Published July, 1976

Leaf and Bract Trichome Density and Boll-type Influence on Cotton Lint Grade Index[1]

D. F. Wanjura[2], R. V. Baker[2], and L. L. Ray[3]

ABSTRACT

Little quantitative information is available that relates physical cotton (*Gossypium hirsutum* L.) plant characteristics to lint grade for stripper harvested cultivars. In a 4-year study, the effect of varying levels of leaf and bract pubescence and degrees of boll compactness on lint grade index of hand-harvested seedcotton and burcotton were investigated. Leaf and bract trash, mechanically mixed in raw cotton after harvest, did not adhere to raw lint as tightly as trash incorporated by natural field weathering. Variations in growing season had more effect on lint grade index than specific plant characteristics. However, the following plant character effects were observed: (a) Increasing levels of blade trichome density (BTD) in leaves and bracts reduced lint grade index, (b) Maximum bur diameter was positively correlated with boll fluffiness index (BFI), (c) BFI was inversely related to grade index for lint obtained from burcotton. (d) Bur strength did not affect lint grade index. The results indicate that the bract attached to the bur is responsible for burcotton having lower lint grade indices than seedcotton.

Additional index words: **Cotton harvesting, Cotton ginning, Boll fluffiness index, Bur diameter, Lint contamination.**

THE mechanical stripper harvester removes the entire boll from the cotton (*Gossypium hirsutum* L.) plants, including bracts and some leaves, stems, and branches. This extraneous "foreign material" reduces the economic value of cotton lint and seed. Vegetable foreign matter contained in cotton after harvest creates problems in lint processing, and Lowenschuss and Wakelyn (2) suggested that it is a health hazard.

The condition of the plant at harvest (determined by the cultivar, seasonal growing conditions, and weather factors before and during harvest) determine the quantity and composition of foreign material in mechanically stripped cotton. The fine trash components, leaves and bracts, are the most difficult parts of the foreign matter to separate from the lint; however, small pieces of broken burs, stems, and branches also affect lint cleaning.

The more pubescent cotton cultivars are generally associated with higher trash contents in mechanically harvested cotton according to Smith (4) and Ramey (3). Quantitative measurements relating pubescence to trash levels in harvested cotton and lint quality are lacking.

This study was conducted to estimate the effect of pubescence of the plant vegetative material and the type of boll on the fine trash content of stripper harvested burcotton and on the cleanability of the cotton lint during ginning as measured by lint grade index.

MATERIAL AND METHODS

Tests were conducted from 1971-74 with irrigated cotton produced under farm conditions within 96.54 km (60 miles) of Lubbock, Tex. The commercially available cultivars, 'Dunn 119,' 'Dunn 56C,' 'Paymaster 111,' 'Stripper Cala S,' 'Tamcot SP 21,' and 'Lockett BXL' were chosen to provide variability in leaf and bract pubescence and in boll type. All cultivars were not included in all years.

Pubescence Measurements. Leaves with intact petioles and bracts were removed from the bottom half of the cotton plant in September for pubescence measurements. Trichomes were counted with the aid of a microscope at 40× magnification on the adaxial surface of leaves and bracts. Trichome counts were made on the petiole, leaf margin near the tip, the midvein, and the blade on both sides of the midvein near the bottom of the leaf. Two counts were made on the adaxial surface of the bract near the center.

Boll Character Analysis. The number of carpels, the maximum open- boll diameter measured as the distance from tip to tip of opposite carpels, the energy required to break the carpel wall, and the boll fluffiness index were determined from mature bolls. Breaking energy was the energy expended by a swinging pendulum as it impacted and broke a stationary positioned boll. Bolls were conditioned for 1 week at 21 C and 35% relative humidity before breaking energy measurements were made. Fluffiness index was expressed as the average of the maximum and minimum distance in mm from the tip of the carpel to a flat surface when an open boll was placed on the surface with its open end pointed downward.

Burcotton and Seedcotton Samples. In early October seedcotton and burcotton were hand harvested from each cultivar and determinations were made of the foreign matter components — burs, sticks, and fine trash.

Burcotton of each cultivar was divided into lots of 1.1 kg and seed-cotton was divided into lots of 0.91 kg. Leaves and bracts (in a 9:1 ratio) that had been harvested from each cultivar in September were mixed with burcotton and seedcotton samples from each cultivar. All cultivar combinations of trash sources and lint sources were made. Two and one-half percent by weight of air-dried foreign material was mixed with each sample before ginning in 1971-1973, and 5% in 1974. The sample was placed in a small drum-type mixer and the trash material was evenly distributed over the sample. Mixing time was 15 sec using an agitating beater speed of 330 rpm. In 1974 the seedcotton was cleaned by processing through extractor-feeders before mixing-in added trash. Burcotton and seedcotton samples to which trash was not added were agitated in the same manner as those to which trash was added.

All samples were processed on a 10-saw ginning system equipped with one lint cleaner as described by Kirk et al. (1) which was shown to produce grades comparable to those produced in commercial gins.

The lint samples were graded by a certified cotton classer. The grades were based only on trash content (leaf), disregarding color and preparation. Numerical grade index values as shown in reference (5) were used for statistical and comparative purposes. The middling grade has a grade index value of 100, with higher grades indicated by numbers greater than 100 and lower grades indicated by numbers less than 100.

[1] Contribution from the ARS, USDA, in cooperation with the Tex. Agric. Exp. Stn., Lubbock, Tex. Approved by TAES as Tech. Article No. 12102. Received 3 Nov. 1975.

[2] Agricultural engineers, Southern Region, ARS-USDA D. F. Wanjura is at Texas Agric. Exp. Stn., Lubbock, Tex., and R. V. Baker is at the South Plains Cotton Ginning Research Laboratory; Lubbock, Tex.

[3] Professor, Texas Agric. Exp. Stn. at Lubbock, TX 79401.

Table 1. Blade trichome densities of leaves and bracts for five cotton cultivars; 1971-74.

Cultivar	Year			
	1971	1972	1973	1974
	no. of trichomes/cm^2			
Leaves				
Dunn 119†	122 a*	141 a	138 a	84 a
Paymaster 111	85 b	75 b	59 b	--
Stripper Cala S	37 c	57 b	30 c	--
Tamcot SP 21	--	15 c	10 d	14 c
Lockett BXL	87 b	--	--	58 b
Bracts				
Dunn 119	--	100 a	61 a	34 a
Paymaster 111	--	108 a	33 bc	--
Stripper Cala S	--	43 b	17 c	--
Tamcot SP 21	--	34 c	2 d	13 b
Lockett BXL	--	--	--	42 a

* Numbers in the same column for the character followed by a common letter are statistically the same at the 0.05 level according to Duncan's multiple range test. † This cultivar was Dunn 56C in 1971.

RESULTS AND DISCUSSION

Leaf and Bract Characteristics. The density of trichomes (BTD) on the blades of the leaves and bracts varied widely between cultivars (Table 1). The Dunn cultivars (119 and 56C) had the highest BTD, followed by Paymaster 111, Stripper Cala S, and Tamcot SP 21. Lockett BXL, included in only 2 years, 1971 and 1974, had about the same BTD as Paymaster 111. The average BTD of Dunn leaves was almost 2 times higher than Paymaster 111 leaves, 3 times higher than Stripper Cala S, and almost 10 times higher than Tamcot SP 21 leaves.

The BTD relationship between cultivars for bracts was different from that for leaves. The BTD was lower for bracts than for leaves, and this reduction was greater for Dunn and Stripper Cala S than for Paymaster 111 and Tamcot SP 21. BTD of Dunn bracts was about 50% greater than Paymaster 111 bracts and about 300% greater than Stripper Cala S. BTD is apparently influenced by growing conditions, since year-to-year variation was found among the cultivars. Our data and the findings of Smith (4) prompted the use of BTD as the single characterization of leaf and bract pubescence in this study.

Boll Characteristics. Carpel number differed significantly between cultivars (Table 2). However, this difference was small; the greatest, only 0.3 of a Carpel, was between Dunn, 4.3 carpels, and Paymaster 111, 4.6 carpels per boll average for the 3 years in which both varieties were grown.

The carpel breaking energy (CBE) varied significantly between cultivars in all years except 1973 (Table 2). The season (year) seemed to have a greater effect on CBE than cultivars. Lint grade index was not affected by CBE.

Stripper Cala S had the smallest boll, according to criterion of maximum open-boll diameter. The diameter of the Dunn boll was slightly greater than that of Paymaster 111 and Tamcot SP 21 (Table 2).

The boll fluffiness index (BFI) was highly correlated with maximum open-boll diameter. The BFI and maximum open-boll diameter correlation coefficients for 1971, 1972, 1973, and 1974 were 0.94, 0.99, 0.90, and 0.07, respectively. The low correlation coefficient in 1974 was apparently caused by high rainfall in late August and September, which masked any differences in BFI. The year-to-year variation of BFI and open boll diameter indicated a seasonal effect. BFI of Stripper Cala S was much lower than that of any other cultivars. Stripper Cala S has a boll in which the seedcotton adheres tightly to the carpel walls and tends to keep the lock compacted in the bur. This characteristic came from the 'Macha' cultivar and has been termed the "Macha stormproof" character.

Table 2. Boll characteristics of five cotton cultivars; 1971-74.

Cultivars	Year			
	1971	1972	1973	1974
Carpel number				
Dunn 119†	4.4 ab*	4.3 b	4.3 a	4.4 a
Paymaster 111	4.7 a	4.7 a	4.5 a	--
Stripper Cala S	4.4 ab	4.6 ab	4.4 a	--
Tamcot SP 21	--	4.6 ab	4.4 a	4.4 a
Lockett BXL	4.3 b	--	--	4.4 a
Carpel breaking energy‡				
Dunn 119†	.56 a	.92 a	.53 a	1.16 a
Paymaster 111	.46 ab	.77 b	.55 a	--
Stripper Cala S	.43 b	.69 b	.71 a	--
Tamcot SP 21	--	.67 b	.67 a	.85 b
Lockett BXL	.30 c	--	--	.77 c
Maximum bur diameter, mm				
Dunn 119†	67 a	69 a	59 a	72 a
Paymaster 111	68 a	64 b	57 b	--
Stripper Cala S	51 c	52 d	51 c	--
Tamcot SP 21	--	62 c	57 b	62 b
Lockett BXL	62 b	--	--	65 b
Boll Fluffiness Index§				
Dunn 119†	19.4 a	21.6 a	25.2 a	16.3 a
Paymaster 111	19.8 a	18.5 b	23.2 a	--
Stripper Cala S	6.1 b	5.5 d	9.1 c	--
Tamcot SP 21	--	15.5 c	15.5 b	16.3 a
Lockett BXL	19.7 a	--	--	16.1 a

* Numbers in the same column for the same character followed by a common letter are statistically the same at the 0.05 level according to Duncan's multiple range test. † This cultivar was Dunn 56C in 1971. ‡ Carpel breaking energy is the energy expressed in joules expended by a swinging pendulum in breaking a single carpel wall of a fixed stationary boll. § Boll fluffiness index is the average of the maximum and minimum distance in mm from the tip of the carpel to a flat surface when an open boll is placed on the surface with its open end pointed downward.

Fine trash. The amount of fine trash in hand harvested burcotton and seedcotton from Tamcot SP 21 was generally lower than for the other cultivars (Table 3). Tamcot SP 21 also had the lowest BTD. However, over all years and cultivars the correlation between fine trash and BTD of leaves was low; $r = 0.21$ for burcotton and $r = 0.15$ for seedcotton. Over all samples the fine trash content of bur cotton was considerably higher (4.0) than that of seedcotton (2.9). The fine-trash content of seedcotton in 1974 was low because some trash was removed in processing the seedcotton through extractor feeders.

Grades Without Added Trash. Grade index values of lint from burcotton and seedcotton samples without added trash are shown in Table 4. The grade index values were not significantly different between cultivars for burcotton in 1971 and 1973 or for seedcotton in 1973 and 1974. Tamcot SP 21 had the highest overall grade index values. The spread in grade index values between cultivars was greater for burcotton than seedcotton. The burcotton of Tamcot SP 21 averaged

Table 3. Fine trash percentages of hard harvested seedcotton and burcotton from five cotton cultivars; 1971-1974.

Cultivars	Year			
	1971	1972	1973	1974
	Burcotton			
Dunn 119†	4.6 b*	6.4 a	3.0 a	4.7 a
Paymaster 111	6.0 a	5.4 a	3.4 a	--
Stripper Cala S	7.3 a	5.3 a	3.6 a	--
Tamcot SP 21	--	3.4 b	2.2 b	5.3 a
Lockett BXL	6.1 a	--	--	6.1 a
	Seedcotton			
Dunn 119†	3.3 a	2.8 a	2.4 ab	.7 b
Paymaster 111	4.5 a	4.6 a	2.0 bc	--
Stripper Cala S	4.3 a	4.7 a	2.7 a	--
Tamcot SP 21	--	3.1 a	1.5 c	.8 b
Lockett BXL	4.6 a	--	--	1.1 a

* Fine trash percentages in the same column for the same character followed by a common letter are statistically the same at the 0.05 level according to Duncan's multiple range test. † This cultivar was Dunn 56C in 1971.

Table 4. Lint grade index of hand-harvested seedcotton and burcotton without added trash from five cultivars; 1971-74.

Cultivar*	Year			
	1971	1972	1973	1974
	Burcotton			
Dunn 119†	87.3 a*	85.0 c	103.0 a	100.0 b
Paymaster 111	94.0 a	95.5 b	104.0 a	--
Stripper Cala S	89.5 a	94.0 b	103.0 a	--
Tamcot SP 21	--	100.0 a	105.0 a	102.7 a
Lockett BXL	94.0 a	--	--	100.0 b
	Seedcotton			
Dunn 119†	97.0 b	104.0 a	104.2 a	105.0 a
Paymaster 111	104.0 a	102.0 ab	105.0 a	--
Stripper Cala S	97.0 b	97.0 b	103.2 a	--
Tamcot SP 21	--	104.0 a	105.0 a	105.0 a
Lockett BXL	104.0 a	--	--	105.0 a
	Difference (Seedcotton-Burcotton)			
Dunn 119†	9.7	19.0	1.2	5.0
Paymaster 111	10.0	6.5	1.0	--
Stripper Cala S	7.5	3.0	0.2	--
Tamcot SP 21	--	4.0	0.0	2.3
Lockett BXL	10.0	--	--	5.0

* Numbers in the same column for the same character followed by a common letter are statistically the same at the 0.05 level according to Duncan's multiple range test. † This cultivar was Dunn 56C in 1971.

about one grade higher (103 vs. 94 grade index) than Dunn. In burcotton, Dunn averaged about one-half grade lower than Paymaster 111 (94 vs. 98) and less than one-half grade lower than Stripper Cala S (94 vs. 96). The grade index values for seedcotton were lowest for Stripper Cala S (99) followed by Dunn (103), Paymaster 111 (104), and Tamcot SP 21 (105).

The differences between the grade index values of burcotton and seedcotton are indicative of the bur's effect on cleanability during gin processing (Table 4). The differences varied greatly between years. Tamcot SP 21 and Stripper Cala S cultivars showed the least grade index value reduction due to the bur. Tamcot SP 21 had the lowest trichome density and Stripper Cala S the lowest BFI. The bur's adverse affect on cleanability may be associated with the bract, which is attached to the bur and becomes entangled in the seedcotton of other bolls during harvesting and early stages of gin processing. Thus, few trichomes on the bracts of Tamcot SP 21 resulted in more effective removal of bract particles from the burcotton than

Table 5. Lint grade index of hand-harvested seedcotton and burcotton resulting from adding five leaf and bract trash sources; 1971-74.

Trash source	Year			
	1971	1972	1973	1974
	Burcotton			
Dunn 119†	86.1 a*	88.2 b	103.1 a	93.3 c
Paymaster 111	87.3 a	91.2 a	104.2 a	--
Stripper Cala S	88.4 a	91.0 a	104.1 a	--
Tamcot SP 21	--	91.0 a	104.1 a	98.7 a
Lockett BXL	87.3 a	--	--	96.3 b
	Seedcotton			
Dunn 119†	91.4 b	99.0 b	104.2 a	102.6 a
Paymaster 111	92.1 b	100.1 b	104.7 a	--
Stripper Cala S	95.3 a	99.9 b	104.5 a	--
Tamcot SP 21	--	102.5 a	104.7 a	104.7 a
Lockett BXL	93.3 b	--	--	104.1 a

* Numbers in the same column for the same character followed by a common letter are statistically the same at the 0.05 level according to Duncan's multiple range test. † This cultivar was Dunn 56C in 1971.

Table 6. Effect of added trash source on lint grade index differential (average cultivar check grade index minus trash source grade index) for all cultivars; 1971-74.

Cultivar	Year			
	1971	1972	1973	1974
	Burcotton			
Dunn 119†	5.1	5.4	0.7	7.6
Paymaster 111	3.9	2.4	-0.4	--
Stripper Cala S	2.8	2.6	-0.3	--
Tamcot SP 21	--	2.6	-0.3	2.2
Lockett BXL	3.9	--	--	4.6
Mean	3.9	3.3	-0.1	4.8
	Seedcotton			
Dunn 119†	9.1	2.8	0.2	2.4
Paymaster 111	8.4	1.7	-0.3	--
Stripper Cala S	5.2	1.9	-0.1	--
Tamcot SP 21	--	-0.7	-0.3	0.3
Lockett BXL	7.2	--	--	0.9
Mean	7.5	1.4	-0.1	1.2

† This cultivar was Dunn 56C in 1971.

in the other varieties. The small difference between grade index values of seedcotton and burcotton associated with the low BFI of the Stripper Cala S may be due to less of the seedcotton being exposed to possible contamination. Within years the correlation coefficients of BFI with the differences in grade index values were 0.99, 0.73 and 0.88, respectively, for 1971, 1972, and 1973.

Grade index values of lint from seedcotton and burcotton for all years and cultivars were correlated with the fine trash content of the cotton before ginning; $r = -0.71$ for burcotton, and $r = -0.60$ for seedcotton.

Effect of Trash source on Grade. Lint grade index values that resulted from adding different trash sources are shown in Table 5. Grade index values of all treatments receiving the same trash source were averaged to obtain the grade index for that cultivar as a trash source. The effects of trash source on grade index values were small, but the burcotton values were slightly lower for Dunn and somewhat higher for Tamcot SP 21 than those of Paymaster 111 and Stripper Cala S. The pattern with seedcotton was similar, although the grade index values were slightly smaller.

Lint grade index values from the added trash treatments varied considerably between years. The yearly variations in the effect of added trash source on lint grade index were examined by calculating grade index differentials. Grade index differential is defined as the average grade index for all treatments without added trash within years minus the grade index for the added trash source (Table 6). Grade index differential reflects the influence of only the added trash source on grade index by removing the effects of the seedcotton or burcotton source.

Grade index was reduced by the added trash sources in 1971, 1972, and 1974. For those years grade index differential ranged from 3.3 to 4.8 for burcotton and from 1.2 to 7.5 for seedcotton. Added trash sources did not reduce grade index in 1973 (as indicated by the small negative grade index differential values). Fine trash levels were low in all cultivars in 1973 (Table 3).

The Dunn added trash source had the highest grade index differential in each year for both burcotton and seedcotton. This trash source was the most pubescent (Table 1) and indicates the negative effect of highly pubescent vegetable trash on lint grade index.

The grade index differential values also showed that the bur had no influence on the added trash effect on grade index. The overall difference in the mean lint grade differential values between burcotton and seedcotton was 0.3. This similarity in mean lint grade differential values is consistent with the hypothesis that the bract attached to the bur is chiefly responsible for lower lint grade index values of burcotton.

Seasonal variations had more influence on lint grade index than the plant vegetative characters we measured. Vegetable trash pubescence (BTD) and boll fluffiness (BFI) showed a significant negative influence on lint grade index. The bract attached to the bur is the primary cause for lint from burcotton having a lower grade index than lint from seedcotton.

Mechanical stripper harvesting causes factors such as BTD and BFI to have a significant effect on lint grade index. The use of glabrous cultivars (BTD$<$20) with compact bolls (BFI $=$ 10 to 20) would result in significant grade improvement over that obtained with many cultivars currently grown in the Texas High Plains.

REFERENCES

1. Kirk, I. W., Bilbro, J. D., Jr., and L. L. Ray. 1963. Evaluation of a laboratory gin for processing hand-snapped and machine-stripped cotton. ARS 42-85.
2. Loewenschuss, H., and Wakelyn, P. J. 1972. Occurrence of gossypol in dried bract of the cotton plant. J. Am. Oil Chem. Soc. 49:678-680.
3. Ramey, H. H. 1962. Genetics of plant pubescence in upland cotton. Crop Sci. 2:269.
4. Smith, A. L. 1964. Leaf trichomes of upland cotton varieties. Crop Sci. 4:348-349.
5. USDA Agricultural Marketing Service Cotton Division Staff. 1974. Summary of cotton fiber and processing test results. 4840 Summer Ave., Memphis, Tenn. p. 101.