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A Rating System for Leaf Pubescence of Cotton

F. M. Bourland*, J. M. Hornbeck, A. B. McFall, and S. D. Calhoun

ABSTRACT

A rating system for leaf pubescence is needed to characterize cotton cultivars having intermediate densities of leaf trichomes. We propose a system that is based on visual examination of the relative density, distribution and length of abaxial trichomes. Our objectives were to evaluate trichome density associated with this proposed leaf pubescence rating system, to evaluate the variation of trichomes on leaves located at different positions on the main stem, and to compare leaf pubescence ratings of cultivars made over locations and years. Number of trichomes (defined as total number of trichomes and trichome branches) associated with each leaf rating was determined from leaves sampled over three years. Leaves of contrasting cultivars were also sampled from the top, middle and bottom of plants in 1995 and 2001. Pubescence of each leaf was rated both years, and trichomes were counted in the 2001 tests. Leaf pubescence of cultivars in state variety tests was rated over locations and years. Differences in density of trichomes between leaf pubescence ratings were found. Pubescence ratings and trichome counts were highest for upper canopy leaves. Trichomes became less dense as leaves enlarged, then tended to abscise as leaves aged, therefore leaf pubescence should be rated using the youngest, fully expanded main-stem leaves. Within each field test, leaf pubescence ratings varied significantly among cultivars and were consistent for cultivars at different locations and across years. These data indicate that the rating system has a morphological basis and can be used to characterize the leaf pubescence of cotton cultivars.

F. M Bourland and A. B. McFall, University of Arkansas, Northeast Res. & Ext. Center, P.O. Box 48, Keiser, AR 72351; J. M. Hornbeck, University of Arkansas, Cotton Branch Station, P.O. Box 789, Marianna, AR 72360; S. D. Calhoun, Stoneville Pedigreed Seed Company, P.O. Box 857, Idalou, TX 79329.
*Corresponding author (bourland@uark.edu).

Leaf trichomes received relatively little attention from cotton breeders until the advent of mechanical harvesting and the release of 'Deltapine Smooth Leaf' in 1957. Lint from smooth leaf cultivars is easier to clean and, consequently, tends to have less trash (improved leaf grades) relative to hairy leaf cultivars (Rayburn and Libous, 1983; Anthony and Rayburn, 1989). As summarized by Jenkins and Wilson (1996), the smooth leaf trait is associated with increased resistance to some insects (e.g. cotton bollworm, *Helicoverpa zea* [Boddie], and bandedwinged whitefly, *Trialeurodes abutilonea* [Haldeman]), but increased susceptibility to other insects (e.g. leaf hoppers, *Empoasca* spp. and plant bugs, *Lygus* spp).

Smith (1964) evaluated trichomes on cotton genotypes grown in Alabama in 1962 and found the average number of trichomes on leaf blades varied from 2 to 205 trichomes cm^{-2}. He proposed that Deltapine Smooth Leaf (ca. 5 trichomes cm^{-2}) serve as a standard for defining cultivars designated as "smooth leaf." Since Deltapine Smooth Leaf is now obsolete, other cultivars with similar leaf hair phenotypes may serve as the standard. He did not indicate a standard for "hairy leaf" or any intermediate types. Rayburn (1986) proposed a hairiness index with three classes that was based on the density of trichomes. The three classes were labeled "smooth", "moderately hairy" and "hairy", representative cultivars in each class were identified.

With the release of widely adapted, early-maturing, smooth leaf lines in the early 1980's and the advantage of being easier to clean, smooth leaf cultivars (e.g. Deltapine 50) became preferred by many producers in the Mississippi River Delta region. In a report by Rayburn (1986), all of the cultivars included in the "smooth" and "hairy" classes, but none in a "moderately hairy" class, were adapted to the Mississippi River Delta region. All adapted cultivars available to Delta producers at that time were classified as either smooth leaf or hairy. Since then, several cultivars (e.g. Stoneville 132, Paymaster H1220, Sure-Grow 501) identified as "reduced hair"

or "semi-smooth" have been released. No standard description exists for cultivars with intermediate amounts of leaf pubescence.

In this paper, we propose a leaf pubescence rating system that is based on visual examination of the relative density, distribution, and length of leaf trichomes on the abaxial leaf surface, and attempt to validate it through comparisons with trichome densities and consistency across locations and years. The objectives of this study were to evaluate trichome densities associated with the proposed leaf pubescence rating system, to evaluate the variation of trichomes on main-stem leaves on individual plants, and to compare leaf pubescence ratings among cultivars.

MATERIALS AND METHODS

Rating system for leaf pubescence. The proposed system includes a visual rating of trichomes on the abaxial surface of the leaf using a scale of 1 (smooth leaf), 3 (lightly hairy), 5 (hairy), 7 (very hairy), and 9 (pilose) with representative cultivars within each class (Table 1). An intermediate rating of "2" is used for a lightly hairy leaf if trichome density is non-uniform with intermittent smooth leaf areas between clumps of trichomes. Even-numbered ratings may be assigned to plants that appear to be between the major rating classes. Pubescence on leaves is rated independently of pubescence on other plant parts, including stems, leaf margins, and bracts.

Seed sources. Seed submitted for evaluation in the Arkansas Cotton Variety Tests were used in these tests. Seed were obtained for "Deltapine", "Sure-Grow" and "Paymaster" brand cultivars and DES 119 from Delta and Pine Land Company (Scott, MS); for "FiberMax" brand cultivars from Aventis Crop Science (Collierville, TN); for "Germain's" brand cultivars from Germain's Cotton Seed Incorporated (Fresno, CA); for HyPerformer HS23 from HyPerformer Seed Company (Memphis, TN); for Phytogen 355 from PhytoGen Seed Company, LLC (Leland, MS); for "Stoneville" brand cultivars from Stoneville Pedigreed Seed Company (Collierville, TN); for Terra 292 from Terra International, Inc. (Leland, MS); and for Ark 8712 from University of Arkansas (Fayetteville, AR).

Trichome numbers. The relationship between leaf pubescence rating and number of trichomes was examined in 1995, 1999, and 2001. In August of 1995, ca. 20 fully expanded leaves from each of five cultivars (Deltapine 50, Paymaster H1244, Paymaster H1330, Stoneville 474, and Sure-Grow 501) were randomly collected at Keiser, AR. Pubescence on each leaf was rated using the scale in Table 1. An index card with a 0.65 cm diameter hole (0.33 cm^2) was laid over the interveinal area on the abaxial side of each leaf. Trichomes in the circle were then counted with the aid of a stereo-microscope. Each branch of stellate trichomes was counted as a separate trichome. The mean and standard deviation for trichomes cm^{-2} were determined for each leaf pubescence rating.

In 1999, 15 leaves having leaf pubescence ratings of 1, 3, 5, and 7 were sampled on 2 Septem-

Table 1. Rating scale for cotton leaf pubescence

Rating	Name	Representative Cultivar	Description of trichomes on abaxial leaf surface[z]
1	Smooth	Deltapine 51 Sure-Grow SG747	None or few (trichomes may be present on leaf veins).
3	Lightly hairy	Paymaster H1220 Sure-Grow SG105	Light density, short and evenly distributed.
5	Hairy	Sure-Grow SG501 Paymaster H1330	Moderate density, medium length and evenly distributed.
7	Very hairy	Stoneville 474 DES 119	High density, relatively long and evenly distributed.
9	Pilose	Pilose genotype	Very high density, very long and evenly distributed.

[z] Interveinal areas on the abaxial surface of youngest full-size leaf (ca. 5th to 7th main-stem leaf from plant apex) are rated. Rating of "2" is used for lightly hairy leaf if trichomes are scattered rather than evenly distributed. Ratings of 4, 6, & 8 may be assigned to leaves that are intermediate to types 3, 5, 7, & 9, respectively. Pubescence on leaves is rated independently of other plant parts including stems, leaf margins, and bracts.

ber at Keiser, AR. Cultivars sampled (5 leaves/cultivar for each rating) for rating 1 (Deltapine NuCOTN 33B, FiberMax FM989, and Sure-Grow 125,), rating 3 (FiberMax FM832, Paymaster PM1220BG/RR, and Sure-Grow 105), rating 5 (Paymaster PM1330BG, Paymaster PM1560BG, and Sure-Grow 501), and rating 7 (Deltapine 5111, Stoneville 474, and Stoneville BXN47) provided a range of genetic backgrounds. Number of trichomes cm^{-2} was determined using the same method described previously.

In 2001, leaves were sampled from seven cultivars (Deltapine 451BR, Paymaster 1218BR, Ark 8712, Paymaster1199RR, Phytogen 355, Stoneville 4892BR, and Sure-Grow 215BR) at Keiser (8 August) and the same seven cultivars plus Germain 106 at Marianna, AR (16 August), respectively. A top, middle and bottom leaf from 10 random plants of each cultivar was collected, rated for pubescence, and number of trichomes cm^{-2} was determined as above. Leaves collected from the top were the 2nd or 3rd highest unfolded leaf, leaves in the middle were the 10th to 12th node, and leaves at the bottom were the lowest non-abscised main-stem leaf.

Variation on the same plant. In 1995, representative plants of five cultivars (Deltapine 50, Paymaster H1244, Paymaster H1330, Stoneville 474, and Sure-Grow 501) were sampled from tests at Stoneville, MS (20 plants each), Marianna, AR (10 plants each), and Keiser, AR (10 plants each). At each site, leaf pubescence of main-stem leaves at the top, middle, and bottom of plants (as described previously) were used to evaluate variation among leaves in the plant canopy. Leaves were rated in mid-August using the scale in Table 1. The 2001 data for leaf pubescence ratings and trichome counts for top, middle, and bottom leaves were used to evaluate variation among leaves in the plant canopy. Means and standard deviations for each cultivar and plant position were determined in 1995 and 2001.

Cultivar ratings. In 1995, leaf pubescence of 16 cultivars that were grown in both the Arkansas and Mississippi cotton cultivar tests were rated at Keiser, Marianna (irrigated and non-irrigated tests), and Rohwer, AR, and at Stoneville, MS. Different individuals at each location using the descriptions in Table 1 rated the cultivars. In the Arkansas tests, ratings for 10 plants per plot in two replications were averaged. In the Mississippi test, a consensus rating based on the modal ratings from six replications was made for each cultivar. Linear correlation coefficients of the cultivar means were determined among locations.

The rating scale was also used to evaluate leaf pubescence of entries in the Arkansas Cotton Variety Test at six locations in 1996 (Bourland et al., 1997), one in 1997 (Bourland et al., 1998), three in 1998 (Bourland et al., 1999) and six in 1999 (Bourland et al., 2000). Leaf pubescence ratings for 10 cultivars common to all tests were extracted from these reports. Means with standard deviations for each cultivar and linear correlation coefficients over tests were determined.

All data were analyzed using appropriate SAS statistical programs (SAS Institute, Inc., Cary, NC).

RESULTS AND DISCUSSION

The leaf pubescence rating system proposed in this manuscript expands the three-class system proposed by Rayburn (1986). The intermediate classes allow one to distinguish whether a genotype is more similar to smooth leaf or very hairy types, and ratings are provided for extremely pubescent genotypes (more pubescent than normally found in commercial cultivars).

In this discussion, "number of trichomes" refers to the total number of trichome branches observed with each branch of stellate trichomes counted as a trichome. For most reports, it is not clear whether the authors counted actual number of trichomes or total number of trichome branches. Smith (1964) found the average number of branches to vary from 1.2 to 3.0 for different cultivars and indicated that there was no apparent relationship between number of trichomes and number of trichome branches. Intuitively, total branches should provide an accurate reflection of the observed and functional "hairiness" of a leaf.

Trichome number. Number of trichomes on leaves increased geometrically as the leaf pubescence rating increased (Table 2). Although the range of trichomes sometimes overlapped, the mean number of trichomes for each rating was different between ratings within a test. The wide range in number of trichomes within a rating may be due to a mistaken visual rating of some leaves or to variation in trichomes on an individual leaf. The latter may be due to actual differences in trichome density or to accidental removal of some trichomes while handling the leaves. Nevertheless, the rating scale reflected actual differences in degree of leaf pubescence.

Table 2. Number of trichomes associated with leaf pubescence ratings at Keiser and Marianna, Arkansas

Year-location[z]	Leaf rating	No. of plants	Abaxial trichomes cm^{-2}	
			No. ± st.dev.	Range
1995 Keiser	1 (smooth leaf)	10	1.8 ± 1.7	0 to 4
	2 (intermediate)	23	8.1 ± 3.5	2 to 16
	3 (lightly hairy)	35	29.2 ± 8.6	11 to 42
	5 (hairy)	24	56.1 ± 12.3	35 to 81
	7 (very hairy)	12	104.3 ± 17.2	74 to 135
1999 Keiser	1 (smooth leaf)	15	8.7 ± 8.1	0 to 23
	3 (lightly hairy)	15	66.6 ± 39.9	18 to 142
	5 (hairy)	15	217.5 ± 65.3	133 to 361
	7 (very hairy)	15	335.8 ± 80.9	205 to 485
2001 Keiser	1 (smooth leaf)	59	9.0 ± 14.3	0 to 63
	2 (intermediate)	8	60.4 ± 27.5	25 to 102
	3 (lightly hairy)	60	134.6 ± 58.0	42 to 326
	5 (hairy)	52	225.5 ± 93.6	46 to 466
	7 (very hairy)	61	465.2 ± 168.3	189 to 980
2001 Marianna	1 (smooth leaf)	49	11.3 ± 33.5	0 to 175
	2 (intermediate)	27	53.0 ± 51.4	0 to 179
	3 (lightly hairy)	79	159.2 ± 73.3	14 to 361
	5 (hairy)	25	331.8 ± 182.0	119 to 739
	7 (very hairy)	30	474.1 ± 176.2	207 to 763

[z] **In 1995, an equal number of leaves were randomly collected from representative cultivars (Deltapine 50, Paymaster H1244, Paymaster H1330, and Stoneville 474, and Sure-Grow 50), while 15 leaves having specified ratings were collected in 1999. In 2001, a top, middle and bottom leaf was collected from Ark 8712, Deltapine 451BR, Germain 105, Paymaster 1218BR, Paymaster 1199RR, Phytogen 355, Stoneville 4892BR, and Sure-Grow 215BR. In each test, the number of trichomes (with branches counted as individual trichomes) was counted and leaf pubescence of each leaf was rated using a 1-to-9 scale, where 1=smooth leaf, 2=lightly hairy, 5=hairy, 7=very hairy, and 9=pilose.**

Except for the counts made in 1995, the number of trichomes associated with each rating was relatively constant over tests (Table 2). Large variation in leaf trichome counts is not unusual. Norman and Sparks (1997) reported more than a 10 fold variation in number of trichomes within the same cultivar grown over different years in the Rio Grande Valley of Texas, but trichome numbers for the 15 cultivars were highly correlated over years. Means over years varied from less than 10 trichomes cm^{-2} for smooth leaf cultivars to 80 trichomes cm^{-2} for Stoneville 474. Rayburn (1986) reported counts ranging from 54 to 676 trichomes cm^{-2} in a 1985 test of smooth leaf and hairy leaf cultivars grown at Stoneville, MS in 1985. Relative numbers of trichomes on smooth and hairy leaf cultivars at Maricopa, AZ, in 1999 (Chu et al., 2000) were similar to the average of our 1995 and 1999 data. Smith (1964) reported the number of trichomes on the leaf blade and the average number of trichome branches on 31 cotton cultivars grown in Alabama in 1962. Multiplication of these two parameters provides a range (4 to 336 trichomes cm^{-2}) for smooth leaf to very hairy leaf cultivars that is similar to our 1999 and 2001data.

Although not included in these tests, leaves of a pilose genotype had nearly twice as many trichomes compared to a typical very hairy (rating of 7) leaf (data not shown). Also, trichomes on the pilose leaf were longer than trichomes on leaves from any other cotton genotype.

Variation on same plant. Visual ratings in 1995 (Table 3) and 2001 (Table 4) indicated that leaf pubescence varies on the same plant. Regardless of the expected pubescence rating of the cultivar, leaves in the top of the plant always exhibited the highest leaf pubescence ratings, and leaves from the bottom of the canopy tended to have the lowest pubescence ratings. Counts of trichomes in 2001 confirmed the visual difference in pubescence at different plant positions.

Except for the two smooth leaf cultivars, the relative change in number of trichomes from middle to bottom leaves was similar for all cultivars (Table 4). The greatest relative variation was found for the middle and bottom leaves of the smooth leaf cultivars, where the standard deviation exceeded the mean in each case. The few trichomes found on leaves of smooth leaf cultivars often occur in unevenly distributed clumps. This uneven distribution contributes to large sampling variation because only small areas of each leaf were examined.

The decrease in pubescence from the top to the middle of the plant is likely due to thinning of the trichomes as the leaf enlarges. The decline in the number of trichomes from the middle to bottom may be due to mechanical loss of trichomes associated with movement and age of the leaves. Because of this variation, care must be taken to evaluate leaves from similar positions on the plant. We choose the highest fully expanded leaf, which typically occurs at ca. five to seven nodes from the plant apex.

The 2001 cultivar by plant position data at Keiser and Marianna further validated the rating system (Table 4). Correlation coefficients of pubescence ratings and number of trichomes across cultivars and plant positions at Keiser (r=0.89) and Marianna (r=0.97) were highly significant. Additionally, pubescence ratings (r=0.80) and number of trichomes (r=0.81) of the cultivars at the two locations were significantly correlated.

Cultivar ratings. As expected, leaf pubescence of the 16 cultivars was variable in each test in 1995

Table 3. Leaf pubescence ratings for main-stem leaves located at the top, middle, and bottom of plants at three locations in 1995

Cultivar (expected pubescence)	Position of leaf on plant	Pubescence rating ± st. dev.[z]		
		Keiser, AR	Marianna, AR	Stoneville, MS
Deltapine 50	Top	1.4 ± 0.7	2.8 ± 0.4	2.3 ± 1.9
(smooth leaf)	Middle	1.5 ± 0.3	1.2 ± 0.6	1.6 ± 1.1
	Bottom	1.0 ± 0.0	1.0 ± 0.0	1.5 ± 1.1
Paymaster H1244	Top	3.0 ± 0.8	4.7 ± 1.6	6.1 ± 1.5
(lightly hairy)	Middle	2.9 ± 0.9	3.8 ± 1.2	3.6 ± 1.1
	Bottom	2.3 ± 0.9	3.4 ± 1.4	4.2 ± 1.3
Sure-Grow 501	Top	3.1 ± 0.3	4.8 ± 1.5	7.0 ± 0.0
(hairy)	Middle	3.3 ± 0.5	2.8 ± 0.4	6.1 ± 1.5
	Bottom	2.1 ± 1.1	2.8 ± 0.7	6.6 ± 1.0
Paymaster H1330	Top	4.2 ±1.4	6.3 ± 1.8	6.0 ± 1.9
(hairy)	Middle	4.0 ± 1.3	3.9 ± 1.5	5.9 ± 1.7
	Bottom	3.1 ± 1.7	2.9 ± 0.9	5.7 ± 2.1
Stoneville 474	Top	6.5 ± 0.7	7.0 ± 0.0	7.0 ± 0.0
(very hairy)	Middle	6.6 ± 0.7	4.8 ± 1.6	6.9 ± 0.4
	Bottom	5.8 ± 1.0	5.1 ± 0.2	7.0 ± 0.0

[z] At each location, leaf pubescence of main-stem leaves at top (2nd or 3rd highest unfolded leaf), middle (10th to 12th node), and bottom (lowest non-abscised main-stem leaf) of plants (10 plants at Keiser and Marianna, 20 plants at Stoneville) were rated in mid-August using a 1-to-9 scale, where 1=smooth leaf, 2=lightly hairy, 5=hairy, 7=very hairy, and 9=pilose.

Table 4. Leaf pubescence ratings and number of leaf trichomes on the abaxial surface of main-stem leaves located at the top, middle and bottom of plants at Keiser and Marianna, AR, in 2001[z]

Cultivar (expected pubescence)	Leaf position	Pubescence rating		No. of trichomes cm^{-2}	
		Keiser	Marianna	Keiser	Marianna
Deltapine 451BR	Top	2.2 ± 0.9	2.8 ± 0.9	80.5 ± 35.2	116.6 ± 113.0
(smooth leaf)	Middle	1.0 ± 0.0	1.2 ± 0.4	14.2 ± 15.6	5.6 ± 9.8
	Bottom	1.0 ± 0.0	1.0 ± 0.0	3.2 ± 4.8	2.8 ± 4.9
Sure-Grow 215BR	Top	1.1 ± 0.3	2.4 ± 1.0	16.5 ± 18.2	49.4 ± 43.5
(smooth leaf)	Middle	1.4 ± 0.8	1.0 ± 0.0	29.8 ± 56.2	1.4 ± 3.0
	Bottom	1.0 ± 0.0	1.0 ± 0.0	2.8 ± 5.9	2.1 ± 6.6
Paymaster 1218BR	Top	3.2 ± 0.6	5.4 ± 1.3	246.1 ± 77.5	413.4 ± 184.4
(lightly hairy)	Middle	2.8 ± 0.4	3.0 ± 0.0	111.0 ± 39.4	157.9 ± 31.8
	Bottom	3.0 ± 0.0	2.3 ± 0.7	114.1 ± 34.7	118.0 ± 50.1
Ark. 8712	Top	3.2 ± 1.5	4.2 ± 2.3	130.6 ± 87.9	197.8 ± 149.7
(lightly hairy)	Middle	2.6 ± 0.7	2.1 ± 1.0	104.0 ± 59.0	71.8 ± 65.5
	Bottom	2.0 ± 1.1	2.1 ± 1.0	56.0 ± 58.9	55.7± 47.7
Paymaster 1199RR	Top	5.0 ± 0.9	5.0 ± 1.6	363.7 ± 84.4	326.2 ± 145.7
(hairy)	Middle	4.6 ± 0.8	3.0 ± 0.0	163.1 ± 41.8	121.5 ± 46.5
	Bottom	3.9 ± 1.2	2.6 ± 0.5	93.8 ± 55.1	87.5 ± 51.4
Phytogen 355	Top	6.8 ± 0.6	6.4 ± 1.0	654.2 ± 189.4	505.1 ± 117.4
(hairy)	Middle	6.0 ± 1.1	3.6 ± 1.0	398.3 ± 122.9	234.5 ± 72.3
	Bottom	5.2 ± 1.8	3.0 ± 0.0	203.4 ± 85.7	172.9 ± 39.3
Stoneville 4892BR	Top	6.8 ± 0.6	7.0 ± 0.0	399.0 ± 152.2	626.5 ± 159.3
(very hairy)	Middle	5.8 ± 1.0	5.0 ± 1.9	273.7 ± 88.3	248.9 ± 91.2
	Bottom	6.2 ± 1.0	3.4 ± 1.3	194.3 ± 85.4	192.9 ± 56.2
Germain's 106	Top	7.0 ± 0.0	nt	569.5 ± 144.3	nt
(very hairy)	Middle	7.0 ± 0.0	nt	437.9 ± 80.1	nt
	Bottom	5.4 ± 1.6	nt	260.4 ± 102.1	nt

[z] **Trichomes were counted and leaf pubescence were rated on the main-stem leaves at the top (2nd or 3rd highest unfolded leaf), middle (10th to 12th), and bottom (lowest non-abscised main-stem leaf) of 10 plants/cultivar/location in mid-August using a 1-to-9 scale, where 1=smooth leaf, 2=lightly hairy, 5=hairy, 7=very hairy, and 9=pilose; nt = data not taken.**

(Table 5). Several cultivars had intermediate levels of leaf pubescence, i.e. ratings of ca. 3 to 5. All correlation coefficients among ratings of the cultivars at the different locations exceeded 0.85 and only two were less than 0.90 ($r > 0.48$ were significantly different from zero). The high correlation coefficients indicated that the proposed leaf pubescence rating scale is transferable and can be used to describe variation in cultivars. Across locations, standard deviations for several smooth leaf cultivars tended to be relatively larger than standard deviations for the hairy leaf cultivars. Apparently, visual ratings by some individuals may have been affected by the sparse trichomes on some smooth leaf cultivars. Stoneville 474 is often used as the reference for "very hairy" plants (rating 7), so its rating is less variable and likely contributed to its low standard deviation. The relatively consistency of the means and standard deviations within each location adds confidence to the use of the rating system.

Pubescence ratings for 10 cultivars over 15 sites of the 1996 through 1999 Arkansas Cotton Variety Tests provided experience with the rating system over years and locations. Variation in these ratings

Table 5. Leaf pubescence ratings for 15 cultivars at five locations in the 1995 Arkansas and Mississippi Cotton Variety Tests

Cultivar	Leaf pubescence rating[z]					
	Keiser, AR	Marianna, AR		Rohwer, AR	Stoneville, MS	Mean + sd
		Irrig.	No irrig.			
Deltapine 50	1.6	2.3	1.2	1.2	1	1.5 ± 0.5
Deltapine 20	2.2	2.7	1.1	1.0	1	1.6 ± 0.8
Deltapine 51	2.2	2.5	1.4	1.1	1	1.6 ± 0.7
Sure-Grow 404	3.2	2.9	1.6	1.4	1	2.0 ± 0.7
Stoneville 495	3.2	2.8	2.1	1.2	1	2.1 ± 1.0
Sure-Grow 125	3.4	2.6	1.3	1.1	3	2.3 ± 1.0
PayMaster H1220	3.0	3.2	3.2	3.0	3	3.1 ± 0.1
PayMaster H1244	3.6	3.3	3.4	3.2	3	3.3 ± 0.2
PayMaster H1215	4.4	3.3	2.8	3.3	3	3.4 ± 0.6
Stoneville 132	3.4	3.0	3.6	3.0	4	3.4 ± 0.4
Sure-Grow 501	4.0	3.1	3.6	4.0	5	3.9 ± 0.7
PayMaster H1330	5.0	3.9	5.5	3.9	5	4.7 ± 0.7
HyPerformer HS23	5.0	3.8	5.5	6.2	6	5.3 ± 1.0
Stoneville LA887	5.6	5.5	6.3	5.0	7	5.9 ± 0.8
DES 119	6.6	5.6	6.3	7.0	7	6.5 ± 0.6
Stoneville 474	6.6	6.7	6.8	7.0	7	6.8 ± 0.2
Mean	4.9	4.6	4.5	4.3	4.3	--
St. dev.	1.5	1.3	2.0	2.1	2.3	--

[z] At each Arkansas location, 10 leaves per plot (two replications) were rated, while at Stoneville a consensus leaf rating was determined for each cultivar within six replications using a 1-to-9scale, where1=smooth leaf, 2=lightly hairy, 5=hairy, 7=very hairy, and 9=pilose.

was similar to that found in 1995, except that no difference in standard deviations between smooth and hairy leaf cultivars was apparent (Table 6). Additional experience with the rating system may have negated the problem with higher standard deviations associated with smooth leaf cultivars as found in1995. Again, the standard deviation for Stoneville 474 was relatively low.

As might be expected, correlation coefficients for ratings within a year were higher than coefficients between years (Table 7). Among the correlation coefficients, 91 and 86% of comparisons within year and across years, respectively, exceeded 0.80. In addition to variation due to individuals conducting the ratings and to possible environmental interactions, differences in pubescence between years might also be affected by source of seed. In these tests, the same lot of seed was used to plant all tests

Table 6. Mean leaf pubescence ratings for 10 cultivars at 15 locations in the Arkansas Cotton Variety Test from 1996 through 1999

Cultivar	Leaf Pubescence Rating (Mean ± st. dev)
Sure-Grow 125	2.0 ± 0.6
Germain's GC251	2.2 ± 0.8
Deltapine NuCOTN 33B	2.2 ± 0.9
Terra 292	2.3 ± 0.7
PayMaster PM1220RR	3.8 ± 0.5
PayMaster PM1560BG	3.8 ± 0.7
Sure-Grow 501	4.2 ± 0.8
PayMaster PM1330BG	4.6 ± 0.8
Stoneville BXN47	5.2 ± 0.8
Stoneville 474	6.4 ± 0.5

[z] At each location, 10 leaves per plot (2 replications) were rated using a 1-to-9 scale, where 1=smooth leaf, 2=lightly hairy, 5=hairy, 7=very hairy, and 9=pilose.

Table 7. Frequency distributions of correlation coefficients obtained from pair-wise comparisons for leaf pubescence ratings of 10 cultivars planted at multiple locations in the 1996-1999 Arkansas Cotton Variety Tests

Parameter	Frequency by ranges of correlation coefficients[z]			
	0.90-1.00	0.80-0.89	0.70-0.79	0.60-0.69
Within years:				
1996 vs. 1996	15	0	0	0
1998 vs. 1998	1	2	0	0
1999 vs. 1999	9	3	2	1
Across years:				
1996 vs. 1997	5	1	0	0
1996 vs. 1998	8	7	2	1
1996 vs. 1999	13	17	4	2
1997 vs. 1998	1	2	0	0
1997 vs. 1999	5	1	0	0
1998 vs. 1999	10	5	3	0

[z] **Leaf pubescence ratings of 10 cultivars at multiple locations within the same year and at multiple locations across years were correlated. Correlation coefficients > 0.67 were significantly different from zero at $P \leq 0.05$.**

within a year, but different lots were used each year. The high correlation coefficients indicated that the rating scale was effective in characterizing the leaf pubescence of cotton cultivars

CONCLUSIONS

The degree of leaf pubescence among different cotton cultivars varies from essentially none (smooth leaf) to very hairy. Classing a cultivar as “smooth” or “hairy” does not sufficiently characterize the extent of leaf pubescence. We developed a leaf pubescence rating system that is simple to learn and can be used to quickly determine the level and variation of leaf pubescence in a cultivar or plant population. The leaf pubescence ratings were strongly related to number of trichomes, indicating that the rating system has a sound morphological basis. Leaves of all cultivars tended to become less pubescent as they expanded to full size and as they aged. To obtain consistent pubescence ratings, we sample the youngest fully expanded leaves (usually located 5 to 7 nodes from plant apex). The rating system was effectively used to compare leaf pubescence of cultivars by different individuals over several locations.

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