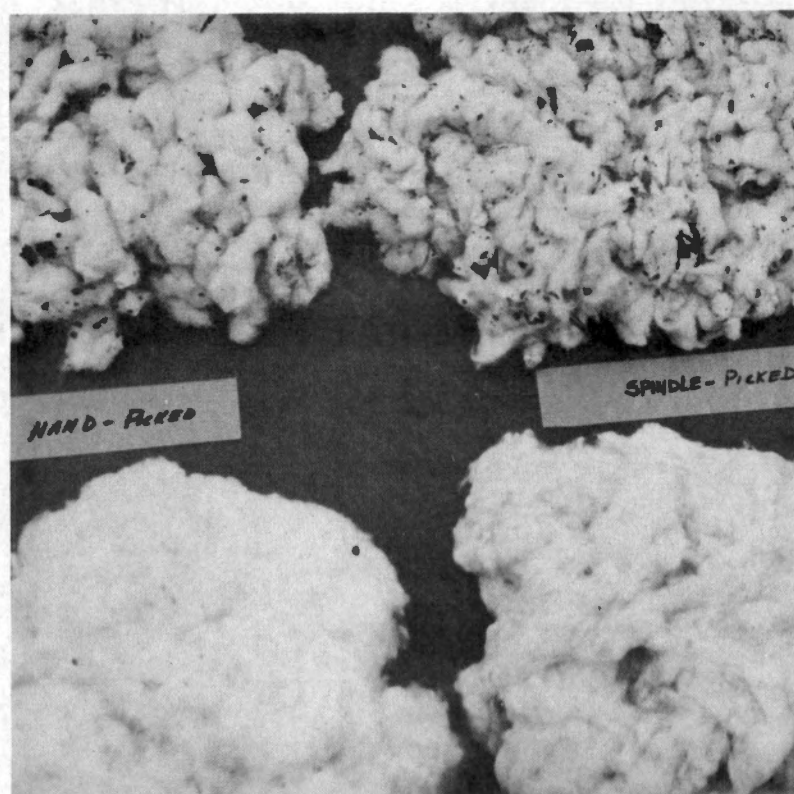


Figure 4. Seed cotton and lint from spindle-picked and hand-picked cotton.



Figure 5. Final stages of the ginning process.

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V. SAMPLING TECHNIQUES

Two lint samples, one 170-gram and one 75-gram, were prepared from each of the processed spindle-picked and stripped samples (Figures 6 and 7). The classer's grade and staple length were determined by the USDA Cotton Classing Office in Memphis, Tennessee. Micronaire index, fiber strength, length, color, elongation, and yarn strength were determined by the USDA Spinning Laboratory in Knoxville from the 75-gram lint samples.

VI. TESTING FIBER AND YARN PROPERTIES

Grade and staple length were determined by the USDA Classing Office as previously described. The other properties mentioned above were determined by the USDA Spinning Laboratory.

Fiber elongation and tenacity were measured using the Stelometer. Values reported are means of four determinations each. A 51-gram sample was used to determine the micronaire index by means of the Speedar II (9). The two span lengths (50 and 2.5 percent) were measured by the digital Fibrograph and are the means of two determinations per sample. Reflectance values were determined by means of the colorimeter (12).

Yarn strength was determined at 27 tex. Twenty miniature skeins were wound from ten spinning bobbins, and the strength was measured by the Automated Digital Skein Testers and converted to the strength of a standard skein. The average of the 2.5 percent span length determinations was used to determine the roll setting and spinning twist gear for maximum yarn strength (13).

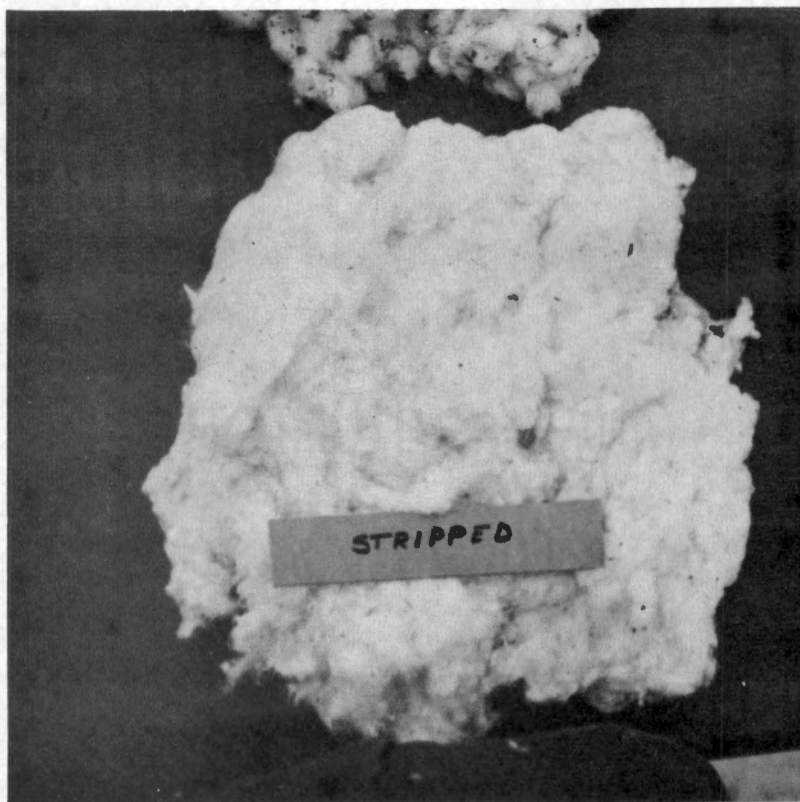


Figure 6. Lint sample of stripped cotton.

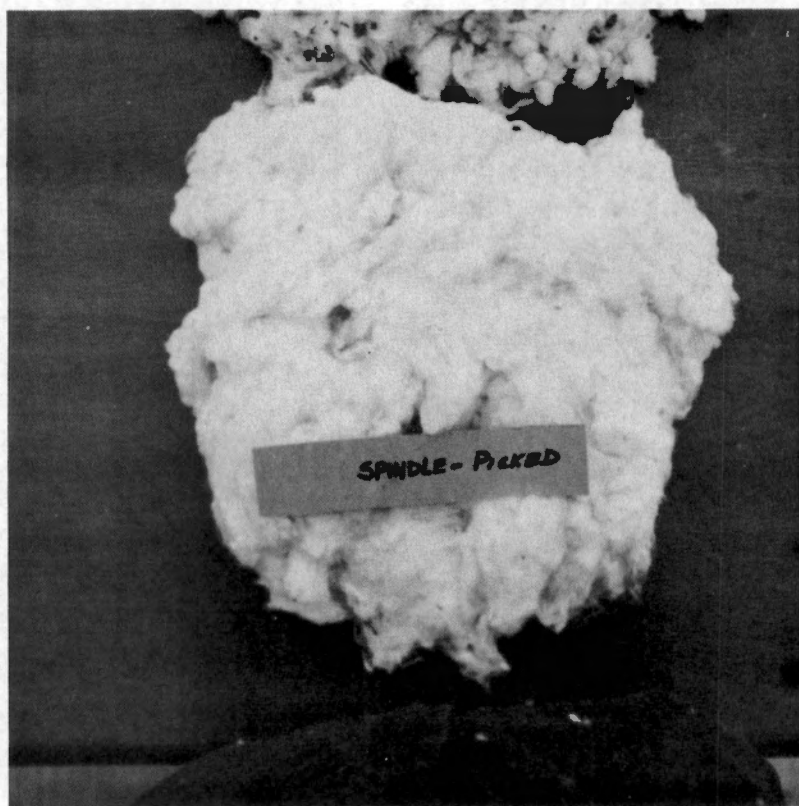


Figure 7. Lint sample of spindle-picked cotton.

Split-plot analysis of variance tests for the combined years were used to analyze the results obtained (14).

VII. SAMPLES OF HAND-PICKED COTTON WITH ADDED INCREMENTS OF TRASH

In 1969 hand-picked 'Auburn M' from an experimental plot located at the West Tennessee Experiment Station was used in evaluating the effects of the various types of trash contained in stripped cotton. The USDA Cotton Ginning Research Laboratory at Leland, Mississippi, had previously determined the foreign matter content of stripped seed cotton from Ames Plantation (16). Leaves, stems, sticks, grass, bracts, and burrs were identified as the primary foreign matter content with percentages as shown in Table I.

A total of seven treatments (six trash treatments and a check) were prepared. Each trash treatment was prepared by adding an amount of one type of trash, as determined above, to the hand-picked cotton. The check consisted of hand-picked cotton with no added trash. The treatments were replicated six times. All the seed cotton was ginned at the West Tennessee Experiment Station laboratory gin.

The procedure previously described for the lint samples of the mechanically harvested cotton was used to measure the fiber properties and yarn strength of the lint samples.

The data were analyzed by means of analysis of variance for comparisons among means. Duncan Multiple Range tests were used to determine significant differences among the means (20).

TABLE I
FOREIGN MATTER CONTENT OF STRIPPED SEED COTTON

Type of Foreign Matter	Amount of Trash in Stripped Cotton Percent ^a
Burrs	15.3
Sticks	1.3
Stems	1.3
Leaves	1.6
Grass	0.3
Bracts	0.1

^aAs determined by the USDA Cotton Ginning Research Laboratory at Leland, Mississippi.

CHAPTER IV

RESULTS AND DISCUSSION

I. FIBER AND YARN PROPERTIES OF SPINDLE-PICKED AND STRIPPED COTTON

Elongation

The combined analysis of variance of elongation at break showed that there were no significant differences between harvesting methods. However, there were significant differences² for the harvesting method x variety interaction, and for the harvesting method x year interaction. The significant differences for the harvesting method x variety interaction were due to the fact that the varieties reacted differently to the harvesting methods for the two years (Tables II and III). This effect can be illustrated by the Arkansas Experimental Stripper variety which had significantly higher elongation values when stripped in 1968 and similar values when spindle picked or stripped in 1969. Spindle-picked cotton had significantly lower values in 1968, but the differences in 1969 were not significant. These variations caused significant differences in the harvesting method x year interaction for the combined analysis (Table IV).

The results suggested that, with respect to elongation, stripped cotton would perform as well as spindle-picked cotton. These results are consistent with the findings of Garner et al. (6).

²Significant differences are at the 99 percent probability level unless otherwise stated.

TABLE II
MEANS FOR FIBER AND YARN PROPERTIES FOR TWELVE 1968 VARIETIES
OF MACHINE HARVESTED COTTON

Variety	Type of Harvesting	Elon- gation Percent	Tenacity gr/tex	Micro- naire Index	Reflect- ance Percent	50% Span Length Inches	2.5% Span Length Inches	Yarn Strength Lbs.
<u>Early Maturity:</u>								
'Auburn M'	Picked	8.4	19.1	4.4	70	0.50	1.09	116.0
	Stripped	** 8.1	18.4	** 4.2	72	0.48	1.07	112.0
'Rex Smooth Leaf'	Picked	8.3	19.0	4.4	68.5	0.47	1.08	106.8
	Stripped	** 8.7	18.9	** 4.0	69.3	0.47	1.09	112.3
Arkansas Experimental Stripper	Picked	8.4	19.0	4.5	69.5	0.49	1.08	103.0
	Stripped	** 8.8	18.7	** 4.2	69.5	0.46	1.07	110.0
'Hancock'	Picked	8.6	18.5	4.5	69.3	0.46	1.04	107.8
	Stripped	** 8.6	** 17.6	** 4.2	69.0	0.45	1.04	106.0
Experimental T-59-538	Picked	8.5	17.9	4.2	69.5	0.48	1.10	110.0
	Stripped	** 9.0	18.4	** 3.9	69.5	0.46	** 1.07	108.0

TABLE II (continued)

Variety	Type of Harvesting	Elon- gation Percent	Tenacity gr/tex	Micro- naire Index	Reflect- ance Percent	50% Span Length Inches	2.5% Span Length Inches	Yarn Strength Lbs.
<u>Mid-season Maturity:</u>								
'Deltapine 45A'	Picked	8.3 **	19.2	4.5 **	70.8	0.48	1.07 **	107.8
	Stripped	8.2	18.5	4.2	69.8	0.46	1.04	112.5
'Dixie King II'	Picked	7.2 **	18.6	4.4 **	70.0	0.47	1.07	106.8
	Stripped	7.4	18.7	4.1	71.3	0.46	1.05	113.3
<u>Late Maturity:</u>								
'Deltapine 16'	Picked	8.8 **	18.6 **	4.4 **	70.5	0.48	1.10 **	109.8
	Stripped	8.9	17.7	4.1	72.8	0.46	1.07	106.5
'Deltapine Smooth Leaf'	Picked	8.7 **	18.8	4.5 **	70.5	0.48	1.06 **	110.5
	Stripped	9.4	18.8	4.1	71.3	0.45	1.03	108.5
'McNair 1032'	Picked	8.5 **	18.1	4.4 **	70.3	0.50	1.10	114.3
	Stripped	8.6	18.0	4.1	70.3	0.46	1.10	108.0

TABLE II (continued)

Variety	Type of Harvesting	Elon- gation Percent	Tenacity gr/tex	Micro- naire Index	Reflect- ance Percent	50% Span Length Inches	2.5% Span Length Inches	Yarn Strength Lbs.
'Coker 413'	Picked	7.9	18.3	4.4	69.0	0.49	1.10	116.0
	Stripped	7.9	17.8	** 4.1	70.3	0.49	1.10	112.5
'Stoneville 213'	Picked	8.2	18.9	4.6	69.3	0.48	1.06	105.5
	Stripped	** 8.0	18.2	** 4.3	71.0	0.46	1.06	108.3

** Denotes significant differences at the 99 percent probability level.

TABLE III

MEANS FOR FIBER AND YARN PROPERTIES FOR TWELVE 1969 VARIETIES
OF MACHINE HARVESTED COTTON

Variety	Type of Harvesting	Elon- gation Percent	Tenacity gr/tex	Micro- naire Index	Reflect- ance Percent	50% Span Length Inches	2.5% Span Length Inches	Yarn Strength Lbs.
<u>Early Maturity:</u>								
'Auburn M'	Picked	8.7	18.1	4.0	68.3	0.48	1.10	107.0
	Stripped	8.5	17.8	** 3.7	70.8	0.46	1.09	104.8
'Rex Smooth Leaf'	Picked	8.1	18.3	4.1	68.3	0.51	1.15	100.5
	Stripped	8.2	17.9	4.0	70.8	0.49	1.14	103.0
Arkansas Experimental Stripper	Picked	8.1	18.4	4.3	68.0	0.48	1.09	107.3
	Stripped	7.8	19.4	** 4.0	70.0	0.46	** 1.02	111.8
'Hancock'	Picked	8.7	18.4	4.0	69.3	0.45	1.07	102.3
	Stripped	8.2	17.8	3.9	69.3	0.45	** 1.05	104.3
Experimental T-59-538	Picked	8.6	19.5	3.5	67.8	0.48	1.14	106.5
	Stripped	8.7	19.5	3.4	66.8	0.46	** 1.10	105.0
<u>Mid-Season Maturity:</u>								
'Deltapine 454'	Picked	8.8	17.8	4.5	67.3	0.49	1.08	105.0
	Stripped	9.0	18.0	4.4	70.0	0.46	1.07	107.0

TABLE III (continued)

Variety	Type of Harvesting	Elon- gation Percent	Tenacity gr/tex	Micro- naire Index	Reflect- ance Percent	50% Span Length Inches	2.5% Span Length Inches	Yarn Strength Lbs.
'Dixie King II'	Picked	7.7	18.7	4.3	68.0	0.47	1.07	105.0
	Stripped	7.3	17.5	4.3	69.8	0.45	1.06	101.5
<u>Late Maturity:</u>								
'Deltapine 16'	Picked	9.3	18.2	4.1	70.5	0.49	1.13	102.3
	Stripped	9.9	18.0	**	**	**	**	
				3.8	74.0	0.47	1.10	104.3
'Deltapine Smooth Leaf'	Picked	9.1	18.0	4.3	67.8	0.48	1.09	103.8
	Stripped	9.2	17.5	4.1	**	**	**	
					72.5	0.46	1.08	103.0
'McNair 1032'	Picked	8.3	18.8	4.2	67.3	0.49	1.10	110.3
	Stripped	8.1	19.3	4.3	68.5	0.48	**	118.0
							1.08	
'Coker 413'	Picked	7.8	18.5	3.9	67.5	0.51	1.16	113.3
	Stripped	7.8	19.3	**	**	**	**	
				3.6	70.3	0.50	1.16	117.5
'Stoneville 213'	Picked	8.8	18.0	4.2	68.8	0.48	1.09	105.8
	Stripped	8.7	17.5	4.1	70.0	0.46	1.08	99.8

**Denotes significant differences at the 95 percent probability level.

TABLE IV
MEAN FIBER AND YARN PROPERTIES FOR SPINDLE-PICKED
AND STRIPPED COTTON 1968 AND 1969 CROP

Year	Type of Harvesting	Elon- gation Percent	Tenacity gr/tex	Micro- naire Index	Reflect- ance Percent	50% Span Length Inches	2.5% Span Length Inches	Yarn Strength Lbs.
1968	Picked	8.29 **	18.7 **	4.42 **	69.8	0.48	1.08 **	111.8
	Stripped	8.44	18.3	4.11	70.4	0.46	1.07	107.6
1969	Picked	8.50	18.4	4.15 **	68.2 **	0.48	1.11 **	105.8
	Stripped	8.45	18.3	3.94	70.2	0.47	1.09	106.9
Combined Years	Picked	8.39	18.5 **	4.22 **	69.0 **	0.48 **	1.09 **	108.8 **
	Stripped	8.45	18.3	4.03	70.3	0.46	1.08	107.2

** Denotes significant differences at the 99 percent probability level.

Tenacity

Harvesting methods were significantly different for tenacity in the combined analysis. Mean tenacity values for the spindle-picked cotton were significantly higher than those of stripped cotton for 1968 and for the combined analysis (Table IV, page 32). Differences were also significant for the harvesting method x variety interaction, and for the harvesting method x year interaction (Tables II and III, pages 27 and 30). These differences were probably caused by the same factors previously discussed for elongation.

The significantly lower tenacity of stripped cotton was probably due to the presence of immature fibers which were harvested along with the mature fibers. The results also indicated that, since cottons with higher strength give less trouble in the manufacturing process, the spindle-picked cotton would probably be in greater demand by the textile mills as previously indicated by Garner et al. (6).

Micronaire

The micronaire index in the combined analysis showed that significant differences existed between harvesting methods. These results were consistent with those of Garner et al. (6). These data showed (Table IV, page 32) that stripped cotton had significantly lower micronaire index than spindle-picked cotton for the combined analysis. This was probably due to the presence of immature fibers in the lint samples caused by the nonselective stripper.

Significant differences were also found for the harvesting method x variety interaction, and for the harvesting method x year interaction. The reasons for these existing differences were probably the same as those previously discussed (Tables II and III, pages 27 and 30). The 1968 crop had significantly higher micronaire values than the 1969 crop. This difference was probably due to the differences in growing conditions for the two years.

Reflectance

Reflectance values were significantly different between harvesting methods for the combined analysis. Stripped cotton had significantly higher reflectance values than spindle-picked cotton for the combined analysis (Table IV, page 32). The higher reflectance values of stripped cotton were probably due to the presence of unopened bolls which were harvested by the stripper along with the open bolls. These unopened bolls contained fibers which were whiter than the fibers contained in open bolls which had more exposure to weathering. These results were similar to those obtained by Garner et al. (6) at Clemson in 1964, but different from those obtained at Clemson in 1965, and at Auburn in 1964 and 1965.

Significant differences also existed for the harvesting method x variety interaction and for the harvesting method x year interaction. The causes for these differences were probably the same as those previously discussed (Tables II and III, pages 27 and 30). The 1968 crop had significantly higher reflectance values than the 1969 crop (Table IV, page 32). This was probably due to the fact that the 1968 cotton

was machine harvested at an earlier date than the 1969 crop, and therefore was less exposed to weathering.

50 Percent Span Length

The 50 percent span length values for the combined analysis showed that there were significant differences between harvesting methods (Table IV, page 32). Spindle-picked cotton had significantly higher 50 percent span length values than stripped cotton in the combined analysis corroborating the findings of Garner et al. (6). The shorter fibers of stripped cotton probably resulted as a consequence of damages during the required cleaning to eliminate the excessive trash content and in the ginning of seed cotton. Immature fibers are more readily damaged than mature fibers, and stripped cotton, as previously explained, perhaps contained more immature fibers.

Differences were also significant for the harvesting method x variety interaction, and for the harvesting method x year interaction. These differences were probably due to the same causes previously discussed under elongation. The 1969 crop had significantly higher 50 percent span length than the 1968 crop (Table IV, page 32).

2.5 Percent Span Length

Harvesting methods were significantly different for the 2.5 percent span length for the combined analysis (Table IV, page 32). Stripped cotton had significantly lower 2.5 percent span length values than spindle-picked cotton in the combined analysis. This is in accord with Garner et al. (6). The lower 2.5 percent span length values of

stripped cotton were probably due to the same causes explained in the 50 percent span length section.

Significant differences were found for the harvesting method x variety interaction, and for the harvesting method x year interaction. These differences were probably the result of effects previously discussed in the elongation section. The 1969 crop had significantly higher 2.5 percent span length values than the 1968 crop (Table IV, page 32).

Grade

Spindle-picked samples for the 1968 harvest yielded at least one full grade better than the stripped cotton samples for all twelve varieties (Table VI, Appendix).

For the 1969 harvest, spindle-picked cotton had better grades for nine of the twelve varieties. Grades were similar for Arkansas Experimental Stripper, 'Deltapine 16,' and 'Deltapine Smooth Leaf' (Table VI, Appendix). The higher trash content in stripped cotton caused the lower grade. Similar results were obtained by Garner et al. (6).

Yarn Strength

Harvesting methods were significantly different for yarn strength for the combined analysis (Table IV, page 32). Spindle-picked cotton had significantly higher yarn strength than stripped cotton for the combined analysis. This was in agreement with results obtained by Garner et al. (6). Differences in yarn strength were not significant for the individual years.

There were significant differences in the harvesting method x year interaction. The differences for the harvesting method x variety interaction were significant at the 95 percent probability level. These differences were probably caused by the same factors previously discussed in the elongation section. The 1968 crop had significantly higher yarn strength than the 1969 crop (Table IV, page 32).

Maturity Groups

No attempt was made to make comparisons among maturity groups because the early, mid-season, and late maturing varieties were all harvested on the same date. The early and mid-season maturing varieties were exposed to weathering for a longer period of time than they would normally have been exposed, therefore invalidating any realistic comparisons among maturity groups. Also, the classification by maturity dates was subjective in nature and represents average performance for a series of years at a particular location.

II. FIBER AND YARN PROPERTIES OF HAND-PICKED COTTON HAVING ADDED INCREMENTS OF TRASH

Check versus Types of Trash

The check, prepared as described in Section VII of the Procedure, had significantly lower reflectance, 2.5 percent span length, and yarn strength values than the trash treatments. The apparent higher values for the fiber properties and yarn strength of the samples with added trash as compared to the check could not have been due to the presence

of the trash. However, there were probably sampling errors and errors of determinations which masked the true effects. The check should have had equal or higher values for the fiber properties and yarn strength (Table V).

Trash Treatments

The samples with the added sticks had significantly lower³ elongation, 2.5 percent span length, and yarn strength as compared to the other trash treatments. This indicates that bark and wood fiber fragments from the sticks tended to lower the properties mentioned above (Table V).

The burrs added to the hand-picked cotton resulted in samples with significantly lower 2.5 percent span length and yarn strength (Table V).

The stems added to the hand-picked cotton resulted in significantly lower yarn strength values (Table V) than the other trash treatments.

Adding bract fragments to the hand-picked cotton did not affect the fiber properties and yarn strength values (Table V).

The grass added to the hand-picked cotton resulted in samples having significantly lower 2.5 percent span length values (Table V).

Adding leaf particles to the hand-picked cotton had no effect with the exception of grade. The samples treated by adding leaf fragments yielded the lowest grades.

³All differences for the Duncan Multiple Range tests were at the 95 percent probability level.

TABLE V

MEANS FOR FIBER AND YARN PROPERTIES OF 1969 HAND-PICKED 'AUBURN M' WITH SIX TRASH TREATMENTS

Type of Trash	Elongation Percent	Tenacity gr/tex	Micro-naire Index	Reflectance Percent	50% Span Length Inches	2.5% Span Length Inches	Yarn Strength Lbs.
Leaves	7.73a*	18.5a	4.2a	73.8a	0.45a	1.05a	104.7a
Grass	7.63a	18.2a	4.2a	74.8a	0.45a	1.02bc	103.2ab
Bracts	7.60a	18.5a	4.2a	74.0a	0.45a	1.03abc	102.0abc
Stems	7.23ab	18.0a	4.5a	74.7a	0.46a	1.04ab	99.8bc
Burrs	7.23ab	18.2a	4.5a	74.0a	0.45a	1.01c	99.2bc
Sticks	6.78b	17.5a	4.5a	74.2a	0.45a	1.02bc	98.5c
Check	7.26	17.8	4.6	73.5	0.45	0.99	97.8

*Means followed by the same letter are not significantly different at the 95 percent probability level.

CHAPTER V

SUMMARY AND CONCLUSIONS

Fiber and yarn properties of stripped cotton as compared to spindle-picked cotton provide a way to evaluate the performance of the stripper on open-boll varieties in Tennessee. The evaluation of the fiber and yarn properties of the hand-picked cotton with added trash may provide an indication of the effects of the various types of trash on stripped cotton.

In 1968 and 1969, twelve cotton varieties of different maturity dates (early, mid-season, and late) were spindle picked and stripped. The machine harvested seed cotton was processed in a laboratory gin. The classer's grade and staple length were determined by the USDA Classing Office in Memphis, Tennessee. The USDA Spinning Laboratory in Knoxville measured elongation, tenacity, fineness, reflectance, 2.5 percent span length, 50 percent span length and yarn strength. The split-plot analysis of variance was used to analyze the data.

In 1969, six different trash treatments (leaves, stems, sticks, bracts, grass, and burrs) were added individually to hand-picked 'Auburn M' to simulate the trash content of stripped cotton and to isolate the effects of the different types of trash. Hand-picked cotton with no added trash was used as the check. The treatments were replicated six times. The samples were processed in a laboratory gin, and their fiber and yarn properties were evaluated as described above. Analysis of variance for comparisons among means were used to analyze the data.

Duncan Multiple Range tests were used to determine significant differences among the means.

The results for the fiber properties and yarn strength of stripped and spindle-picked cotton indicated that stripped cotton was of a lower quality than spindle-picked cotton. This was based on the fact that stripped cotton had lower grade, tenacity, micronaire index, 50 percent span length, 2.5 percent span length, and yarn strength for the combined analysis. On the other hand, stripped cotton had similar elongation values and significantly higher reflectance values. These results are very similar to those obtained by Garner et al. (6) in their three year study of fiber quality and spinning performance of stripped and spindle-picked cotton for the 'Auburn 56' variety at Clemson.

The results for the fiber properties and yarn strength of the hand-picked cotton with added increments of trash led to the following conclusions:

1. The addition of sticks to the hand-picked cotton tended to significantly lower elongation, 2.5 percent span length, and yarn strength.
2. Adding burr fragments to the hand-picked cotton tended to significantly lower the 2.5 percent span length and yarn strength.
3. The addition of stems tended to significantly lower yarn strength.
4. The addition of grass tended to significantly lower 2.5 percent span length.
5. Adding bracts to the hand-picked cotton did not have any apparent effect on the fiber properties and yarn strength.

6. The addition of leaves to the hand-picked cotton lowered the grades from Middling to Strict Low Middling.

7. No apparent relationships were found among the different types of trash for micronaire index, reflectance, and 50 percent span length.

No attempt was made to compare maturity groups because the early, mid-season, and late maturing varieties were all harvested on the same date, and also because the classification by maturity date was subjective in nature.

In relating the results obtained for the fiber properties and yarn strength of the hand-picked cotton with added increments of trash to the performance of stripped cotton, the following conclusions were drawn:

1. The lower grade of stripped cotton as compared to spindle-picked cotton was probably due to the excess leaves harvested by the stripper along with the bolls.

2. The lower 2.5 percent span length values of stripped cotton as compared to spindle-picked cotton were probably due in part to the presence of burrs and sticks which were harvested by the nonselective stripper along with the bolls. Fiber damages resulting from the ginning process also probably contributed to the shorter fibers.

3. The lower yarn strength of the stripped cotton as compared to the spindle-picked cotton was probably due in part to the presence of sticks, burrs, and stems harvested by the stripper along with the bolls. The wood fibers from these three types of trash probably contributed to the reduced yarn strength.

4. The lower micronaire index and 50 percent span length values of stripped cotton were not caused by the excess foreign matter contained in stripped cotton, but more likely by the presence of immature fibers and fiber damage resulting from the ginning process as previously discussed.

The differences in fiber properties and yarn strength for the two harvesting methods should be examined closely in order to determine which of these differences are truly meaningful for processing and end use value. It is recommended that further study and testing be done in an effort to determine whether the differences existing in fiber and yarn properties for cotton harvested by the two methods previously discussed are really significant from a practical standpoint with respect to processing.

Until modifications can be made on the stripper to prevent immature bolls from being mixed with the mature bolls, and to eliminate most of the trash content especially burrs, sticks, and stems, stripped cotton will be a lower quality product than spindle-picked cotton as determined by tenacity, micronaire index, span length, and yarn strength. Also since grade, staple length, and micronaire index determine the price of cotton in the present system, stripped cotton with its lower grade will not be as profitable as spindle-picked cotton.

It is recommended that further investigations be conducted to isolate and evaluate the individual effects of the various types of trash contained in stripped cotton.

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APPENDIX

TABLE VI

GRADES FOR TWELVE VARIETIES OF MACHINE HARVESTED
COTTON 1968 AND 1969 CROP

Variety	Type of Harvesting	Year	Grade
'Auburn M'	Picked	1968	SIM Lt. Sp.
	Stripped	1968	SGO+
	Picked	1969	LM
	Stripped	1969	SGO+
'Rex Smooth Leaf'	Picked	1968	LM
	Stripped	1968	SGO
	Picked	1969	LM+
	Stripped	1969	LM
Arkansas Experimental Stripper	Picked	1968	LM+
	Stripped	1968	SGO
	Picked	1969	LM
	Stripped	1969	SGO+
'Hancock'	Picked	1968	LM
	Stripped	1968	SGO
	Picked	1969	LM
	Stripped	1969	SGO
Experimental T-59-538	Picked	1968	LM+
	Stripped	1968	SGO
	Picked	1969	SGO+
	Stripped	1969	GO+
'Deltapine 45A'	Picked	1968	LM+
	Stripped	1968	SGO+
	Picked	1969	LM
	Stripped	1969	SGO+
'Dixie King II'	Picked	1968	LM+
	Stripped	1968	SGO+
	Picked	1969	LM
	Stripped	1969	SGO
'Deltapine 16'	Picked	1968	LM+
	Stripped	1968	SGO+
	Picked	1969	LM
	Stripped	1969	LM

TABLE VI (continued)

Variety	Type Harvesting	Year	Grade
'Deltaphine Smooth Leaf'	Picked	1968	LM+
	Stripped	1968	SGO+
	Picked	1969	LM
	Stripped	1969	SGO+
'McNair 1032'	Picked	1968	LM
	Stripped	1968	SGO+
	Picked	1969	LM
	Stripped	1969	SGO+
'Coker 413'	Picked	1968	LM+
	Stripped	1968	SGO+
	Picked	1969	LM
	Stripped	1969	SGO
'Stoneville 213'	Picked	1968	LM
	Stripped	1968	SGO+
	Picked	1969	LM
	Stripped	1969	SGO

VITA

Aurelio Lorenzo Infante was born in Holguin, Cuba, on February 16, 1941. He attended elementary schools in that city, and he obtained his High School diploma from the Instituto Holguin in 1957. He attended the University of Havana studying Agricultural Engineering from 1959 through 1961. He taught High School science and mathematics in Venezuela from 1961 to 1965. He received a Bachelor of Science degree in Agricultural Engineering from the University of Tennessee in March of 1968. In the Summer of 1968, he accepted a research assistantship at the University of Tennessee and began studying toward a Master's degree. This degree is to be granted in June of 1970.