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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR

COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 580 DECEMBER 1939

DIVISION OF AGRICULTURAL ENGINEERING

Mechanical Harvesting Of Cotton As Affected By Varietal Characteristics And Other Factors

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

T. O. WALTON, President

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The influence of cotton's varietal characteristics on the efficiency of mechanical harvesting, extracting, and cleaning equipment has not been fully realized until recent years. During the past ten years the Texas Station Cotton Harvester has been improved so that it will harvest 94 to 98 per cent of the cotton from varieties developed for mechanical harvesting. Experiments indicate that an ideal plant type is one having relatively short, short-noded fruiting branches, no vegetative branches, an open type growth, light foliage, storm resistance, and large strong bolls spread open enough to permit the locks of cotton to protrude from the bolls in a fluffy condition and borne singly on peduncles (boll stems) that will snap easily under tension but withstand plant agitation. In an effort to combine these qualities into one strain, new types of cotton are being developed through the process of breeding and selection. Some new strains developed compare favorably with most of the better known varieties in quality and lint turnout and, in addition, have the desired characteristics from the standpoint of mechanical harvesting. Many high yielding varieties are not adaptable to mechanical harvesting because of unsuitable vegetative characteristics.

One of the major unsolved problems in harvesting cotton by machinery is the lack of adequate equipment to remove the green-leaf trash from mechanically harvested cotton. Improvements in the Station Harvester and Extractor have resulted in greatly reducing the amount of green-leaf trash left in the harvested cotton, but further improvements are necessary before the cotton can be carried directly to the gin or bulked without danger of heating.

Varietal characteristics affecting the efficiency of mechanical cotton harvesters are shape and height of plant, length and number of branches, density of foliage, type of boll, whether bolls are borne singly rather than in fused clusters, storm resistance, fluffiness of the cotton, brittleness of branches and boll peduncles, and height of first branches above ground. Spacing of the plants in the row has also been found to be influential.

Physical factors and varietal characteristics influencing the efficiency of bur extracting equipment are feeding rate, which is determined by yield of cotton and rate of travel of machine; rate of flow of material through machine; speed of extractor saws; compactness of material; uniformity of distribution along saws; agitation of material; amount of burs and foreign trash; size, shape and weight of bur; degree of boll spread; fluffiness of cotton; storm resistance; and fiber drag between seeds.

The cleaning of mechanically harvested cotton is affected by several factors: previous handling; amount and kind of trash; type of cleaner; speed of cleaner parts; kind and condition of cleaner screen; rate of feeding; moisture content; and such fiber characteristics as density on seed, fineness, and length of staple.

Varietal types having medium-length staple and coarse-bodied fiber which is dense on the seed clean much better and produce higher grades than sparse-linted, fine, longer staple types of cotton.

The grade of mechanically harvested cotton is affected by the amount of trash; weather conditions; kind of trash; time of exposure; fiber injury by harvester, extractor, cleaner, and gin; and fiber characteristics such as fineness, density, and length.

Harvesting cotton mechanically does not appreciably affect the staple length of the cotton.

Under comparable conditions of plant type and growth the Texas Station Harvester harvests equally well cotton producing low or high yields.

CONTENTS

BULLETIN NO. 580 DECEMBER 1939

MECHANICAL HARVESTING OF COTTON AS AFFECTED BY VARIETAL CHARACTERISTICS AND OTHER FACTORS

H. P. Smith,[1] D. T. Killough,[2] D. L. Jones,[3] M. H. Byrom[4]

The efficiency of mechanical cotton harvesters depends, to a large extent, on cotton varietal characteristics. Many well-designed cotton harvesting machines may have failed largely because varietal characteristics were not given due consideration. The inventors looked upon all varieties of cotton as just cotton and apparently did not realize that there is relatively as much difference in varieties of cotton as there is in breeds of horses, cattle, sheep, or dogs.

When the Texas Station began work several years ago on the mechanical harvesting of cotton, it was recognized that varietal characteristics played an important part. It was generally known that a machine without change in adjustment could not harvest different varieties of cotton with equal degrees of efficiency (4, 5, 6).[5] Consequently, a number of commonly grown varieties, together with a number of new strains and varieties, have been tested for their suitability to machine harvesting.

New types of cotton are being developed through a breeding process of selection, crossing, and back-crossing for the purpose of combining in one strain as many as possible of the characteristics found to be most desirable from the standpoint of mechanical harvesting. Each year several hundred selections and hybrids are planted at both College Station and Lubbock. Notes are recorded on plant type and vegetative growth, boll type, leaf structure, storm resistance, yield, earliness, lint turnout, fiber characteristics, and other factors that may appear to affect the adaptability to machine harvesting. The most promising selections and crosses are increased and tested for their adaptability to machine harvesting, extracting, and cleaning. The newly developed varieties and strains reported in this bulletin are Ducona, Mebane 95 and 96, Mebane 140, Cut Leaf x Acala, Cut Leaf x Clark, Macha,[6] and Lightning Express x Westex.[7]

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[5]Numbers introduced thus throughout this bulletin refer to the bibliography.

[6]Mr. H. A. Macha of Tahoka, Texas, found this cotton in 1930 growing in a field of Half and Half. Selections were made for several years by Mr. Macha. Later, about 1936, Mr. D. L. Jones of the Lubbock Station made selections from Mr. Macha's field and named the type Macha.

[7]This cross was named Western Early in 1939.

Bulletins 452 and 511 of the Texas Station report the findings of these studies from 1927 to 1934, inclusive (7, 9). This bulletin reports results obtained during the four-year period 1935-1938 and treats largely of the reaction of varietal characteristics to machine harvesting.

Harvesting dates at College Station for the four years were: 1935, October 8 and 9; 1936, October 14; 1937, August 27 and 28; 1938, September 6 and 7. In 1935 and 1936 the cotton was practically all open and ready for harvest early in September, but a tractor was not available on which to mount the harvester.

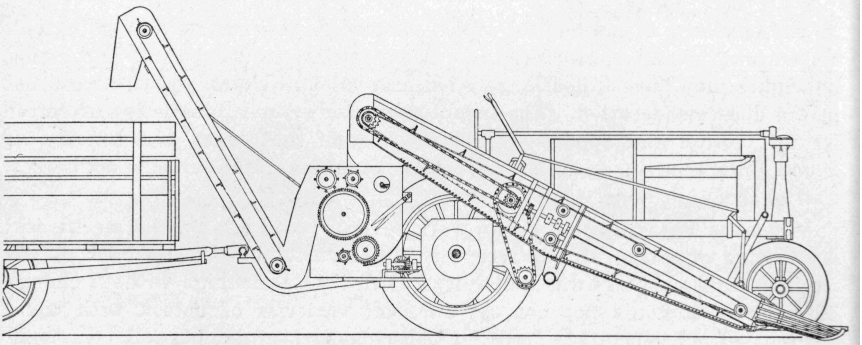


Figure 1. Cross section of Texas Station Harvester and Bur Extractor.

No tests were made at Lubbock in 1935 because of the drought. The cotton grown for mechanical harvesting during the three years 1936 to 1938 was irrigated, so that material for tests would be assured. Tests were made at Lubbock in 1936 on November 12, in 1937 on November 6, and in 1938 on November 9. Each year light frosts killed some of the leaves, but considerable green foliage was on the plants at harvest. In no case were 100 per cent of the bolls open, but most of the green, unopened bolls were thrown out with the burs by the extractor.

EQUIPMENT AND VARIETIES USED

Equipment

Texas Station Harvester: The machine used in the studies reported in this bulletin was first described in Texas Station Bulletin 452, page 24, 1932. Improvements made in the machine up to 1934 were enumerated in Bulletin 511, page 6, 1935. The principal changes made since 1935 are:

(1) The front bearings for the stripping rolls were mounted at the lower and front end;

(2) The size of the stripping rolls was reduced from $2\frac{3}{8}$ to $1\frac{7}{8}$ inches, outside diameter, and they were constructed of ordinary iron pipe with a knurled surface;

(3) In 1937 expanded sheet metal was used in the bottom of the conveyor troughs, giving considerably more open space for trash and dirt to sift through as the cotton was conveyed to the extractor unit. In 1938 perforated sheet metal was substituted for the expanded metal. Rectangular slots, $\frac{3}{8}$-inch by 1 29/32 inches with the length of the slots running crosswise the trough, screened out more green leaves, stems, and trash as the cotton moved over the slots. Figure 1 shows a cross section of the machine, figures 2 and 3 show it harvesting cotton at College Station, and figure 4 shows the machine harvesting cotton at Lubbock in early November 1938.

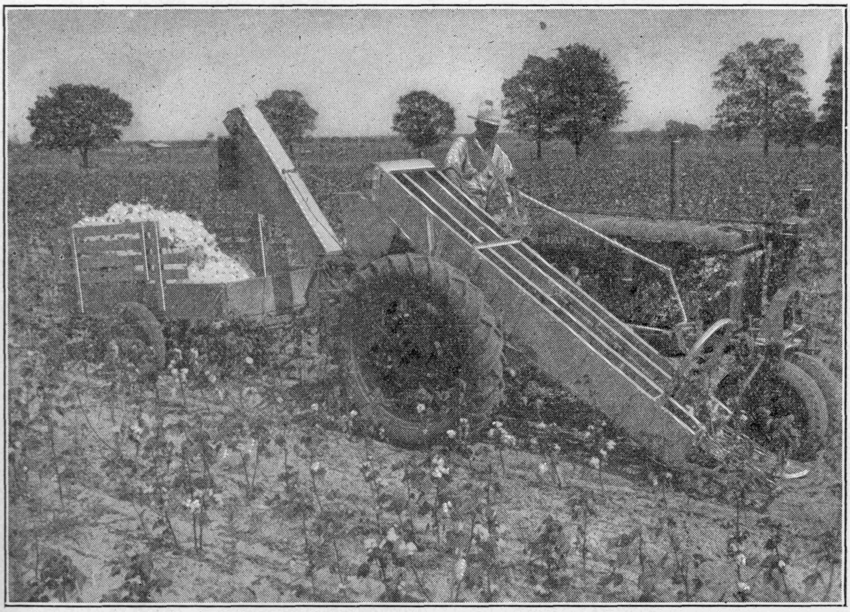


Figure 2. Texas Station Cotton Harvester and Bur Extractor harvesting and extracting cotton at College Station.

Texas Station Extractor: This machine was described in Bulletin 511, page 9, 1935. Figure 1 shows a cross section of the extractor and its position in relation to the harvesting unit as used in 1938. Figures 2 and 3 show the extractor mounted on a tractor with the harvester. Several changes have been made in the extractor since 1934, and these are:

(1) An auger was placed in the feed throat to distribute the stripped cotton along the extracting saw;

(2) Stronger stationary and oscillating fingers were installed to prevent their bending and catching on the extracting saws;

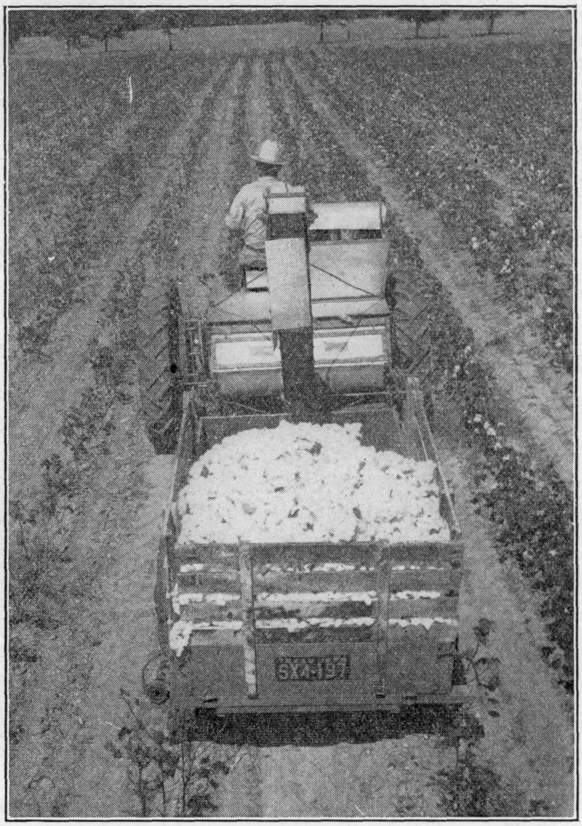


Figure 3. Rear view of Texas Station Cotton Harvester and Bur Extractor showing harvested and extracted cotton in trailer.

(3) A reclaiming saw was placed below the stationary and oscillating fingers and adjacent to the main extracting saw to reclaim cotton that dropped through the fingers with the burs;

(4) Stationary fingers of spring steel were installed with the ends curving under and fitting close to the reclaiming saw to direct the burs and any loose cotton in them under the reclaiming saw;

(5) A brush with 2-inch bristles was mounted at the ends of the spring steel stationary fingers to deflect the cotton in the burs up against the reclaiming saw and cause it to be more firmly impinged on the saw teeth; and

(6) A bur doffer was mounted to the rear of the reclaiming saw to doff the burs and prevent their following the reclaiming saw around and being crushed between it and the extracting saw.

Figure 4. The Texas Station Cotton Harvester harvesting cotton at Lubbock in November 1938.

Texas Station Vertical Cleaner: No changes have been made in this unit since it was described in Bulletin 511, page 10, 1935.

Varieties

During the four-year period, 1935-1938 a total of 18 varieties, strains of varieties, or progenies of crosses were tested from one to four years at College Station to determine the suitability of their varietal characteristics to mechanical harvesting, extracting, and cleaning. Lists of the varieties tested appear in the various tables. The more promising of these varieties will be tested further. Several strains of Ducona were tested, but data are shown only for the parent strain, which is typical for the variety.

At Lubbock 14 varieties were tested. These included some of the same varieties that were tested at College Station.

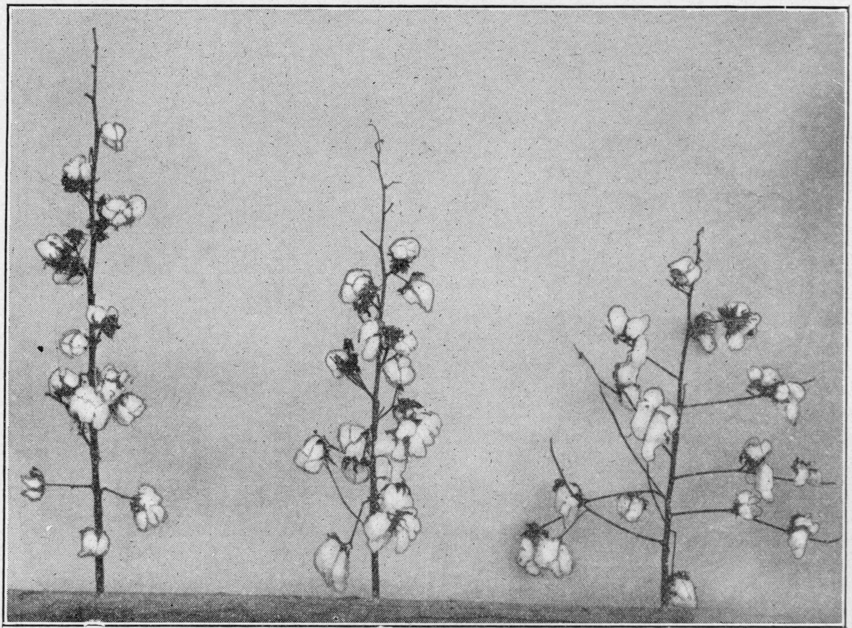
FACTORS AFFECTING THE EFFICIENCY OF COTTON HARVESTING MACHINERY

The factors affecting the efficiency of mechanical cotton harvesters may be classified as follows: varietal characteristics, mechanical factors, and cultural methods.

Varietal Characteristics

Plant characteristics which may affect the efficiency of any type of mechanical cotton harvester are as follows: (1) shape of plant, (2) height of plant, (3) length of branches, (4) number of branches, (5) density of foliage, (6) type of boll, (7) bolls borne singly or in clusters, (8) storm resistance, (9) degree of boll spread, (10) fluffiness of the cotton, (11) brittleness of branches and boll peduncles, and (12) height of first branches above ground.

Years have been spent testing varieties possessing variable characteristics, and it appears that an ideal plant type for both the mechanical stripper and the picker is one having relatively short-noded fruiting branches 8 to 10 inches in length, no vegetative branches, an open type growth, light foliage, storm resistance, and a medium to large strong boll borne singly on a peduncle that will snap easily under tension but will withstand plant agitation. When a variety has been developed that will meet these specifications, it will no doubt aid in increasing the effi-



1 2 3

Figure 5. Types of cotton plants. Plant 1 has short limbs with bolls borne in clusters; plant 2 has short limbs with bolls borne singly; and plant 3 has long limbs with long nodes. Plant 2 appears to be a more desirable type than either of the others.

ciency of harvesting machinery and in reducing the amount of green-leaf trash collected, thereby raising the grade of the harvested cotton.

One bad characteristic may be of such nature that it will offset the good qualities of a number of features. For example, if a variety produces numerous long branches that overlap between the rows, it would be difficult for any mechanism to harvest all of the cotton from such a mass of vegetation folded into a narrow space only a few inches wide. Also it would be almost impossible for a mechanical device to remove all the cotton from such a compressed mass of tangled vegetation, even though all other characteristics were excellent for mechanical harvesting.

Shape of plant: The suitability of a variety of cotton for mechanical harvesting is influenced by a number of varietal characteristics. From the stripper harvester standpoint, the foremost characteristic is plant type. A variety that produces a wide spreading type of plant with numerous long vegetative and fruiting branches is not suitable for the stripper harvester and will reduce the efficiency of the picker harvester.

Figure 5 shows three types of stalk development. Plant No. 1, on the left, has very short limbs to which are attached clusters of bolls by large short peduncles. The bolls on such a plant are hard to remove and many limbs are pulled from the main stalk with the bolls. On the other hand, the branches are too long and spreading on plant No. 3 and will cause lower machine efficiency. Plant No. 2 has medium-short fruiting branches with short nodes, and each boll is borne on a separate peduncle. Such growth is favorable for either mechanical stripping or picking of cotton. Figure 6 shows a type selected in August 1939, which has some of the characteristics of plant No. 2.

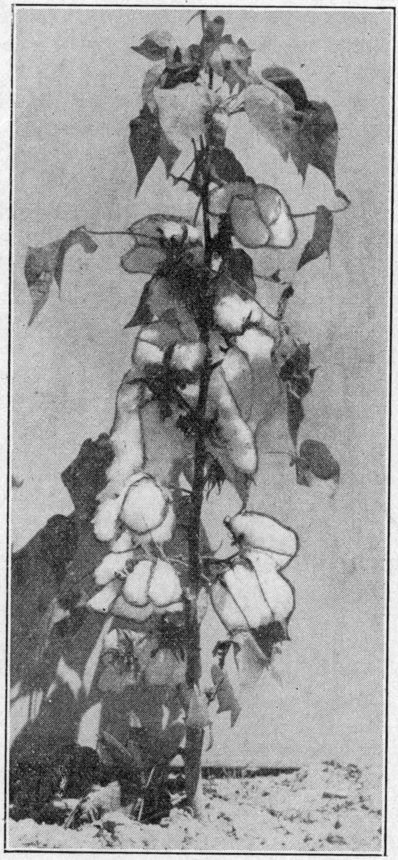


Figure 6. A desirable type of Ducona plant selected in 1939 for increase. This plant resembles plant No. 2 in Figure 5.

The original Ducona variety, which is better adapted to machine harvesting than most varieties, was bred for a plant type like No. 1 in Figure 5 but, proved objectionable because the peduncles were too strong, the bolls were borne in clusters, and the limbs were too short. The object of the present breeding program is to obtain a type similar to plant No. 2. Data in Table 1 show that for a four-year average at College Station, when harvesting Ducona cotton, the machine harvested 94.3 per cent of the cotton on the plants at harvest.

Height of plant: Medium-size cotton plants up to 36 inches in height can be handled successfully by cotton harvesting machinery. The tops of tall plants will not pass through the stripping rolls before they reach the rear end of the rolls, and other tall plants pressing against them form a mass of vegetative material and cause much needless foliage to be stripped off. Drums on a mechanical cotton picker usually do not exceed 30 inches in length, and tall cotton plants must be bent down within range of the picking units. This, of course, increases the volume of vegetation in contact with the picking units. Such a condition makes it difficult for any mechanical device to remove the cotton from the bolls which may be folded within.

Data collected but not presented show that the average height of cotton plants at College Station on uplands ranges from 30 to 32 inches. At Lubbock under irrigation the plant height averaged from 20 to 24 inches (Fig. 7.) A few plants were above 30 inches in height. The small plants at Lubbock gave higher average machine efficiency than the larger plants at College Station (Tables 1 and 2). The lowest efficiency obtained at Lubbock was 94.8 per cent for Burnett in 1936, while the highest was 99.2 per cent for Mebane 96 in 1937. A study of Table 2 shows that for the three years the loss by the harvester for all varieties at Lubbock averaged less than 2 per cent. Figure 8 shows a section of the field harvested in 1938 before the cotton lost by the harvester was picked up. It can be seen that only a few locks of cotton were lost.

Length of branches: The H. X., Rothcamp's Cluster, Roger's Cluster, and Clark varieties have numerous branches with a rather dense foliage and, as a result, machine efficiency ranged from 84.9 to 89.2 per cent for these varieties (Table 1). They do not appear, therefore, so suitable for mechanical harvesting as varieties such as Gorham's Lone Star, Mebane 140, Kinsler's Cluster, New Boykin, Kubela, Mebane 96, Cut Leaf x Acala, Cut Leaf x Clark, and Lightning Express x Westex. The average machine efficiency for these varieties ranged from a low of 92.0 per cent for Cut Leaf x Clark to a high of 97.3 per cent for Kinsler's Cluster (Table 1). The plant type for these varieties was rangy, with spreading limbs and considerable foliage. Even though Kinsler's Cluster gave high machine efficiency, it was discarded because the plant was too brittle.

Varieties producing branches long enough to meet, and sometimes overlap, between rows spaced 38 to 42 inches apart, create a close mass of matted vegetation from which mechanical picking devices have diffi-

Table 1. Varieties of cotton tested for machine efficiency, grade, staple, and acre yield at College Station

Variety	Percentage of machine efficiency of the Texas Station Harvester					Grade					Staple in 32nd inches					Acre yield of lint pounds				
	1935	1936	1937	1938	Av.	1935	1936	1937	1938	Av.	1935	1936	1937	1938	Av.	1935	1936	1937	1938	Av.
Ducona	92.7	90.7	96.5	97.2	94.3	LM	SGO	SLM	LM	LM	30	34	31	31	31	249	136	182	341	227
Gorham's Lone Star	90.6	92.8	92.7	97.4	93.4	LM	SLM	SLM+	SLM	SLM	29	31	30	29	30	309	55	220	262	212
Kelly's Lone Star	88.3	91.4	97.3	.....	92.3	LM+	LM	SLM+	.....	LM+	30	31	30	.....	30	250	69	234	.....	184
H. X.	89.2	.....	.....	.....	89.2	LM	.....	.....	.....	LM	29	.....	.....	.....	29	287	.....	.....	.....	287
Rothcamp's Cluster	90.5	87.9	.....	.....	89.2	LM	SGO	.....	.....	LM—	30	32	.....	.....	31	342	116	.....	.....	229
Roger's Cluster	84.9	.....	.....	.....	84.9	LM—	.....	.....	.....	LM—	30	.....	.....	.....	30	251	.....	.....	.....	251
Clark	78.5	.....	.....	93.7	86.1	LM—	.....	.....	SLM	LM	30	.....	.....	26	28	306	.....	.....	348	327
Price's Cut Leaf Acala	.....	89.1	94.7	88.9	90.9	.....	LM—	SLM+	SLM	SLM	.....	32	30	29	30	.....	59	216	216	164
Kubela	.....	.....	97.4	95.4	96.4	.....	.....	LM	LM+	LM	.....	.....	30	30	30	.....	.....	244	360	302
Mebane 140	.....	.....	95.4	94.2	94.8	.....	.....	M+	SLM+	M	.....	.....	28	26	27	.....	.....	278	374	326
New Boykin	.....	.....	95.8	94.8	95.3	.....	.....	SLM+	SLM	SLM+	.....	.....	30	28	29	.....	.....	198	276	237
Cut Leaf x Acala	.....	.....	.....	92.2	92.2	.....	.....	.....	SLM	SLM	.....	.....	.....	30	30	.....	.....	.....	263	263
Cut Leaf x Clark	.....	.....	.....	92.0	92.0	.....	.....	.....	SLM	SLM	.....	.....	.....	29	29	.....	.....	.....	254	254
Delta and Pine Land	.....	.....	.....	93.0	93.0	.....	.....	.....	SLM	SLM	.....	.....	.....	29	29	.....	.....	.....	388	388
Kinsler's Cluster	.....	.....	.....	97.3	97.3	.....	.....	.....	SLM+	SLM+	.....	.....	.....	28	28	.....	.....	.....	360	360
Mebane 96	.....	.....	.....	92.4	92.4	.....	.....	.....	SLM	SLM	.....	.....	.....	28	28	.....	.....	.....	371	371
Mebane 95	.....	.....	.....	89.1	89.1	.....	.....	.....	SLM	SLM	.....	.....	.....	29	29	.....	.....	.....	289	289
Lightning Express x Westex	.....	.....	.....	94.9	94.9	.....	.....	.....	SLM+	SLM+	.....	.....	.....	29	29	.....	.....	.....	408	408
Average	87.8	90.4	95.7	93.8	92.1	LM	LM—	SLM+	SLM	SLM+	29	31	29	28	29	285	87	225	322	282

Table 2. Varieties of cotton tested for machine efficiency, grade, staple, and acre yield at Lubbock

Variety	Percentage of machine efficiency of the Texas Station Harvester				Grade				Staple in 32nd inches				Acre yield of lint pounds			
	1936	1937	1938	Av.	1936	1937	1938	Av.	1936	1937	1938	Av.	1936	1937	1938	Av.
Ducona	97.4	....	98.1	97.8	LMsp*	....	M+	SLMsp	33	......	30	31	515	......	384	450
Mebane 140	98.3	....	....	98.3	SLMsp	....	....	SLMsp	30	......	......	30	559	......	......	559
Mebane 804	97.7	....	97.8	97.8	SLM	....	SM	M	31	......	30	30	572	......	291	432
Cut Leaf x Acala	97.8	99.1	97.4	98.1	SLM	M	M+	M	33	32	31	32	757	366	316	480
Burnett	94.8	98.6	96.5	96.6	SLMsp	M+	SM	M+	31	31	29	31	679	474	218	457
Kubela	98.5	99.0	96.0	97.8	SLM	M	M+	M	34	32	31	32	463	520	400	461
Clark	....	98.7	....	98.7	....	M+	....	M+	......	30	......	30	......	641	......	641
Mebane 95	....	97.6	....	97.6	....	M	....	M	......	29	......	29	......	535	......	535
Mebane 96	....	99.2	....	99.2	....	SM	....	SM	......	30	......	30	......	666	......	666
Lightning Express x Westex	....	99.1	98.1	98.6	....	SLM	SM	M	......	32	30	31	......	608	245	426
Cut Leaf x Clark	....	97.6	....	97.6	....	SLM+	....	SLM+	......	32	......	32	......	491	......	491
Macha	....	....	98.9	98.9	....	....	SM	SM	......	......	30	30	......	......	296	296
Acala	....	....	98.7	98.7	....	....	SM	SM	......	......	32	32	......	......	545	545
Ferguson 406	....	....	98.8	98.8	....	....	SM	SM	......	......	29	29	......	......	299	299
Average	97.4	98.6	97.8	98.2	SLMsp	M+	SM	M+	32	31	30	30	591	538	333	481

*SP—Spotted condition of the lint.

Figure 7. View of part of the field of varieties of cotton before harvesting with the Texas Station Harvester at Lubbock in 1938.

culty in removing the open cotton. Figure 9 shows how cotton is lost when long limbs are present. A contrast is seen in Figure 10 where the plant had short limbs and clusters of bolls.

Number of branches: A number of short, short-noded branches are more desirable than a few long branches with the bolls spaced several inches apart. One or two long branches that start near the base of the plant can cause the loss of more cotton with the stripper harvester than twice as many short branches uniformly spaced over the plant. Figures 9 and 10 show comparatively the influence of long and short branches on cotton losses.

Density of foliage: A dense foliage (Fig. 11) with great numbers of large stems hinders the operation of mechanical strippers and pickers by folding over the cotton and bolls. Dense foliage shades the bolls, delays their opening, reduces the degree of boll spread, and during damp weather may cause weak bolls and loss of cotton by rotting of bolls. Brown (2) states that the leaf blades of most species are rather thin and papery, but that some are thick and leathery. Efforts are being made to reduce the density of foliage on varieties for mechanical harvesting by adapting varieties with leaves of a deep-lobed or cut-leaf type (Fig. 12).

Figure 8. Field of cotton plants at Lubbock after harvesting with the Texas Station Harvester and before the cotton lost by the harvester had been collected, November 1938.

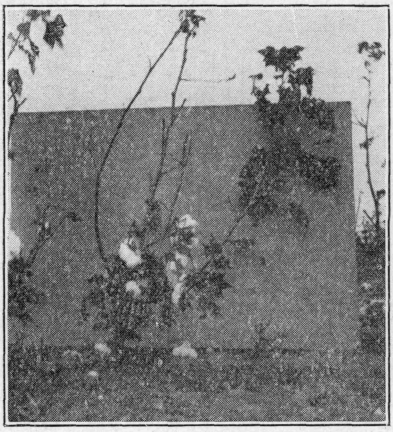


Figure 9. Showing how long branches cause the loss of cotton by folding around the bolls when harvested with the Texas Station Harvester.

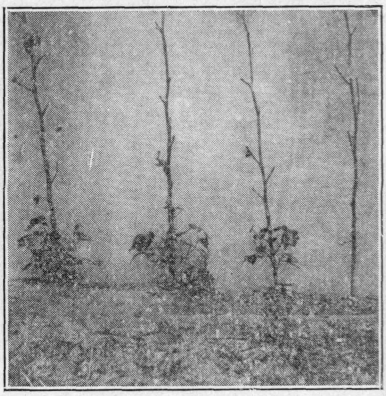


Figure 10. The cotton from plants with no long vegetative limbs is all removed by the Texas Station Harvester.

Type of boll: Large bolls are more suitable than small bolls for both mechanical stripping and picking. In stripping, the large bolls are usually stronger, more easily snapped off, and are more readily thrown from the stripping units into the conveyor trough than small bolls. Cotton in large bolls expands and fluffs out so the picker units can get hold of the cotton and remove it from the boll.

Single bolls versus clusters of bolls: Bolls borne singly are more satisfactory for all methods of harvest than two or more bolls attached to the same peduncle or boll stem. When a cluster of bolls opens, the carpels may overlap and even make picking by hand difficult. The peduncle or boll stem is larger where the bolls are borne in clusters than for single

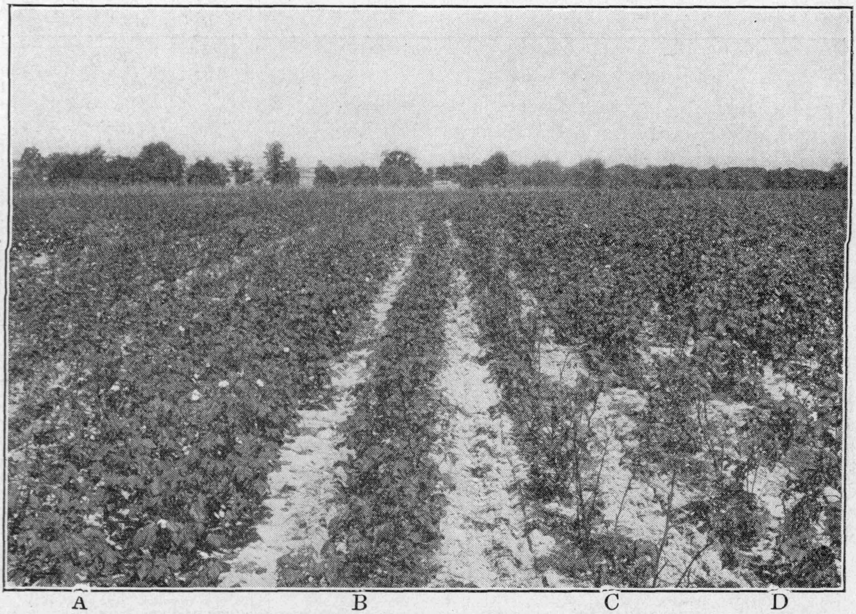


Figure 11. Dense foliage causes more green leaves to be removed when the cotton is harvested with machines. The cotton from rows B and C has been harvested by the Texas Station Harvester, while the cotton from rows A and D has not been harvested. Rows A and B are Gorham's Lone Star, and rows C and D are Ducona cotton. Note the amount of foliage left on the plants by the machine.

bolls, and this makes it harder to remove a cluster of bolls from the plant. A cluster of bolls will not readily pass through the extractor because of its size. Mechanical cotton pickers do not harvest cotton from bolls borne in clusters as efficiently as that from bolls borne singly, because one or two picking units cannot handle the amount of cotton concentrated in the cluster.

Storm resistance: Cotton hanging loosely in the boll often falls out as a result of the slightest jar to the plant. Gusts of wind and hard dashing rains may cause many locks to fall out on the ground. For mechanical harvesting, the cotton should be held firmly in the boll but should pull out fairly easily without leaving "tags" or one or two seeds of the lock between adjacent parts of the boll. Long, strung-out, dangling locks are often lost by the mechanical harvester, as the cotton catches, hangs, and wraps around parts of the plant when an attempt is made to harvest it.

Fluffiness of the cotton: Fluffiness of cotton is closely related to storm resistance, as many cottons that expand and fluff out of the boll are easily shaken from the plant. Many fluffy cottons, however, are rather

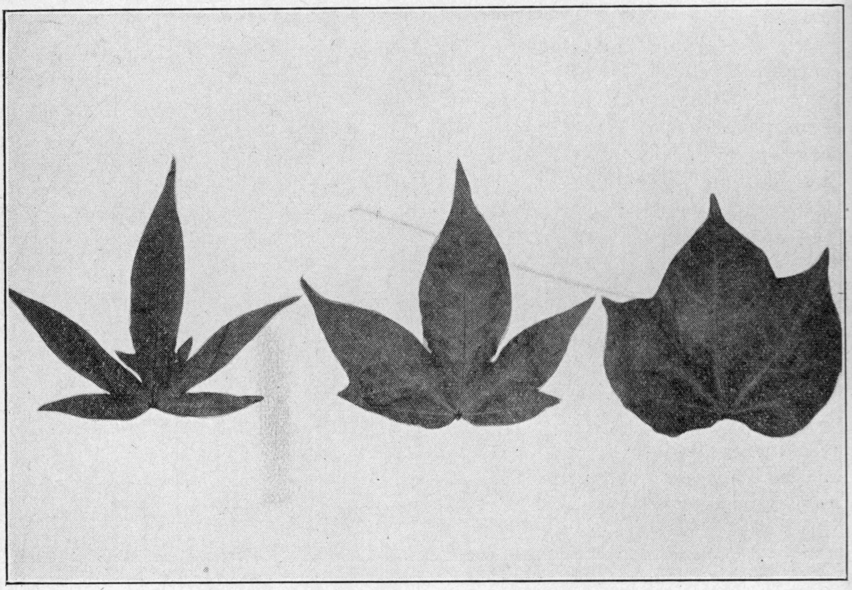


Figure 12. Three types of cotton leaves. The leaf on the left is a deep-lobed, cut-leaf, okra type; the one on the right is a typical leaf found on most varieties; and the leaf in the center is an intermediate type. Less trash in harvesting is collected from plants with smaller leaf areas.

storm resistant. Fluffiness is not an essential characteristic for mechanical stripping but is necessary for mechanical pickers so that the picking units can readily get hold of the fiber. In stripping, many of the fluffy locks are likely to catch on parts of the plant and be lost.

Degree of boll spread: A widely opened boll permits cotton to fluff out more than does a boll that is not opened wide. Cotton is easier to pick from widely spread bolls. Late maturing bolls that crack open from one-eighth to one-fourth inch may be termed "smiley" bolls, as the white cotton showing between the carpel edges resembles a row of white teeth when a person smiles.

Brittleness of branches and boll stems: In stripping cotton, the number of limbs removed depends, to a large extent, on their brittleness and the ease with which the peduncle or boll stem snaps. Table 10 shows that the pounds of pull required to remove bolls and the number of limbs pulled off with them vary with different varieties. The H. X. and Kelly's Lone Star varieties were discarded because of the quantity of limbs that broke off in harvesting.

Height of first branches above ground: The pick-up fingers of mechanical harvesters can slip under low branches without digging into the soil if the lowest branches are slightly above the ground. Seasonal conditions, particularly in the northwestern part of the state, will affect the height of the first branches. Bolls on branches near the ground are stripped from the plant by the pick-up fingers and swept into the machine by the plant. With mechanical pickers, the picking drums cannot be adjusted low enough for picking units to remove the cotton from bolls borne close to the ground. It is for this reason that the mechanical picker cannot harvest the low cotton from plants grown and left in lister furrows. The pick-up fingers on the Texas Station Harvester are so shaped that they will lift the low branches and remove the cotton from plants grown either in listed furrows or on ridges.

Mechanical Factors

Pick-up fingers: The first part of a cotton harvester which touches the cotton plant is the pick-up fingers (Figs. 2 and 4). They should be so shaped that they will slide under, lift up, guide, and fold the low branches into the narrow passage between stripper rolls or picker drums. They should be flexible enough not to ride over cotton plants when the machine gets slightly out of line with the row. It requires close attention and careful steering to keep a cotton harvester in perfect alignment with the row.

Stripping rolls: The size, length, type of surface, angle with ground, flexibility, tension, and peripheral speed of the rolls influence the efficiency of a mechanical stripper. The effect of these factors is discussed in detail in Station Bulletin 511, pages 11 to 19.

Stripper plate: Several devices were tried before a satisfactory method was found to remove the cotton from the stripping rolls without considerable loss of cotton. For smooth and knurled surface rolls, a one-inch flat steel bar set edgewise to the roll does excellent work. The bar is set directly under the center of the roll close enough to prevent cotton seed from passing between the bar and the roll. To prevent the stripper rolls from drawing cotton under the plate, the cotton should be moved away from the rolls as quickly as possible after it falls into the conveyor trough.

Rate of travel: Cotton must be harvested at a relatively slow rate of travel to obtain the highest efficiency. At fast speeds, it is difficult to steer the tractor to keep the harvester in alignment with the row, and the pick-up fingers will hit the base of the plants with such force that bolls will be shaken off. A fast speed will also cause the limbs to be whipped around with such force that some bolls will be thrown off and lost. It has been found in operating the Texas Station Harvester that speeds ranging from 1¼ to 1½ miles per hour give best results. The effect of harvesting in low, second, and high tractor gears is discussed in Station Bulletin 511, page 17.

Cultural Methods

To obtain the highest efficiency with mechancal harvesters it is necessary to practice cultural methods that will aid the performance of the machine. Best results are obtained when a slight ridge is left along the base of the plants. This sets the plants higher and makes them more accessible to the harvesting units and facilitates the operation of the pick-up fingers. Less trash from the ground is collected by the pick-up fingers when they are run close to the ground, as winds shift dead leaves and other loose trash into the protected depressions between the rows. Straight, uniformly-spaced rows give better machine performance than crooked and sharply curving rows.

Spacing of plants: Plants left unthinned increase the amount of foliage and the number of stalks, which have somewhat the same effect as long limbs. The bolls are folded in between plants, thus hindering their removal. Spacing of 9 to 12 inches is satisfactory, while plants spaced widely apart often grow too large and usually have several long limbs.

EFFECT OF DIFFERENT HARVESTING METHODS ON THE QUALITY OF COTTON

Two general methods of harvesting cotton are practiced in Texas—hand-picking in the central, southern and eastern areas and hand-snapping in the northwestern part.

The picking of cotton by hand often is done carelessly and much trash in the form of dead leaves, bract trash, and parts of burs is collected with the cotton. Trashy hand-picked cotton is run through cleaning machinery at the gin but, even so, not all of the trash is removed and lower grades are the result.

Hand-snapping is the practice of pulling individual bolls by hand. This selected method of snapping is used during the early season and until a killing frost occurs. In snapping cotton only those bolls that are fully matured and open should be harvested. Snapped cotton should not be tramped in the wagon because the trash becomes more intermingled with the fiber and makes it harder to remove. After frost when the leaves are dead and the bolls are open or dry, all the cotton is removed from the plant in one operation—i. e., the hands are placed on each side of the plant near the base and moved upward to the top, removing all bolls and cotton. This method is termed "pulling cotton." Where the plants are fairly large and branching, pulling is impractical and the cotton is snapped, one or two bolls at a time.

Of course, much trash is collected with the cotton in either snapping or pulling, and the cotton trade has tried to discourage these methods of harvesting, with meager or no response. In fact, the practice of snapping is spreading. Reports in 1938 indicated that some hand-snapping was done in the extreme southern part of the State.

Hand-picked and hand-snapped cotton: Because of the widespread practice of snapping, samples of hand-picked and hand-snapped cotton were collected in 1938 from several varieties of short, medium, and long staple cottons at Lubbock, Spur, and Chillicothe to compare grade, staple, and character as influenced by methods of harvesting. The snapped cotton was run through the Station Bur Extractor to remove the burs and as much trash as possible. Both the hand-picked and hand-snapped cottons were cleaned with the Station Cylinder Cleaner and all samples ginned on a 20-saw gin. Table 3 shows that all samples from the three locations classed strict middling, regardless of the method of harvesting. The greatest difference was in the staple length and character of the cotton.

At Lubbock two of the six varieties showed longer staple for hand-snapped than hand-picked cotton, while only one was longer for the picked cotton. The other three varieties showed the same length for the two methods of harvest. At Spur longer staple was obtained for hand-snapped Bryant's Mebane, while Missdel classed longer for the hand-picked cotton. Four varieties were of equal length for the two methods of harvest. Two varieties at Chillicothe showed longer staple for hand-picked cotton. Other varieties were the same length. These differences in length of staple are probably due to environmental conditions in the field (perhaps to soil moisture) and not to the method of harvesting. The hand-picked cotton was run through a cleaner only, while the snapped cotton was run through both an extractor and a cleaner.

Cotton from Spur had shorter staple and poorer character than cotton from Lubbock or Chillicothe. This probably can be attributed to differences in weather conditions; therefore, different conditions give different results and the data given for one year should not be taken as conclusive.

Hand-picked, hand-snapped, and machine-harvested cotton: Tables 4 and 5 show a comparison of grades obtained when cotton was harvested by hand-picking, hand-snapping, and machine-harvesting (stripping). Table 4 shows that for 1938 at College Station for all varieties tested the hand-picked cotton averaged middling plus; hand-snapped, middling; and machine-harvested, strict low middling minus. There was a half grade difference in hand-picked and hand-snapped cotton and one and one-half grades difference in hand-picked and machine-harvested cotton.

Table 3. Comparison of hand-picked and hand-snapped cotton at Lubbock, Spur, and Chillicothe for 1938

Variety	Lubbock						Spur						Chillicothe					
	Grade	Length of staple in 32nd inches	Character		Per cent		Grade	Length of staple in 32nd inches	Character		Per cent		Grade	Length of staple in 32nd inches	Character		Per cent	
			Body	Uniformity	Clean seed cotton	Lint turn-out			Body	Uniformity	Clean seed cotton	Lint turn-out			Body	Uniformity	Clean seed cotton	Lint turn-out
Hand-picked																		
Mebane	SM	31	good	good	98.4	37.2	SM	20	weak	wasty	97.9	41.7	SM	30	weak	good	98.1	38.0
Half and Half	SM	28	weak	wasty	97.6	44.0	SM	26	weak	wasty	97.2	34.8	SM	26	weak	good	97.9	43.0
Stoneville	SM	32	good	good	97.3	34.2	SM	26	weak	wasty	97.8	33.8						
Delta and Pine Land	SM	32	good	good	97.3	37.5												
Mebane 141	SM	31	good	good	97.8	36.7												
Hurley Special	SM	32	good	good	98.0	34.2												
Missdel							SM	29	weak	wasty	97.2	29.6						
New Boykin							SM	26	weak	wasty	97.9	35.5						
Mebane (Bryant's)							SM	26	weak	wasty	97.4	38.4						
Watson							SM	28	weak	wasty	98.2	37.5	SM	30	weak	good	98.1	37.0
Mebane 140													SM	29	weak	good	98.9	38.6
Acala 8													SM	33	good	good	98.4	37.4
Roger's Acala													SM	32	weak	good	97.9	36.1
Hand-snapped																		
Mebane	SM	32	good	good	69.1	37.2	SM	20	weak	wasty	69.3	42.3	SM	29	weak	good	70.9	38.4
Half and Half	SM	30	weak	good	72.1	44.2	SM	26	weak	wasty	68.5	34.3	SM	26	weak	wasty	75.0	43.0
Stoneville	SM	32	weak	good	70.7	34.2	SM	26	weak	wasty	67.0	35.5						
Delta and Pine Land	SM	32	good	good	70.7	37.9												
Mebane 141	SM	30	weak	good	70.4	36.8												
Hurley Special	SM	32	good	good	68.4	33.9												
Missdel							SM	28	weak	good	65.1	29.6						
New Boykin							SM	26	weak	wasty	69.4	35.1						
Mebane (Bryant's)							SM	28	good	good	66.5	39.4						
Watson							SM	28	weak	good	69.1	36.7	SM	30	weak	good	73.0	36.6
Mebane 140													SM	29	weak	good	76.7	38.1
Acala 8													SM	32	weak	good	71.4	36.6
Roger's Acala													SM	32	weak	good	70.9	36.0

Table 4. Grade of varieties of cotton when hand-picked, hand-snapped, and machine-harvested at College Station*

Variety	Hand-picked					Hand-snapped	Machine-harvested					Differences between hand-picked and machine-harvested cotton
	1935	1936	1937	1938	Average	1938	1935	1936	1937	1938	Average	
Ducona	SLM	SLM	M	M+	SLM+	SLM	LM	SGO	SLM	LM	LM	1½
Gorham's Lone Star	...	Msp†	M+	SM	M+	M+	LM	SLM	SLM+	SLM	SLM	1½
Kelly's Lone Star	...	SLM	SM	...	M	...	LM+	LM	SLM+	...	SLM—	1½
H. X.	...	...	...	...	...	...	LM	...	...	...	LM	...
Rothcamp's Cluster	...	SLM	...	...	SLM	...	LM	SGO	...	...	SGO+	1½
Roger's Cluster	...	...	...	...	...	...	LM—	...	...	...	LM—	...
Clark	...	...	...	M+	M+	M	LM—	...	...	SLM	LM+	2
Price's Cut Leaf Acala	...	...	M	M+	M	SLM+	...	LM—	SLM+	SLM	SLM—	1½
Kubela	...	...	M+	M+	M+	M	...	...	LM	LM+	LM	2½
Mebane 140	...	...	M+	SM	SM—	M	...	...	M+	SLM+	M	½
New Boykin	...	...	M+	SM	SM—	M	...	...	SLM+	SLM	SLM	1½
Cut Leaf x Acala	...	...	...	M+	M+	SLM+	...	...	...	SLM	SLM	1½
Cut Leaf x Clark	...	...	...	M+	M+	SLM+	...	...	...	SLM	SLM	1½
Delta and Pine Land	...	...	...	SM	SM	M	...	...	...	SLM	SLM	2
Kinsler's Cluster	...	...	...	SM	SM	SLM+	...	...	...	SLM+	SLM+	1½
Mebane 96	...	...	...	SM	SM	M+	...	...	...	SLM+	SLM+	1½
Mebane 95	...	...	...	SM	SM	M	...	...	...	SLM	SLM	2
Lightning Express x Westex	...	...	...	M+	M+	M+	...	...	...	SLM+	SLM+	1
Average	SLM	SLM	M+	SM	M+	M	LM	LM—	SLM+	SLM	SLM	1½

*The nine official American grades of cotton are designated as follows:

1. Middling fair (MF).
2. Strict good middling (SGM).
3. Good middling (GM).
4. Strict middling (SM).
5. Middling (M).
6. Strict low middling (SLM).
7. Low middling (LM).
8. Strict good ordinary (SGO).
9. Good ordinary (GO).

†SP.—Spotted condition of the lint.

Table 5. Grades of varieties of cotton when hand-picked, hand-snapped, and machine-harvested at Lubbock

Variety	Hand-picked				Hand-snapped			Machine-harvested				Differences between hand-snapped and machine-harvested cotton
	1936	1937	1938	Average	1937	1938	Average	1936	1937	1938	Average	
Ducona	Msp*	....	SM	M +	....	SM	SM	LMsp	....	M +	SLMsp	3
Mebane 140	M +	....	....	M +	....	....	....	SLMsp	....	....	SLMsp	....
Mebane 804	M +	....	SM	SM—	....	GM	GM	SLM	....	SM	M	2
Cut Leaf x Acala	M	GM	GM	SM +	M +	SM	SM—	SLM	M	M +	M	½
Burnett	M	GM	SM	SM	SM	SM	SM	SLMsp	M +	SM	M	1
Kubela	M	SM	SM	SM—	M +	SM	SM—	SLM	M	M +	M	½
Clark (late)	....	SM	....	SM	SM	....	SM	....	M +	....	M +	½
Mebane 95	....	SM	....	SM	SM	....	SM	....	M	....	M	1
Mebane 96	....	SM	....	SM	SM	....	SM	....	SM	....	SM	0
Lightning Express x Westex	....	GM	SM	SM +	M +	SM	SM—	....	SLM	SM	M	½
Cut Leaf x Clark	....	GM	....	GM	SM	....	SM	....	SLM +	....	SLM +	1½
Macha	....	....	SM	SM	....	SM	SM	....	....	SM	SM	0
Acala	....	....	SM	SM	....	M +	M +	....	....	SM	SM	+ ½
Ferguson 406	....	....	SM	SM	....	SM	SM	....	....	SM	SM	0
Average	M	SM +	SM	SM	SM	SM	SM	SLMsp	M	SM	M	¾

*SP—Spotted condition of the lint.

Table 6. Staple length, in thirty-seconds of an inch, of varieties of cotton when hand-picked, hand-snapped, and machine-harvested at College Station

Variety	Hand-picked					Hand-snapped 1938	Machine-harvested				
	1935	1936	1937	1938	Average		1935	1936	1937	1938	Average
Ducona	31	34	32	32	32	31	30	34	31	31	31
Gorham's Lone Star	...	32	29	30	30	30	29	31	30	29	31
Kelly's Lone Star	...	32	30	...	31	...	30	31	30	...	30
H. X.	...	...	...	...	...	...	29	...	...	...	29
Rothcamp's Cluster	...	32	...	...	32	...	30	32	...	...	31
Roger's Cluster	...	...	...	...	...	...	30	...	...	...	30
Clark	...	...	...	...	...	...	30	...	...	...	30
Price's Cut Leaf Acala	...	32	30	30	31	30	...	...	30	29	30
Kubela	...	...	30	31	30	30	...	...	30	30	30
Mebane 140	...	...	31	...	31	...	...	...	28	...	28
New Boykin	...	...	28	29	28	28	...	...	30	28	29
Cut Leaf x Acala	...	...	...	30	30	29	...	...	...	30	30
Cut Leaf x Clark	...	...	...	30	30	30	...	...	...	29	29
Delta and Pine Land	...	...	...	30	30	31	...	...	...	29	29
Kinsler's Cluster	...	...	...	29	29	29	...	...	...	28	28
Mebane 96	...	...	...	28	28	28	...	...	...	28	28
Mebane 95	...	...	...	29	29	28	...	...	...	29	29
Lightning Express x Westex	...	...	...	30	30	29	...	...	...	29	29
Average	31.0	32.4	30.0	29.8	30.0	29.4	29.7	32.0	29.9	29.1	29.5

Table 7. Staple length, in thirty-seconds of an inch, of varieties of cotton when hand-picked, hand-snapped, and machine-harvested at Lubbock

Variety	Hand-picked				Hand-snapped			Machine-harvested			
	1936	1937	1938	Average	1937	1938	Average	1936	1937	1938	Average
Ducona	34	......	30	32	......	28	28	33	......	30	31
Mebane 140	31	......	......	31	......	......	......	30	......	......	30
Mebane 804	32	......	30	31	......	30	30	31	......	30	30
Cut Leaf x Acala	34	31	29	31	31	32	31	33	32	31	32
Burnett	33	28	29	30	30	30	30	31	31	29	30
Kubela	32	31	32	32	31	31	31	32	32	31	32
Clark (late)	......	29	......	29	30	......	30	......	30	......	30
Mebane 95	......	28	......	28	29	......	29	......	29	......	29
Mebane 96	......	28	......	28	30	......	30	......	30	......	30
Lightning Express x Westex	......	32	30	31	30	32	31	......	32	30	31
Cut Leaf x Clark	......	31	......	31	31	......	31	......	32	......	32
Macha	......	......	29	29	......	30	30	......	......	30	30
Acala	......	......	33	33	......	32	32	......	......	32	32
Ferguson 406	......	......	29	29	......	30	30	......	......	29	29
Average	32.7	29.8	30.1	30.4	30.2	30.6	30.2	31.7	31.0	30.2	30.6

Comparison of data for two years at Lubbock showed a slight difference in favor of hand-picked over hand-snapped cotton (Table 5). Both averaged strict middling for the two years. In 1937 machine-harvested cotton averaged one grade lower than hand-snapped cotton, but in 1938 the average for the three methods of harvesting was strict middling.

Tables 6 and 7 show a comparison of staple length for the three methods of harvest at College Station and Lubbock. The hand-picked cotton at College Station in 1938 averaged approximately one sixty-fourth inch longer than hand-snapped or machine-harvested cotton (Table 6). For the same year at Lubbock the hand-snapped cotton was slightly longer than cotton harvested by the other two methods (Table 7). In 1937, however, machine-harvested cotton at Lubbock averaged about one thirty-second inch longer than cotton picked or snapped. The data shown in Tables 6 and 7 do not indicate that machine harvesting and extracting affect the staple of the cotton to any appreciable extent. The slight variations in staple length that occur are no doubt due largely to environmental conditions in the field rather than to methods of harvesting.

EXTRACTING QUALITIES OF VARIETIES

In these studies on extracting cotton the harvested cotton was conveyed directly to the extractor, which was mounted on the drawbar of the tractor; and the burs, green bolls, and as much of the green-leaf and other trash as possible were removed before the cotton was conveyed to the trailer (Fig. 1).

The function of an extractor, as used in the field in combination with a cotton harvester of the stripper type, is the removal of burs, green, unopened bolls, either mature or immature, dry hard bolls resulting from insect injury, sticks, rocks, sections of limbs, leaf stems, and leaf sections of various sizes.

Factors affecting the efficiency of extracting equipment used in combination with harvesting equipment may be classed as varietal characteristics and mechanical and other factors.

Varietal Characteristics

The varietal characteristics affecting the efficiency of an extractor are: (1) feeding rate or rate of inflow of material as affected by yield; (2) amount of burs, unopened bolls, limbs, sticks, stems, and leaves mixed with cotton; (3) size of boll; (4) shape of boll; (5) weight of burs; (6) degree of boll spread (how wide the boll carpels spread apart when the boll is completely open); (7) fluffiness or protrusion of cotton from the boll; (8) degree of storm resistance (how hard the cotton is to remove from the boll); and (9) interlocking pull of fibers between seeds.

Rate of feeding: When the harvester and extractor are in operation, the cotton fed into the extractor varies as the yield varies along the row and as the rate of travel varies. These factors were found to affect the efficiency of the extractor.

Amount of burs and trash in cotton: The ratio of cotton to the amount of burs, unopened bolls, limbs, sticks, stems, and leaves has a direct bearing on the efficiency of the extractor and the cleanliness of the extracted cotton. A large amount of foreign material will prevent the cotton from touching the saw teeth readily and more limbs, stems, and sections of leaves will be caught by the saws and thrown out with the cotton.

Size of bolls: Minor adjustments on the extractor enable it to extract equally well from either small or large bolls, provided they are open wide enough. Small burs will flow through the extractor faster than large ones, because they pass between the fingers more readily. Large burs remaining on the fingers after the cotton has been extracted enlarges the volume of material, reduces efficiency, and increases the amount of boll shale, as the burs will be repeatedly thrown against the extractor saw teeth and chips cut out and mixed with the cotton.

Shape of boll: It appears that cotton can be extracted from round, blunt-pointed bolls better than from tapering, pointed bolls, as it is more likely to be fluffed out beyond the ends of the bur carpels. Thin, weak bolls are often crushed by the stripping rolls of the harvester as they are pulled from the plant. As a rule, single carpels are easier to separate from the cotton than whole burs. These carpels, however, sometimes get by the bur doffer and pass out with the cotton. Whole burs cannot get by the doffer and must pass downward between the fingers of the extractor. Bolls are seldom crushed by the extractor, and strong bolls are not crushed as badly in harvesting as weak bolls.

Weight of burs: The size of the bolls and the thickness of the bur determine, to a large extent, the weight and percentage of trash removed by the extractor, as shown in Tables 8 and 9, for varieties harvested at College Station and Lubbock. At both locations harvesting the Ducona variety, which has medium-sized bolls with thick burs, showed that approximately 35 per cent of the total material harvested was trash removed by the extractor. At College Station for the same period Gorham's Lone Star, which is a big boll cotton, averaged 30.7 per cent trash (Table 8). Several other varieties were lower for one-year periods. Table 9 shows that the Lightning Express x Westex cross, having a medium-sized boll with thin burs, averaged 25.4 per cent burs and trash removed by the extractor. The average removed by the cleaner for this variety was 5.9 per cent, leaving an average of 68.7 per cent clean seed cotton, which is 5 per cent above the general average of all varieties. For all varieties at both College Station and Lubbock a general average of approximately 31 per cent of the total material harvested was removed by the extractor (Tables 8 and 9).

Degree of boll spread: The wider a boll is spread open the easier it is for the extractor saws to catch and remove the cotton. Figure 17 shows how the degree of boll spread was measured. The spread varies from year to year, with the season and the variety, as shown in Tables 13 and 14. Such conditions may affect the efficiency of the extractor.

Table 8. The percentage of trash removed from different varieties of cotton by the Texas Station Extractor and the Cylinder Cleaner at College Station

Variety	Extractor					Cylinder Cleaner					Percentage of Seed Cotton remaining				
	1935	1936	1937	1938	Average	1935	1936	1937	1938	Average	1935	1936	1937	1938	Average
Ducona	31.3	36.6	39.4	33.4	35.2	9.0	6.4	6.3	10.0	7.9	59.7	57.0	54.3	56.5	56.9
Gorham's Lone Star	26.9	36.0	31.9	28.1	30.7	10.7	4.9	8.1	11.1	8.7	62.4	59.1	60.0	60.8	60.6
Kelly's Lone Star	18.3	34.1	30.0	....	27.5	7.0	4.1	6.8	....	6.0	74.7	61.1	63.2	....	66.3
H. X.	27.7	....	....	....	27.7	8.8	....	....	....	8.8	63.5	....	....	....	63.5
Rothcamp's Cluster	22.3	37.5	....	....	29.9	8.7	10.2	....	....	9.5	69.0	52.1	....	....	60.5
Roger's Cluster	27.8	....	....	....	27.8	6.4	....	....	....	6.4	65.8	....	....	....	65.8
Clark	26.7	....	....	31.6	29.2	7.8	....	....	6.9	7.1	65.9	....	....	61.5	63.7
Price's Cut Leaf Acala	....	35.0	30.6	31.5	32.4	....	5.5	4.7	8.6	6.2	....	59.2	64.7	59.9	61.3
Kubela	....	....	33.7	31.0	32.3	....	....	5.5	7.9	6.7	....	....	60.8	61.1	61.0
Mebane 140	....	....	30.0	31.1	30.5	....	....	4.2	8.1	6.1	....	....	65.9	60.8	63.4
New Boykin	....	....	32.6	29.8	31.2	....	....	7.1	9.7	8.4	....	....	60.3	60.4	60.4
Cut Leaf x Acala	....	....	....	31.4	31.4	....	....	....	5.1	5.1	....	....	....	63.5	63.5
Cut Leaf x Clark	....	....	....	31.0	31.0	....	....	....	6.9	6.9	....	....	....	62.0	62.0
Delta and Pine Land	....	....	....	31.7	31.7	....	....	....	8.1	8.1	....	....	....	60.2	60.2
Kinsler's Cluster	....	....	....	28.4	28.4	....	....	....	10.5	10.5	....	....	....	61.1	61.1
Mebane 96	....	....	....	35.5	35.5	....	....	....	5.8	5.8	....	....	....	58.7	58.7
Mebane 95	....	....	....	33.4	33.4	....	....	....	8.3	8.3	....	....	....	58.3	58.3
Lightning Express x Westex	....	....	....	29.8	29.8	....	....	....	8.0	8.0	....	....	....	62.2	62.2
Average	25.8	35.8	32.6	31.3	30.9	8.3	6.2	6.1	8.2	7.5	65.9	57.7	61.3	60.5	61.6

Table 9. The percentage of trash removed from different varieties of cotton by the Texas Station Extractor and the Cylinder Cleaner at Lubbock

Variety	Extractor				Cylinder Cleaner				Percentage of Seed Cotton remaining			
	1936	1937	1938	Average	1936	1937	1938	Average	1936	1937	1938	Average
Mebane 804	30.3	......	31.4	30.8	1.4	......	4.0	2.7	68.4	......	64.6	66.5
Burnett	36.8	29.7	31.9	32.8	1.8	3.9	3.0	2.9	61.5	66.4	65.1	64.3
Mebane 140	36.9	......	......	36.9	2.2	......	......	2.2	60.9	......	......	60.9
Cut Leaf x Acala	32.1	28.8	28.4	29.8	1.9	6.2	5.0	4.3	66.0	65.0	66.6	65.9
Ducona	40.0	......	29.9	34.9	1.7	......	3.9	2.8	58.3	......	66.2	62.2
Kubela	24.7	30.6	29.8	28.4	2.3	7.5	6.7	5.5	73.0	61.9	63.5	66.1
Clark (late)	......	31.6	......	31.6	......	7.9	......	7.9	......	60.6	......	60.6
Mebane 95	......	31.0	......	31.0	......	8.9	......	8.9	......	60.0	......	60.0
Mebane 96	......	36.5	......	36.5	......	3.8	......	3.8	......	49.7	......	49.7
Lightning Express x Westex	......	26.4	24.4	25.4	......	7.7	4.1	5.9	......	65.9	71.5	68.7
Cut Leaf x Clark	......	29.4	......	29.4	......	6.8	......	6.8	......	63.8	......	63.8
Macha	......	......	26.5	26.5	......	......	5.0	5.0	......	......	68.5	68.5
Acala	......	......	29.6	29.6	......	......	4.2	4.2	......	......	66.2	66.2
Ferguson 406	......	......	27.9	27.9	......	......	3.6	3.6	......	......	68.5	68.5
Average	33.4	30.5	28.9	30.8	1.9	6.6	4.4	4.8	64.7	61.7	66.7	63.7

Fluffiness: Cotton that expands and fluffs out beyond the boll carpels enables the extractor saw teeth to engage the fibers and pull the cotton from the boll. On the other hand, it is difficult for the saw teeth to catch and remove cotton not fluffed out beyond the boll carpels.

Storm resistance: Open bolls that hold the cotton well during storms or periods of windy weather are termed storm proof. The lower part of each lock is held rather securely between adjacent parts of the bur. Should the lock be held too firmly, it is hard for the extractor to remove all of the cotton. One or two seeds may be left in the bur, and these are usually termed "tags." It is desirable to have sufficient storm resistance for the cotton to remain in the boll until harvested but pull from the boll easily enough for good extraction. This is also an important point in the use of the mechanical picker. The Macha cotton (Figs. 7 and 13) tested at Lubbock in 1938 is extremely storm resistant—so much so that it is difficult to extract without crushing the boll. A number of fibers of each lock are usually attached to the sides of the bur carpels (Fig. 13). The fiber did not expand enough to project

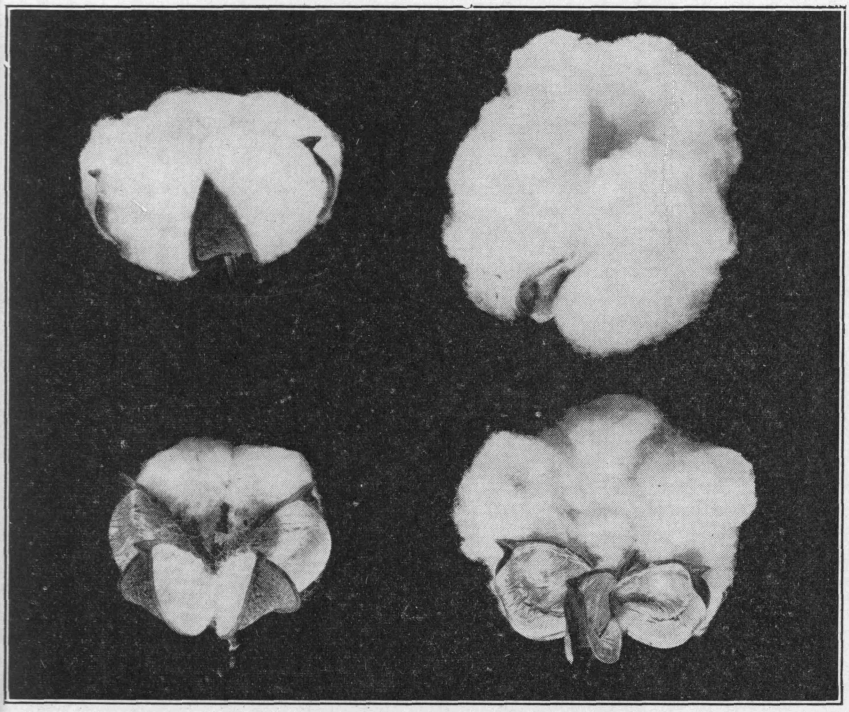


Figure 13. Macha bolls on the left and a common cotton boll on the right. Note the differences in the fluffiness and the fibers hanging to the boll of the highly storm resistant Macha bur, lower left.

beyond the points of the carpels; consequently, some machining of the fiber occurred in the extracting process.

Fiber drag between seed: Fiber drag is the resistance offered to the separation of the seeds of a lock of cotton. It is not uncommon to see a lock of cotton strung out and the seeds almost separated as they hang in the boll, showing the lack of fiber drag between seeds. For good extracting there should be enough fiber drag between seeds of a lock of cotton to enable the coarse extractor saw teeth to catch firmly and pull the cotton from the bur.

Tests indicated that the interlocking pull or drag of fibers between seeds of a lock of the Macha variety was as much as two pounds, while in ordinary varieties the average pull did not exceed one-half pound. A certain amount of inter-seed drag is essential in removing the cotton from the boll for both the extractor and the mechanical picker. The Lightning Express x Westex cross appears to be rather storm resistant and has enough fiber drag between seeds for good mechanical extraction and picking.

Mechanical and Other Factors

Mechanical and other factors that affect the efficiency of extracting equipment are: (1) rate of travel along row, (2) rate of flow of material through machine, (3) speed of extractor saws, (4) compactness of material presented to extractor saws, (5) uniformity of distribution of material along extractor saws, and (6) agitation of material presented to extractor saws.

Rate of travel: It is obvious that when the cotton harvester is traveling along the row at 2 miles an hour more cotton will be fed into the extractor than when traveling at 1¼ or 1½ miles an hour, which is the usual rate of travel. Consequently, when harvesting unusually heavy yields, cotton may be fed into the extractor faster than the extractor saws can remove the cotton from the burs. Such conditions result in poor extracting, greater loss of cotton by the extractor, and more trash being carried out with the extracted cotton. In order to prevent overloading the extractor in harvesting heavy yields of cotton, the harvester must be operated at a rate of travel that will enable the extractor to perform efficiently.

Rate of flow: The rate of flow of the material through the Texas Station Extractor is controlled by adjusting either or both the stationary and oscillating fingers closer to or farther away from the extractor saws and by the peripheral speed of the extractor saws. Adjusting the fingers away from the saws so that the burs will flow easily between them and the extractor saws will result in poor extracting and a greater loss of cotton with the burs. On the other hand, if the fingers are adjusted close to the extractor saws, the burs will not flow easily through the machine and any large burs and clusters of burs will remain on the fingers and be presented to the saws again and again until torn up sufficiently to pass through the spaces provided. Such a condition will cause the saws to chip the burs and result in undesirable boll shale being mixed with the extracted cotton.

Speed of extractor saws: The Texas Station Bur Extractor was designed to handle cotton containing green leaves and green, unopened bolls as well as mature open cotton. It is necessary, therefore, to operate it at a relatively slow rate of speed in order to avoid staining the cotton and to permit the green, unopened bolls to pass between the extractor fingers and the extractor saws without tearing them open. Crushing of the burs, as is done in most factory-made extractors, is not practiced, because of the presence of green material in the cotton.

Compactness of material: The compactness of the material will depend on both the rate of feeding and the rate of flow of the material through the machine and is comparable to the tightness of the gin-roll in the cotton gin. Best results are obtained when the stripped cotton, burs, and other trash are kept fairly loose. A tight, compact mass presses the burs hard against the extractor saws and, as a result, the burs are chipped; green, unopened bolls are ripped open; and pieces of limbs, leaf stems, and large sections of leaves are caught by the saws and carried through with the extracted cotton.

Distribution and agitation: Thorough distribution aids in preventing one side of the extractor from becoming overloaded and the other side from being left practically empty. Agitation is necessary to keep the material in the "extractor roll" agitated so that empty burs, green bolls, limbs, leaves, and other foreign trash can fall between the fingers, and burs with cotton in them can be presented to the extractor saw teeth. Thus, a loose mass permits more trash to pass between the fingers, and obviously the extracted cotton will be cleaner. Unlike the cotton gin, the extractor roll should not be tight enough to depend entirely on the extractor saw to keep it in motion. Consequently, this action is aided by the set of oscillating fingers, which are adjusted so that on the forward movement they pass slightly beyond the edges of the stationary fingers and strike the stripped cotton with enough force to cause it to move. On the backward stroke the oscillating fingers pass far enough back of the stationary fingers to leave an open space between the ends of the fingers and the extractor saws to permit whole burs, unopened bolls, and other trash to pass through. Thus, these two sets of fingers serve a threefold function—namely, they adjust the flow of material, regulate the tightness of the extractor roll, and agitate the roll.

CLEANING QUALITIES OF VARIETIES

Varietal Characteristics

Cleaning is the third process in handling cotton mechanically stripped, and it has much influence on the gin injury and grade of lint. The quality of work done by a cleaner is affected by several varietal characteristics as follows: (1) amount and kind of trash, (2) density of fiber on seed, (3) kind of fiber (whether coarse or fine), and (4) length of fibers.

Amount and kind of trash: The amount and kind of trash influence considerably the efficiency of a cleaner. Obviously, large amounts of trash become more intermingled with the fibers than small amounts and are harder to remove. Dry-leaf trash is easily removed from cotton having dense coarse fibers not over one inch in length. Bract trash with its many fine curling points is hard to remove from any kind of cotton but harder from the fine, silky types. The development of a variety of cotton devoid of bracts would eliminate this kind of trash and should result in cleaner cotton.

Removing green-leaf trash from cotton is much more difficult than removing dry-leaf trash. The foliage of most cotton varieties is slightly pubescent* and readily clings to cotton fibers. The green-leaf trash removed from the plant by mechanical harvesters may range in size from sections one-half inch square or less to the whole leaf. When cotton is harvested with the stripper-type Texas Station Harvester, many sections and whole leaves are removed from the cotton as they pass over the slotted bottom of the conveyor trough and more are removed by the extractor, but under full green foliage condition enough leaves remain in the cotton to require a few hours of drying before the cotton can be bulked safely. Mechanical picker-type harvesters also collect an objectionable amount of green-leaf trash. One of the major problems of mechanical harvesting of cotton, therefore, is the separation and removal of green-leaf trash from the harvested cotton between the time it is taken from the plant and before it reaches the storage bag or trailer.

In these experiments a number of devices and shapes of slots have been installed and tested in the harvester conveyor troughs, and many changes have been made in the extractor in an effort to remove the green-leaf trash harvested with the cotton. These changes and improvements have made it possible to remove a higher percentage of the green-leaf trash than was removed in the earlier tests. The ultimate objective in these experiments is to remove a sufficiently high percentage of green-leaf trash so that the machine-harvested cotton may be carried directly to the gin or bulked without danger of heating.

Density of fiber: In studying cleaning qualities of varieties included in these experiments, it was found that varieties having dense fiber surrounding the seed clean better than those varieties with less dense fibers. The dense fibers prevent particles of trash from becoming embedded or entangled in them and, as a result, are more readily cleaned by adequate cleaning machinery. Typical varieties which appear to have a dense fiber characteristic are Gorham's Lone Star, New Boykin, Mebane 140, Mebane 804, Mebane 96, and Lightning Express x Westex. Mebane 95

*Pubescence is a hairy condition of the foliage.

has rather loose or sparse fiber adjacent to the seed. For comparison, Tables 4 and 5 show that a higher grade was obtained and less trash was removed by the cleaner from the dense-fibered Mebane 96 than from the sparse-fibered Mebane 95, indicating that less trash was left embedded and entangled with the denser fiber by the extractor.

Kind of fiber: Trash can be removed from coarse-bodied cotton much more easily than from fine, silky cotton. It is difficult to say whether silky fibers adhere to the trash or whether the trash hangs and sticks to the fine, silky fibers. At any rate, the trash is hard to remove from fine- and soft-bodied cotton. Naturally the presence of excessive amounts of trash in the lint will result in lower grades. The fiber of Ducona cotton is rather fine, and Table 1 shows that the grade for four years at College Station averaged low middling, which is lower than for Gorham's Lone Star, a variety producing a heavy-bodied cotton fiber. Breeding work is under way to obtain strains of Ducona cotton with a heavier bodied fiber.

Length of staple: Varieties of cotton with a staple length of one inch or more often have a tendency to wrap around trash particles and prevent their removal. As the length of the staple increases above one inch, there is a decided increase in the tendency for the staple to twist and rope in the cleaning machinery.

Mechanical and Other Factors

Mechanical and other factors that affect the efficiency of cleaning equipment are: (1) previous handling, (2) type of cleaner, (3) speed of revolving parts, (4) kind and condition of screens, (5) rate of feeding, and (6) moisture content.

Previous handling: Bennett and Gerdes (1) state that rough handling is responsible for intermingling with seed cotton parts of the cotton plants, such as leaves, burs, and stems, and such foreign matter as sticks, weeds, and trash. When the Texas Station Cotton Harvester, Extractor, and Cleaner were designed, an effort was made to construct and use devices that would start removing trash immediately after the cotton fell into the harvester conveyor. Some dirt, leaves, stems, limbs, and parts of burs are removed before the cotton reaches the extractor. The extractor removes practically all burs, unopened green and dry bolls, and most of the remaining leaves, limbs, stems, sticks, and other trash. The mechanism has not been perfected so that 100 per cent of all the objectionable material is removed, as enough green-leaf trash remains in the cotton to require a few hours of sun drying before it can be bulked without heating (8). As the cleaner is a separate unit and not used in the field, it is necessary to place the cotton in a wagon or trailer and transport it to the cleaner. This handling naturally causes much of the trash to become intermingled with the seed cotton and, of course, makes it more difficult to remove.

Type of cleaner: Cleaners used in connection with gins are classed as air-line cleaners and out-of-air cleaners. The latter are strictly mechanical cleaners with various types of beaters and screens. The Texas Station Cylinder Cleaner used in cleaning the mechanically harvested cotton is a mechanical cleaner employing several sets of finger beaters to throw the cotton against one-half inch mesh hardware cloth. Beaters too close to the screen may cause machining of the cotton and if too far away may produce roping, twisting, or rolling of the cotton. The type of cleaner, therefore, and its adjustment and action on the cotton will affect its efficiency in removing trash from the cotton. Figure 14 shows a comparison of cleaned, extracted, and mechanically harvested cotton with uncleaned, hand-picked cotton.

Speed of cleaner parts: The speed, or revolutions per minute, of cleaner cylinders is a factor that affects the removal of trash and injury

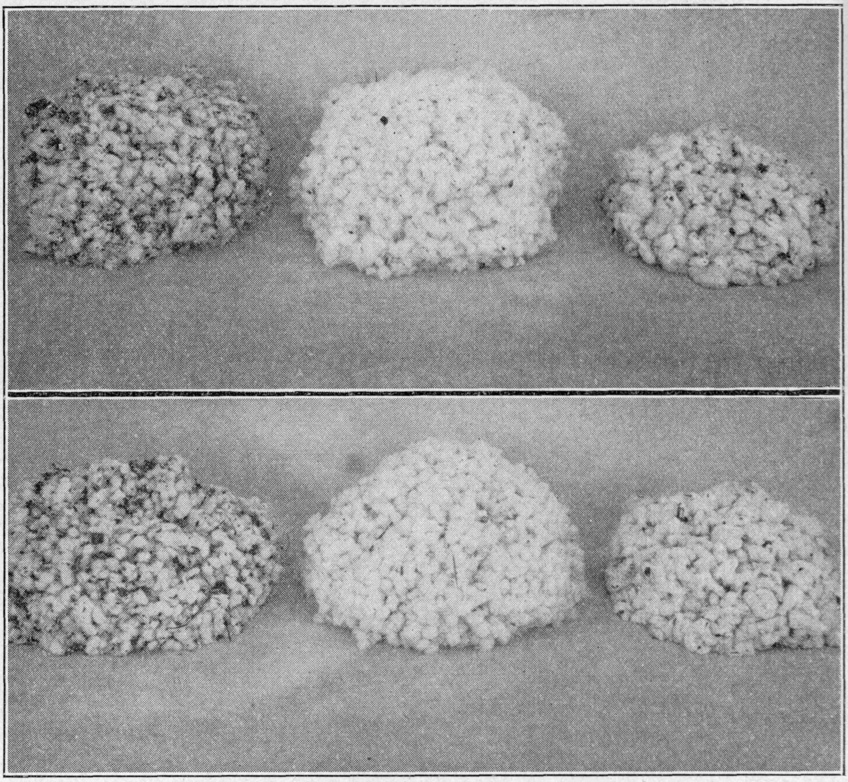


Figure 14. Views showing uncleaned, machine-stripped cotton on the left and uncleaned, hand-picked cotton on the right. The cotton in the center was machine-harvested and cleaned with the Texas Station Cylinder Cleaner. The Ducona cotton in the upper picture does ont clean so well as the Gorham's Lone Star cotton below because of the finer and more silky staple of this variety.

to the seed, which may be cracked if hit too hard. The speed of most cylinder cleaners ranges from 300 to 600 revolutions per minute. Large cylinders may revolve slower than small ones yet have approximately the same peripheral speed at the ends of the beaters. In the Texas Cylinder Cleaner, the beater cylinder is approximately 22 inches in diameter and operates at about 500 revolutions per minute. It has been found that faster speeds have a tendency to cause machining of the fiber and cracking of some seeds. Fast speeds also increase the tendency of the fibers to twist and rope, especially in the longer staple cottons.

Feeding rate: The rate of feeding, or the volume of material passing through a cleaner, materially affects trash removal. Best results are obtained when cotton is fed at a rate that enables the beater arms to spread the cotton in a thin layer over the screen, so that the trash is jarred loose from the cotton as it hits the screen and passes through while the cotton is retained on the screen. Large volumes of cotton prevent such action and reduce the amount of trash removed.

Screens: Most cleaners are enclosed with heavy, one-half inch mesh hardware cloth, but one company makes use of expanded metal. Rough or sharp edged material has a tendency to cause machining of the cotton.

Moisture content: If cotton is at all damp, it will not clean satisfactorily. Both the cotton and the trash must be thoroughly dry for efficient removal of the trash. Crumbly, dry-leaf trash can be readily separated from coarse-fibered cottons of not more than one inch in length. If either the cotton or the trash is damp, they will cling together and are hard to separate. Cotton in a damp condition will also twist and rope when run through a cleaner.

FACTORS AFFECTING THE GRADE OF MECHANICALLY HARVESTED COTTON

The grade of cotton harvested by machinery is affected by varietal characteristics and mechanical and other factors.

Varietal Characteristics

The varietal characteristics that affect the grade of mechanically harvested cotton are as follows: (1) amount of trash collected in the harvesting process, (2) kind of trash collected with the cotton, (3) fineness of the fiber, (4) density of the fiber on the seed, and (5) length of the staple. Any one of these factors, if present, will influence more or less the grade of mechanically harvested cotton. Some, however, are of greater importance than others and will influence the grade regardless of the method of harvest.

Amount and kind of trash in cotton: With the mechanical stripper the amount and kind of trash are important. It is needless to point out that large quantities of any kind of trash are harder to remove than small amounts. The kind and nature of the trash are significant, because fibrous material such as grass or bark from the cotton plant is very hard to remove, while dry, crumbly leaf trash is comparatively easy to remove from seed cotton. Bract trash, which has many pointed sections that curl when dry and catch and hang to the cotton fiber, is extremely hard to remove.

Coarseness, fineness, and density of the fiber: In these studies it has been found that coarse, harsh-bodied cottons clean better than fine, silky cottons and, as a rule, produce higher grades. According to Table 1, Ducona, a fine, silky cotton, averaged low middling for four years, while Gorham's Lone Star, a heavy-bodied cotton, averaged strict low middling, or one grade higher than Ducona. A good comparison between two closely related Mebane strains is found in Table 2. Mebane 96 having dense fibers graded strict middling, while Mebane 95 with thin, sparse fibers graded middling, or one grade in favor of the dense-fibered strain.

Length of staple: Longer staple cottons have a tendency to twist or rope in the cleaning machinery, resulting in poorer cleaning and gin cutting in the ginning process and, consequently, lower grades.

Mechanical and Other Factors

Factors other than varietal characteristics that may affect the grade of cotton harvested with machinery are: (1) injury to fiber by harvester, (2) injury to fiber by extractor, (3) injury to fiber by cleaning equipment, (4) weather conditions between the time the boll opens and harvest, and (5) length of time cotton is left exposed in the field.

Injury to fiber in harvesting and ginning: Injury of the fiber by the mechanical harvester is mostly in the form of stains from crushed green leaves. In extracting and cleaning, the extracting saws, beaters, and other mechanical devices may either machine or cut the fiber or twist it so that gin cutting occurs when the cotton is ginned and thus affects the grade.

Exposure to weather: Studies made on grade, strength, and color of raw cotton as affected by exposure in the field (reported in Texas Station Bulletin 538) (3) indicate that, on the average, cotton dropped one grade when left exposed in the field for four weeks. Weather conditions were found to be an important factor in lowering the grade. Table 1 shows that at College Station in 1935 and 1936, when cotton harvesting was delayed until early October, the average grades for all varieties were low middling and low middling minus, respectively. For 1937 and 1938, however, when cotton was harvested in late August and early September, the average grades for all varieties were strict low middling plus and strict low middling, respectively. At Lubbock where harvesting tests were conducted within a few days of the same date each year, under varying weather conditions, the average grades for all varieties were strict low middling spot in 1936, middling plus in 1937, and strict middling in 1938 (Table 2), indicating that weather conditions and exposure prior to harvest had a decided influence on the grade of cotton harvested.

GRADE DIFFERENCES ATTRIBUTED TO MECHANICAL HARVESTING OF DIFFERENT VARIETIES OF COTTON

In comparing the grade differences between hand-picked and machine-harvested samples of cotton of the same variety, at College Station (Table 4) it was found that the differences ranged from one-half grade for Mebane 140 to two and one-half grades for Kubela in favor of the hand-picked samples. Ten of the 15 varieties compared showed an average difference of one and one-half grades in favor of hand-picked cotton over machine-harvested cotton. The average difference for all varieties compared was also one and one-half grades in favor of hand-picking. At Lubbock (Table 5) the grade differences between hand-snapped and machine-harvested samples ranged from one-half grade in favor of machine harvesting for Acala to three grades in favor of hand-snapping for Ducona. Three of the varieties showed no difference between hand-snapping and machine-harvesting, while four varieties showed only one-half grade in favor of hand-snapping over machine-harvesting. The average difference for all varieties compared was three-fourths of a grade in favor of hand-snapping. It appears, therefore, that the grade differences between varieties may be attributed largely to the differences in the characteristics of the varieties.

SNAPPING QUALITIES OF COTTON BOLLS

A varietal characteristic which has a bearing on the suitability of a variety for mechanical harvesting is the snapping qualities of the bolls. Bolls that are hard to snap off or pull from the plant may cause higher percentages of loss with the stripper-type harvester. On the other hand, those bolls which break off at the least touch are not suitable for the mechanical picker, because the machine does not have a chance to remove the cotton from the boll. A well-anchored boll is desirable for hand-picking, as time is lost if the boll breaks off when an attempt is made to pick the cotton for both hands of the laborer must be employed in separating the cotton from the bur. "Cotton snappers" and "cotton pullers" often complain that cotton bolls are hard to snap from the plants of some varieties.

To obtain data on the pounds of pull required to snap cotton bolls from the plant, the following changes were made in a Chatillon Quick Stop scale: The dial was equipped with both a tight and a loose pointer. The glass cover was removed, and the dial face was made of brass. A special cradle consisted of a weighted fork having two curved prongs spaced about one-eighth inch apart (Fig. 15). In operation the forked prongs were hooked under the boll and tension was applied (Fig. 16. The

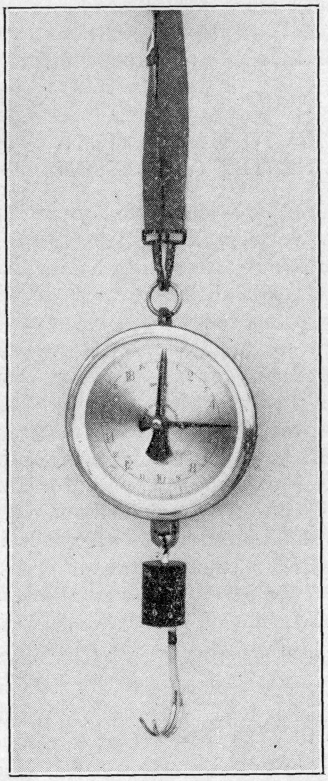


Figure 15. A quick-stop scale used in the boll-pulling tests. Note the prongs of the fork to catch under the bolls and the loose pointer to facilitate reading.

tight pointer carried the loose pointer around the dial until the boll snapped off. The tight pointer returned to zero, while the loose pointer remained at the extreme point of travel, permitting the dial to be read.

The data in Table 10 show that the average pull on varieties tested at College Station ranged from 2.5 pounds for New Boykin to 7.6 pounds for Ducona and 8.5 pounds for Ferguson 406. The general average for all varieties tested was 4.7 pounds. The data indicates that the pull required varies from year to year for the same varieties. This is attributed to seasonal conditions and the condition of the plant.

At Lubbock the same varieties did not react in the same manner as at College Station. For example, Ducona bolls were hard to pull at College Station but comparatively easy at Lubbock, but Cut Leaf x Acala and Cut Leaf x Clark were harder to pull at Lubbock than at College Station (Table 10). Lightning Express x Westex was the most uniform of the varieties tested. The difference in pounds pull for the same varieties at College Station and Lubbock may be attributed largely to climatic conditions and length of time the boll had been open before pulling.

Figure 16. Pulling cotton bolls with special quick-stop scale.

Table 10. Average pounds of pull required to remove cotton bolls from the plant*

Variety	College Station					Lubbock		
	Pounds Pull					Pounds Pull		
	1935	1936	1937†	1938	Av.	1937	1938	Av.
Ducona	7.5	8.1	4.6	10.0	7.6	.....	2.8	2.8
Gorham's Lone Star	6.0	8.5	5.1	3.0	5.6	.....	.....	.....
Kubela	7.4	.....	4.7	3.0	5.0	8.4	4.4	6.4
Price's Cut Leaf Acala	.....	4.4	4.3	2.6	3.8	.....	.....	.....
Kelly's Lone Star	5.4	6.4	4.8	.....	5.5	.....	.....	.....
Startex	8.3	.....	4.1	3.1	5.1	.....	.....	.....
Rothcamp's Cluster	6.4	7.0	.....	.....	6.7	.....	.....	.....
New Boykin	.....	.....	3.0	2.1	2.5	.....	.....	.....
Mebane 140 and 141	8.4	.....	3.5	3.9	5.2	.....	.....	.....
Cut Leaf x Acala	.....	.....	.....	2.8	2.8	4.6	3.1	3.8
Cut Leaf x Clark	.....	.....	.....	3.0	3.0	6.6	.....	6.6
Lightning Express x Westex	.....	.....	.....	3.8	3.8	4.7	3.2	3.9
Mebane 96	.....	.....	.....	5.0	5.0	7.5	3.7	5.6
Mebane 95	.....	.....	.....	4.5	4.5	4.1	.....	4.1
Macha	.....	.....	.....	.....	.....	.....	3.3	3.3
Acala	.....	.....	.....	.....	.....	.....	2.1	2.1
Burnett	.....	.....	.....	.....	.....	5.3	3.2	4.3
Ferguson 406	8.5	.....	.....	.....	8.5	.....	5.6	5.6
Roger's Cluster	4.3	.....	.....	.....	4.3	.....	.....	.....
Kinsler's Cluster	.....	.....	.....	4.1	4.1	.....	.....	.....
Delta and Pine Land	.....	.....	.....	2.0	2.0	.....	.....	.....
Clark	.....	.....	.....	3.0	3.0	6.6	.....	6.6
H. X.	6.2	.....	.....	.....	6.2	.....	.....	.....
Average	7.0	6.9	4.1	3.7	4.7	6.0	3.5	4.6

*Tests were made each year just before the harvesting tests were made.
†From thesis of H. T. Stewart on "A Study of the Snapping Qualities of Cotton Bolls."

A comparison of the machine efficiency of the Texas Station Harvester (Tables 1 and 2) with the pounds of pull (Table 10) does not show a close relationship between efficiency and pull, as shown by simple correlation studies made on 14 varieties grown at College Station in 1938. Other varietal characteristics, such as plant type, size of boll, and strength of boll, may have counteracted the influence of pull.

Seasonal conditions and age of plant appear to have considerable influence on the snapping qualities of cotton bolls. In 1937 at College Station, Stewart (10) made tests at approximately two-week intervals, or on August 10 and 26 and September 8 and 22. Prior to August 10 the weather was hot and dry with no rainfall and light dews. From August 10 to 26 light showers occurred on six days. The mornings were mostly damp and foggy, and all except four days were either cloudy or partly cloudy. The weather continued damp and cloudy from August 26 to September 8 with light showers on five days. No rain fell between the third and fourth tests or from September 8 to 22.

The average pull for the first tests following several days of dry weather was 8.9 pounds (Table 11). The pull decreased as the season advanced, with damp rainy weather, to 4.5 pounds for the second test on August 26 and 4.1 pounds on September 8. After several dry days the pull increased to 4.4 pounds for the test made on September 22.

Table 11. Influence of season on pounds of pull required to remove cotton bolls from the plant at College Station*

Variety	1937					1938		
	Aug. 10	Aug. 26	Sept. 8	Sept. 22	Av.	Aug. 16	Sept. 3	Av.
Ferguson's New Boykin	6.1	2.1	3.0	3.2	3.6	2.9	2.1	2.5
Mebane 140	7.4	4.7	3.5	3.9	4.9	3.3	3.9	3.6
Startex	8.5	6.5	4.1	4.1	5.8	1.8	3.1	2.4
Gorham's Lone Star	10.9	3.6	4.1	4.2	5.7	5.0	3.0	4.0
Price's Cut Leaf Acala	7.2	5.3	4.3	3.4	5.0	1.9	2.6	2.2
Ducona	10.6	4.1	4.6	5.8	6.2	5.8	10.0	7.9
Kubela	9.6	6.4	4.7	4.4	6.2	4.6	3.0	3.8
Kelly's Lone Star	10.9	3.5	4.8	6.4	6.4			
Lightning Express x Westex						2.7	3.8	3.2
Clark (late)						4.2	5.7	5.0
Cut Leaf x Clark						1.9	3.0	2.5
Cut Leaf x Acala						2.2	2.8	2.5
Kinsler's Cluster						5.2	4.1	4.7
Delta and Pine Land						1.4	2.0	1.7
Mebane 96						4.6	5.0	4.8
Mebane 95						4.1	4.5	4.3
Average	8.9	4.5	4.1	4.4	5.5	3.4	3.9	3.7

*From thesis of H. T. Stewart on "A Study of the Snapping Qualities of Cotton Bolls."

Table 11 also shows results obtained on August 16 and September 3, 1938. On August 10, 1.27 inches of rain fell, and light showers occurred on August 11 and 13. Heavy dews prevailed, and a large percentage of the days were cloudy through September 3. The cotton plants were succulent and growing during the period of these tests; consequently, there was only .5 pound difference in the averages of the two tests. These results clearly indicate that the snapping qualities of cotton bolls are greatly influenced by weather conditions, which affect the cotton plants.

In the boll-pulling tests data were kept on the percentage of bolls that pulled off with the peduncle attached and the percentage of peduncles that pulled off with the limbs attached to them. The data in Table 12 show that when harvesting is delayed until October, as it was at College Station in 1935 and 1936, the bolls disintegrate and become weak so that they crush when an attempt is made to pull them. In 1936, 36 per cent of the bolls were crushed and 64 per cent were pulled off with the peduncles attached. The season of 1935 was not as wet as that of 1936, and 93 per cent of the bolls pulled had the peduncle attached to them. In 1937 and 1938 harvest was in late August and early September, and 98 to 100 per cent of the bolls pulled off with the peduncles attached (Table 12). Equally high percentages were obtained at Lubbock in 1936 and 1938 while the plants were in good condition and not damaged by damp weather. No tests were made at Lubbock in 1937.

An examination of the plants after stripping with the machine, and of the harvested bolls verified the above data. It was also found that when the peduncle remained on the plant, the boll crushed, as often part of the bur was attached to it. A comparison of the machine efficiency data in Tables 1 and 2 with the data in Table 12 shows that varieties having a high percentage of the bolls crushed were lower in machine efficiency.

Varieties of cotton with comparatively small, strong, wiry branches are the most suitable for harvesting with the mechanical stripper. The data in Table 12 shows the percentage of peduncles that had limbs attached to them in the pull tests at both College Station and Lubbock. In these tests any section of one-half inch or more in length which broke off with the peduncle was classed as a limb.

In 1936 at College Station damp rainy weather prevailed prior to harvest, which was seasonably late, and the plants were succulent, sappy, and brittle. As a result, an average of 33 per cent of the bolls pulled off with the limbs attached to the peduncle. The averages were only 5 to 7 per cent for tests made in 1935 during dry weather and in 1937 and 1938 when harvesting was done early.

The percentages at Lubbock were generally much higher (Table 12), as the cotton was irrigated and cool weather kept the plants vigorous. Varieties with a lower percentage of limbs than the general average are Ducona, Lightning Express x Westex, Macha, and Cut Leaf x Acala. Varieties which had a high and undesirable percentage of limbs are Mebane 96, Acala, Clark, Kinsler's Cluster, and Cut Leaf x Clark.

A large number of limbs makes extracting and cleaning more difficult and increases the amount of trash left in the seed cotton. Long limbs are especially objectionable, as they may have several leaves attached and have a tendency to wrap around shafts and sprockets and obstruct passageways. They are hard to extract unless broken into several short pieces.

Table 12. Percentage of Peduncles Attached to Bolls and Limbs Attached to Peduncles When Pulled from Plants at College Station and Lubbock

Variety	Peduncle attached to boll								Limbs attached to peduncle							
	College Station					Lubbock			College Station					Lubbock		
	1935	1936	1937	1938	Av.	1936	1938	Av.	1935	1936	1937	1938	Av.	1936	1938	Av.
Ducona	96	56	100	92	86	......	100	100	0	40	8	16	16	......	4	4
Gorham's Lone Star	88	52	100	100	85	......	......	......	12	44	2	4	16	......	......	......
Kubela	100	......	100	100	100	100	100	100	4	......	6	4	5	40	24	32
Price's Cut Leaf Acala	......	84	100	96	93	......	......	......	......	16	6	0	7	......	......	......
Kelly's Lone Star	96	52	100	......	83	......	......	......	4	44	10	......	19	......	......	......
Startex	92	......	100	100	97	......	......	......	0	......	2	4	2	......	......	......
Rothcamp's Cluster	92	76	......	......	84	......	......	......	20	20	......	......	20	......	......	......
New Boykin	......	......	100	100	100	......	......	......	......	......	0	0	0	......	......	......
Mebane 140 and 141	84	......	100	100	95	......	......	......	0	......	6	4	3	......	......	......
Cut Leaf x Acala	......	......	......	100	100	96	100	98	......	......	......	24	24	24	28	26
Cut Leaf x Clark	......	......	......	96	96	92	......	92	......	......	......	0	0	44	......	44
Lightning Express x Westex	......	......	......	96	96	96	100	98	......	......	......	4	4	20	32	26
Mebane 96	......	......	......	96	96	96	100	98	......	......	......	0	0	40	56	48
Mebane 95	......	......	......	100	100	88	......	88	......	......	......	0	0	28	......	28
Macha	......	......	......	......	......	......	100	100	......	......	......	......	......	......	28	28
Acala	......	......	......	......	......	......	100	100	......	......	......	......	......	......	60	60
Burnett	......	......	......	......	......	96	100	98	......	......	......	......	......	44	8	26
Ferguson 406	92	......	......	......	92	......	100	100	0	......	......	......	0	......	24	24
Roger's Cluster	96	......	......	......	96	......	......	......	28	......	......	......	28	......	......	......
Kinsler's Cluster	......	......	......	100	100	......	......	......	......	......	......	8	8	......	......	......
Delta and Pine Land	......	......	......	100	100	......	......	......	......	......	......	0	0	......	......	......
Clark (late)	......	......	......	100	100	100	......	100	......	......	......	4	4	40	......	40
H. X.	92	......	......	......	92	......	......	......	4	......	......	......	4	......	......	......
Average	93	64	100	98	95	99	100	98	7	33	5	5	8	35	29	32

EFFECT OF BOLL SPREAD ON HARVESTING AND EXTRACTING QUALITIES

The cotton bolls collected in the pounds of pull tests were measured to determine how wide the average bolls spread open. This was done by placing the bur on a protractor, as shown in Figure 17. Table 13 shows data for several varieties at College Station and Lubbock for the years 1937 and 1938. At College Station, the average degree of spread of the boll carpels ranged from 89 degrees for Kelly's Lone Star to 140 degrees for Lightning Express x Westex, while at Lubbock the range was from 103 degrees for Macha to 125 degrees for Cut Leaf x Clark. The general average for all varieties was 120 degrees at College Station and 115 degrees at Lubbock.

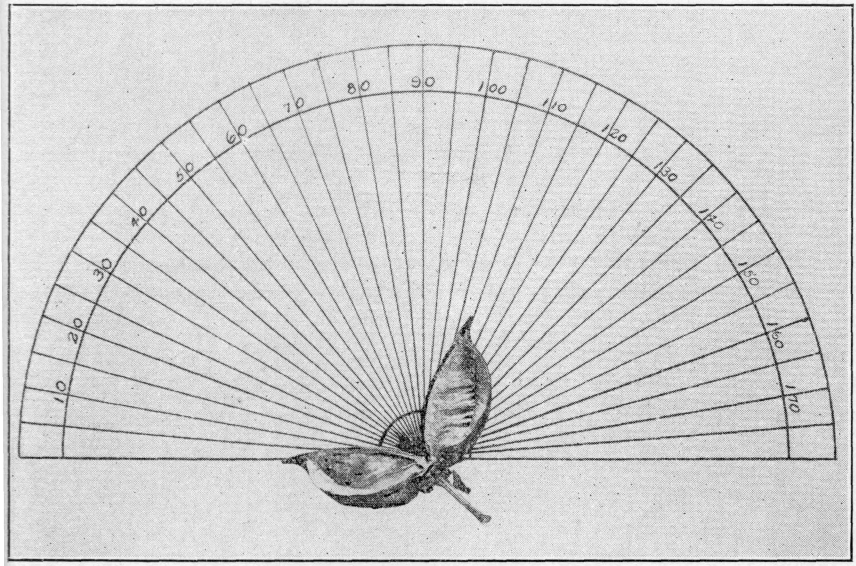


Figure 17. Method used to measure the degree of boll spread of cotton bolls.

From a study of Table 14 it appears that weather conditions at College Station during the season affected the degree of boll spread. For example, the hot dry weather prior to August 10, 1937, caused the average to be wider, or 131 degrees, but prevailing damp weather from August 10 to September 8 reduced the average spread on August 26 to 114 degrees and on September 8 to 101 degrees. During clear weather from September 8 to 22 the spread increased from 101 to 106 degrees. In 1938, when more uniform weather prevailed throughout the season, the degree of boll spread did not vary greatly from August 16 to September 3 (Table 14).

Table 13. Average degree of boll spread for several varieties of cotton at College Station and Lubbock*

Variety	College Station			Lubbock		
	1937	1938	Average	1937	1938	Average
Ducona	116	131	124	...	106	106
Gorham's Lone Star	99	120	110	...	...	...
Price's Cut Leaf Acala	112	120	116	...	...	...
Kelly's Lone Star	89	...	89	...	...	...
Startex	92	120	106	...	...	...
New Boykin	93	122	108	...	...	...
Mebane 140 and 141	108	124	116	...	...	...
Kubela	100	139	120	125	124	124
Cut Leaf x Acala	...	125	125	115	113	114
Cut Leaf x Clark	...	122	122	125	...	125
Lightning Express x Westex	...	140	140	126	115	120
Mebane 96	...	130	130	113	109	111
Mebane 95	...	135	135	120	...	120
Macha	...	...	...	...	103	103
Acala	...	...	...	...	117	117
Burnett	...	...	...	116	104	110
Ferguson 406	...	...	...	...	108	108
Clark	...	...	...	117	...	117
Kinsler's Cluster	...	125	125	...	...	...
Delta and Pine Land	...	118	118	...	...	...
Clark (late)	...	138	138	...	...	...
Average	101	127	120	120	111	115

*Average of 25 bolls for each variety.

Table 14. Influence of season on average degree of boll spread at College Station*

Variety	1937					1938		
	Aug. 10	Aug. 26	Sept. 8	Sept. 22	Av.	Aug. 16	Sept. 3	Av.
New Boykin	124	117	98	96	109	122	99	110
Mebane 140	131	122	108	117	120	124	112	118
Startex	128	105	92	109	108	120	108	114
Gorham's Lone Star	126	113	99	104	110	120	115	118
Price's Cut Leaf Acala	140	124	112	115	123	120	131	126
Ducona	148	124	116	108	124	131	113	122
Kubela	130	111	100	102	111	139	121	130
Kelly's Lone Star	120	95	89	93	99	...	...	...
Lightning Express x Westex	...	...	...	...	...	140	142	141
Clark (late)	...	...	...	...	...	138	128	133
Cut Leaf x Clark	...	...	...	...	...	122	121	122
Cut Leaf x Acala	...	...	...	...	...	125	119	122
Kinsler's Cluster	...	...	...	...	...	125	132	128
Delta and Pine Land	...	...	...	...	...	118	123	120
Mebane 96	...	...	...	...	...	130	114	122
Mebane 95	...	...	...	...	...	135	123	129
Average	131	114	101	106	113	127	120	124

*Average of 25 bolls for each variety.

The general impression among growers using common varieties is that wide spreading bolls reduce storm resistance, but at both College Station and Lubbock the Lightning Express x Westex cross, with an average boll spread of 140 and 120 degrees, respectively, for the two locations, had an extremely low storm loss. At Lubbock the Lightning Express x Westex cross compared favorably in storm resistance with the narrow spreading Macha.

Lightning Express x Westex harvested well, with a machine efficiency of 94.9 per cent at College Station and 98.6 per cent at Lubbock (Tables 1 and 2). The grade, staple, and yields were satisfactory. The burs were light and a high percentage of clean seed cotton was obtained (Tables 8 and 9). The inter-seed drag and a relatively coarse harsh fiber enhanced its extracting and cleaning qualities.

RELATION OF YIELD TO THE EFFICIENCY OF THE HARVESTER

Yield did not appear to influence the efficiency of the Texas Station Harvester greatly, as indicated by the correlation coefficient of .421 between yield and efficiency for the year 1938. This coefficient is not significant on the 5 per cent level (11). The machine seemed to harvest equally well, under comparable conditions of plant type and growth, cotton making high or low yields.

An average machine efficiency of 98.2 per cent was obtained at Lubbock in harvesting relatively small cotton plants yielding a bale to the acre, while at College Station where the plants grew large the average efficiency was 92.1 per cent for cotton yielding about one-half bale to the acre for the years 1935 to 1938, inclusive (Tables 1 and 2). This difference in machine efficiency at Lubbock and College Station may be attributed more to size of plants than to acre yield, as has been previously pointed out.

SUMMARY AND CONCLUSIONS

A number of commonly grown varieties and several new strains of cotton developed by means of selection, crossing, and backcrossing were tested during the four-year period 1935-1938 to ascertain their harvesting, extracting, and cleaning characteristics.

A stripper-type harvester and an extractor, developed by the Texas Agricultural Experiment Station, were mounted on a tractor and used to study varietal characteristics influencing machine efficiency and extracting qualities of different varieties of cotton. The cleaning qualities were tested with the Station Cylinder Cleaner.

Factors affecting the efficiency of cotton harvesting machinery are classed as varietal characteristics, mechanical factors, and cultural methods.

Varietal characteristics affecting machine efficiency are: shape of plant, height of plant, length of branches, number of branches, density of foliage, type of boll, bolls borne singly or in clusters, storm resistance, degree of boll spread, fluffiness of the cotton, brittleness of branches and boll peduncles, and height of first branches above ground.

The best plant type for both the mechanical stripper and the picker is one having relatively short but numerous fruiting branches with short nodes, no vegetative branches, an open type growth, light foliage, storm resistance, and a large, strong boll on a single peduncle which will snap easily under tension but will withstand considerable plant agitation.

Plants at College Station averaging 30 to 32 inches in height gave an average machine efficiency of 92.1 per cent, while at Lubbock where the plants averaged from 20 to 24 inches in height the average efficiency was 98.2 per cent. Varieties producing numerous long branches gave lower efficiency than varieties with shorter branches.

Plant characteristics appear to affect machine efficiency more than either mechanical factors or cultural methods.

At College Station hand-picked cotton averaged middling plus; hand-snapped, middling; and machine-harvested, strict low middling (one-half grade difference in hand-picked and hand-snapped and one and one-half grades difference in hand-picked and machine-harvested cotton). At Lubbock for two years both the hand-picked and hand-snapped cotton averaged strict middling with a slight difference in favor of the hand-picked cotton. In 1937 machine-harvested cotton averaged one grade lower than hand-snapped cotton, but in 1938 the average for the three methods of harvesting was strict middling.

Factors influencing the efficiency of an extractor are: feeding rate; rate of flow of material through machine; speed of extractor saws; compactness; uniformity of distribution; agitation; amount of burs, unopened bolls, limbs, sticks, and leaves; size of boll; shape of boll; weight of bur; degree of boll spread; fluffiness; storm resistance; fiber drag; and length of staple.

Cleaning of cotton is influenced by previous handling, amount and kind of trash, type of cleaner, speed of cleaner parts, kind and condition of screen, rate of feeding, density of fiber on seed, fineness of fiber, length of fiber, and moisture content. Trash is easier to remove from coarse-bodied cotton than from fine, silky cotton.

The grade of mechanically harvested cotton is affected by the amount of trash; kind of trash; weather conditions; time of exposure; fiber injury by harvester, extractor, cleaner, and gin; and fiber characteristics such as fineness, density, and length.

Cotton bolls that are hard to pull from the plant may cause higher percentages of loss with the stripper-type harvester, while bolls that snap off too easily are not desirable either.

The general average degree of spread of cotton bolls for all varieties tested was 120 degrees at College Station and 115 degrees at Lubbock.

The average acre yield of cotton harvested with the Texas Station Harvester ranged from about one-half bale at College Station to approximately a bale at Lubbock. The harvester will harvest low or high yields equally well if under comparable conditions of plant type and growth.

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