RELATIONSHIP OF LEAF AND BRACT TRICHOMES TO TRASH CONTENT OF GINNED LINT

J. Clif Boykin
USDA ARS Cotton Ginning Research Unit
Stoneville, MS
Fred Bourland
University of Arkansas
Keiser, AR
Darrin M. Dodds
Mississippi State University
Mississippi State, MS

Abstract

Spinning efficiency and yarn quality are improved for bales with reduced trash content. Some cotton varieties have been characterized as having smoother leaves (low trichome density) and fewer bract trichomes, and it has been shown that cottons harvested from these varieties are picked with lower trash content. Cotton picked with lower trash content is easier to clean at the gin and mill. Plots from the 2010 and 2011 Mississippi Variety Trials were sampled at multiple locations for leaf and bract trichomes, machine harvested, and ginning in the microgin. Leaf and bract trichomes were highly (positively) correlated with lint trash based on samples collected after lint cleaning and tested by HVI, AFIS, and Shirley Analyzer. These findings are significant in that high HVI leaf grades (and other measures of lint trash) are associated with densely populated trichomes of the leaves and bracts of certain varieties. These results should encourage breeders to select against hairy leaves and bracts. These results also show that variety information for leaf and bract hairiness should help ginners make management decisions and gin researchers develop new and improved technologies to increase the cleanliness of lint and thus bale value.

Introduction

Cotton mills pay a premium for bales of U.S. cotton with low trash content, currently based on HVI leaf measured at the USDA Agricultural Marketing Service Cotton Classing offices. Various methods of reducing lint trash content are implemented in the field, during harvest, in the gin where cotton is cleaned before and after the lint is separated (ginned) from the seed, and in the mill where cotton is cleaned before spinning. Cotton in the U.S. is mechanically harvested, and other parts of the cotton plant tend to be extracted along with the cotton. Defoliants are typically applied prior to harvest to promote leaf drop and reduce the amount of leaf material in the harvested cotton, but some leaves remain attached to stems or cling to cotton bolls.

Lint trash is not the only property mills are interested in, as many other properties of the fiber affect spinning and yarn quality. Fiber length distribution, for example, is important as cotton with longer fibers and higher fiber length uniformity can be spun into finer yarns. Neps (fiber entanglements) also reduce yarn quality. Cleaners in gins are very effective at removing trash from seed cotton and lint, but they also reduce fiber length, reduce length uniformity, and increase neps (Anthony 1990). Therefore, reducing the trash content of cotton before it gets to the gin should reduce the need for cleaning and improve fiber quality.

Morey (1979) examined trash particles in ginned lint and found the origin of lint trash content was primarily other parts of the cotton plant such as leaf, bract, stem, and seed. Some cotton varieties are categorized as “hairy leaf” cottons due to high levels of leaf trichomes (leaf hairs) on the abaxial (bottom) sides of leaves which cause some leaves to cling to opened cotton bolls. This leaf material is harvested with the cotton, increasing trash content. Trichomes are also found attached to the margin (edge) of bracts causing the same problem. Trichomes of the leaf and bract cling to cotton fiber and potentially affect cleaning in the gin and trash content of ginned lint. Cotton varieties differ in leaf and bract trichome density (Bourland and Hornbeck 2007). Though variety differences in leaf and bract trichome density are statistically correlated, bract trichomes may be more strongly related to lint trash content since most leaves are dropped to the ground after defoliation and prior to harvest. A two year study was conducted with two objectives: 1) to determine if lint trash content increased with leaf trichome density or bract trichome density and 2) to determine if these two relationships were independent.

Materials and Methods

Ten varieties were grown at several locations with two replications per location in 2010 and 2011, as part of the Mississippi State Cotton Variety Trials. Plots from four locations in 2010, and three locations in 2011, were sampled to determine leaf trichome density (trichomes/cm^2) and bract trichome density (trichomes/cm) determined by microscopic examination. Leaves and bracts were collected from mid-canopy and analyzed at the University of Arkansas Northeast Research and Extension Center, Keiser, AR, according to methods outlined by Bourland and Hornbeck (2007). Leaf trichomes were counted on the abaxial side of the leaf, and bract trichomes were counted along the margin of the trichome. Plots from six locations in 2010, and five locations in 2011, were machine harvested and ginned in the Stoneville, MS, USDA ARS Microgin (Anthony and McCaskill 1974) with typical gin machinery including dryers, seed cotton cleaners, extractor-feeder/gin stand, and one lint cleaner. Lint samples were collected after lint cleaning for analysis by Shirley Analyzer, High Volume Instrument (HVI), and Advanced Fiber Information System (AFIS). Statistical analysis was done with Proc Glimmix (SAS, 9.2, 2008) with fixed effects as shown in Table 1 and the random effect rep(location year).

Results and Discussion

Statistically significant differences were found among varieties for both bract and leaf trichome counts as well as lint trash measured by Shirley Analyzer, HVI, and AFIS (Table 1). For these measurements, most factors were significant at $p<0.05$. Significant F-values for year*variety and location*variety(year) were much smaller than F-value for variety indicating the dominance of varietal differences in statistical and practical significance. For example the F value for variety differences in bract trichomes was 171.63; while the F values for year*variety and location*variety(year) were 7.03 and 2.57, respectively. This indicated that significant changes were observed in variety differences across years or locations but were minimal compared to the overall differences in varieties. These results show strong differences in varieties for leaf and bract trichomes (see Figures 1, 2, 3, and 4) and lint trash content that were mostly stable across environments.

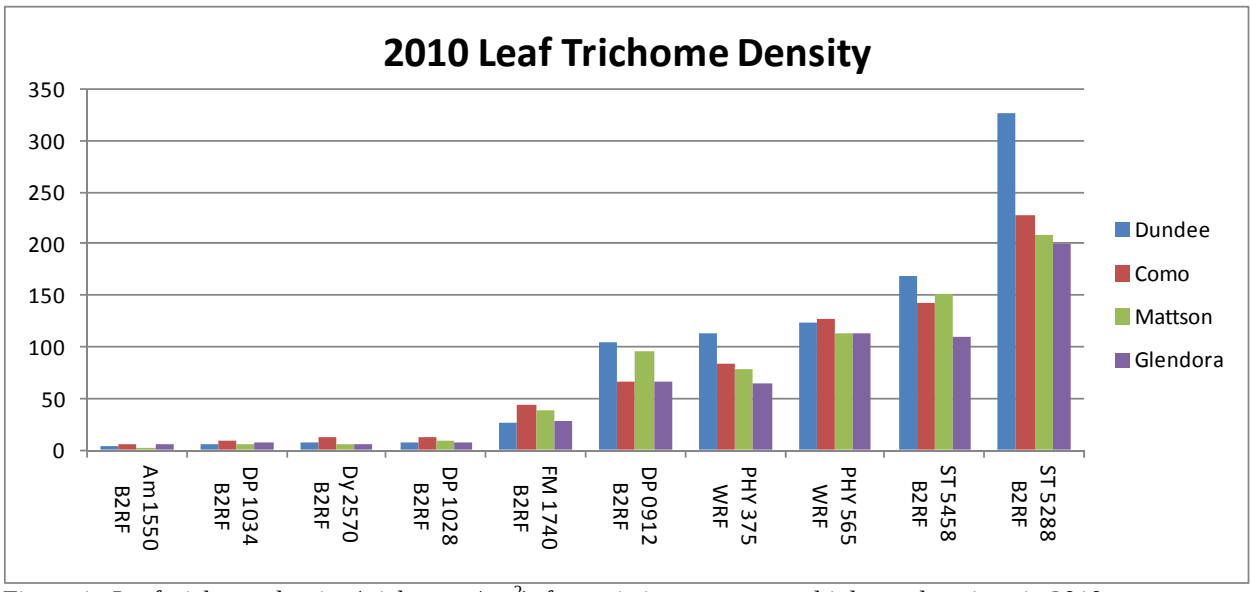

Figure 1. Leaf trichome density (trichomes /cm^2) for varieties grown at multiple test locations in 2010.

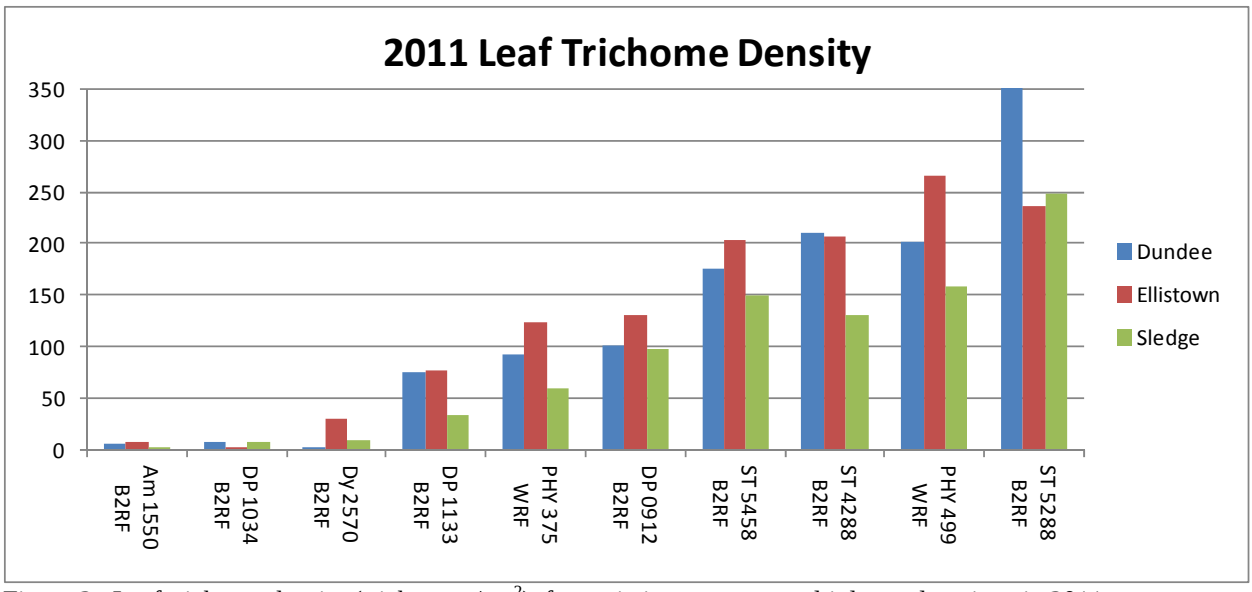

Figure 2. Leaf trichome density (trichomes /cm^2) for varieties grown at multiple test locations in 2011.

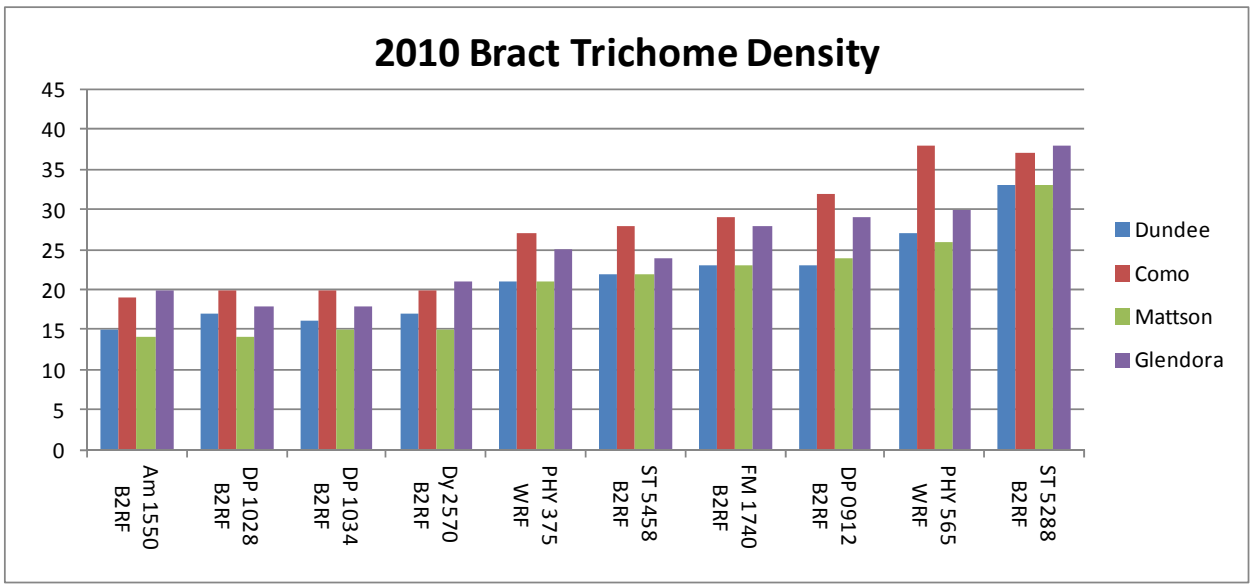

Figure 3. Bract trichome density (trichomes /cm) for varieties grown at multiple test locations in 2010.

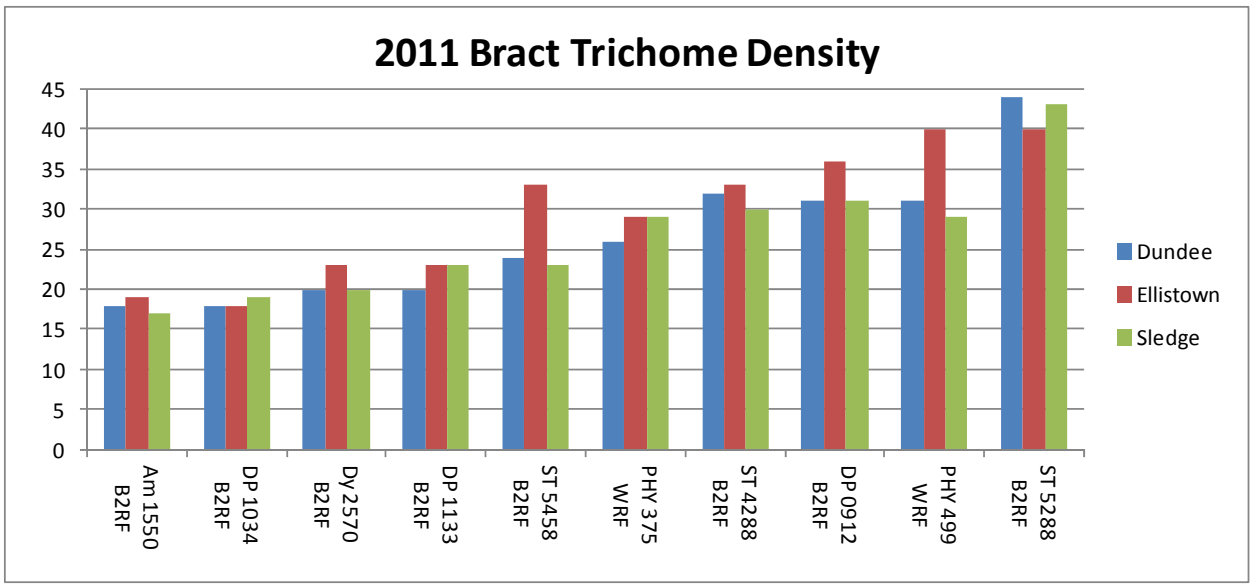

Figure 4. Bract trichome density (trichomes /cm) for varieties grown at multiple test locations in 2011.

Table 1. Statistics (P-values and F-values) for treatment differences in leaf and bract trichome density and lint trash.

Factors	Leaf trichomes /cm2	Bract trichomes /cm	Total bract trichomes	Shirley Analyzer Visible Waste	HVI Leaf Grade	AFIS Visible Foreign Matter
	P values					
Year	0.0092	<0.0001	<0.0001	0.7335	<0.0001	0.0014
Location(Year)	0.0097	<0.0001	0.0001	<0.0001	<0.0001	0.0006
Variety	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Year*Variety	0.1646	<0.0001	<0.0001	0.2849	0.0438	0.1965
Location*Variety(Year)	0.0068	0.0002	0.0037	<0.0001	0.0019	0.0021
	F values					
Year	9.30	98.69	126.97	0.12	32.91	14.75
Location(Year)	7.55	43.42	34.50	18.46	25.82	9.20
Variety	128.23	171.63	121.13	87.28	117.58	86.06
Year*Variety	1.59	7.03	12.64	1.26	2.26	1.47
Location*Variety(Year)	1.96	2.57	2.08	3.14	1.85	1.83

Table 2. Leaf and bract trichomes (averaged over four locations) and lint trash content (averaged over six locations) for varieties tested in 2010.

Variety	Leaf trichomes /cm2	Bract trichomes /cm	Total bract trichomes	Shirley Analyzer Visible Waste	HVI Leaf Grade	AFIS Visible Foreign Matter
ST 5288 B2RF	241 A	35 A	1,073 A	2.43 A	4.5 A	2.9 A
ST 5458 B2RF	143 B	24 ED	685 D	1.69 C	3.0 C	1.7 C
PHY 565 WRF	119 B	30 B	864 B	2.05 B	3.3 B	2.1 B
PHY 375 WRF	85 C	24 E	675 D	1.70 C	2.5 D	1.5 C
DP 0912 B2RF	83 C	27 C	805 BC	1.58 C	2.9 C	1.5 C
FM 1740 B2RF	34 D	26 CD	775 C	1.40 D	1.9 E	1.2 D
DP 1028 B2RF	9 E	17 F	548 E	1.32 DE	1.5 G	0.9 EF
DP 1034 B2RF	7 E	17 F	541 E	1.32 DE	1.6 G	1.0 DEF
Dy 2570 B2RF	7 E	18 F	519 E	1.20 E	1.7 GF	0.9 F
Am 1550 B2RF	5 E	17 F	515 E	1.24 E	1.9 EF	1.1 DE
Average	73	24	700	1.59	2.5	1.5

* Numbers in same column followed by same letter not significantly different at p<0.05.

Table 3. Leaf and bract trichomes (averaged over three locations) and lint trash content (averaged over five locations) for varieties tested in 2011.

Variety	Leaf trichomes /cm2	Bract trichomes /cm	Total bract trichomes	Shirley Analyzer Visible Waste	HVI Leaf Grade	AFIS Visible Foreign Matter
ST 5288 B2RF	280 A	43 A	1,510 A	2.36 A	4.6 A	3.0 A
PHY 499 WRF	208 B	33 B	1,082 B	1.92 B	3.8 B	2.1 B
ST 4288 B2RF	182 BC	32 B	881 C	1.69 DC	3.1 C	1.8 ED
ST 5458 B2RF	176 C	27 C	821 C	1.79 BC	3.6 B	2.1 BC
DP 0912 B2RF	110 D	33 B	1,013 B	1.72 DC	3.1 C	1.8 CD
PHY 375 WRF	92 D	28 C	866 C	1.69 DC	2.9 C	1.8 BCD
DP 1133 B2RF	62 E	22 D	650 D	1.61 D	2.6 D	1.6 E
Dy 2570 B2RF	13 F	21 D	640 D	1.15 F	1.9 E	1.0 F
Am 1550 B2RF	5 F	18 E	558 E	1.25 EF	2.0 E	1.2 F
DP 1034 B2RF	5 F	18 E	614 DE	1.30 E	2.2 E	1.1 F
Average	113	28	864	1.65	3.0	1.8

* Numbers in same column followed by same letter not significantly different at p<0.05.

Leaf and bract trichome and lint trash are reported in Table 2 for varieties grown in 2010, and Table 3 for varieties grown in 2011. Large differences in trichomes and lint trash were found in both years making this an ideal data set for studying the relationship between trichomes and lint trash. Correlations were reported in Tables 4 and 5 for plots grown in 2010 and 2011, respectively. All correlations between trichomes and lint trash were highly significant, but leaf trichomes were consistently the most correlated with lint trash content (Figures 5, 6, 7, and 8). It was also important to note the high degree of correlation between bract and leaf trichomes each year (Tables 4, 5, and Figure 9). In each of these cases, multiple regression models predicting lint trash with both bract and leaf trichomes did not

reveal any significant additive effect or interaction between effects (results not shown). This was possibly related to the relatively strong relationship between leaf and bract trichomes for the varieties included in this study.

Table 4. Correlations between leaf and bract trichomes and lint trash for varieties grown in 2010. All correlations significant at p<0.001.

2010 Pearson correlations (r)	Total bract trichomes	Bract trichomes /cm	Leaf trichomes /cm2
AFIS Visible Foreign Matter	0.92	0.92	0.97
HVI Leaf Grade	0.90	0.91	0.98
Shirley Analyzer Visible Waste	0.91	0.91	0.95
Total bract trichomes	1.00	0.99	0.88
Bract trichomes /cm		1.00	0.88
Leaf trichomes /cm2			1.00

Table 5. Correlations between leaf and bract trichomes and lint trash for varieties grown in 2011. All correlations significant at p<0.001.

2011 Pearson correlations (r)	Total bract trichomes	Bract trichomes /cm	Leaf trichomes /cm2
AFIS Visible Foreign Matter	0.93	0.91	0.95
HVI Leaf Grade	0.92	0.91	0.97
Shirley Analyzer Visible Waste	0.93	0.92	0.94
Total bract trichomes	1.00	0.97	0.89
Bract trichomes /cm		1.00	0.92
Leaf trichomes /cm2			1.00

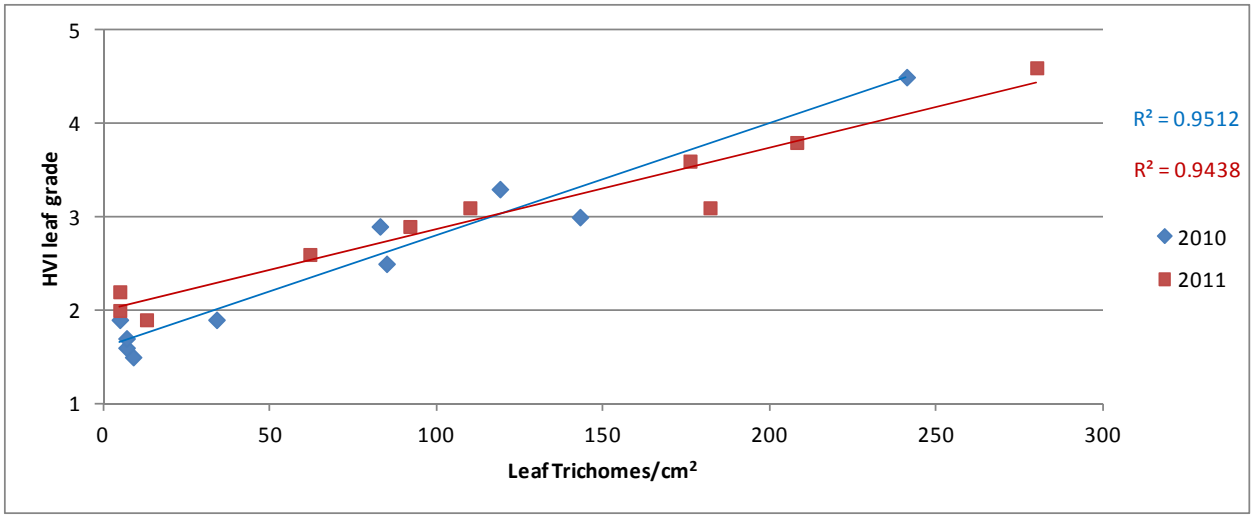

Figure 5. HVI leaf grade vs. leaf trichome density for 10 varieties grown in 2010, and 10 varieties grown in 2011.

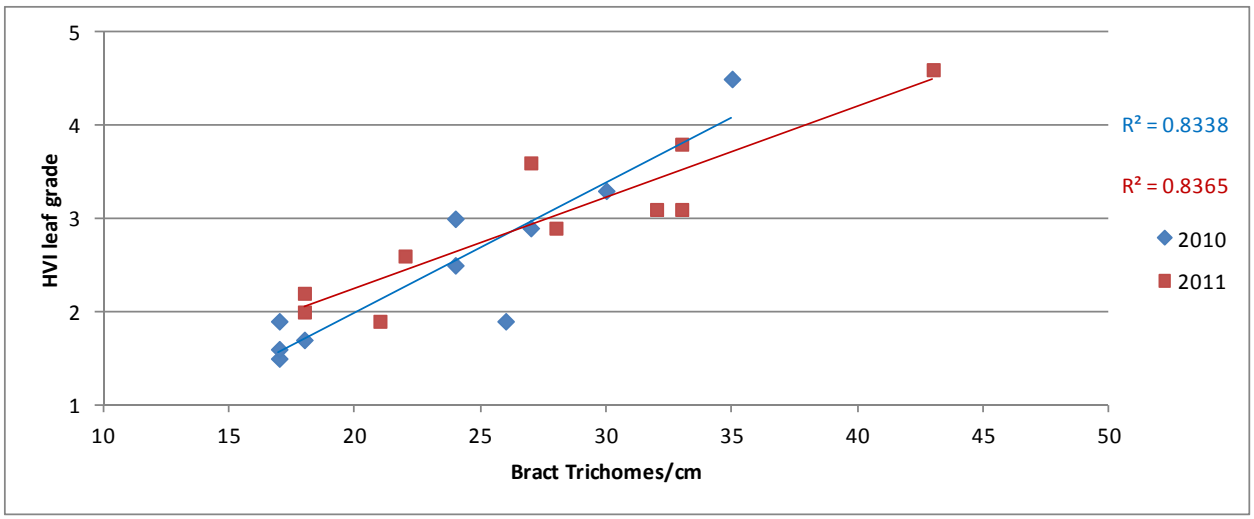

Figure 6. HVI leaf grade vs. bract trichome density for 10 varieties grown in 2010, and 10 varieties grown in 2011.

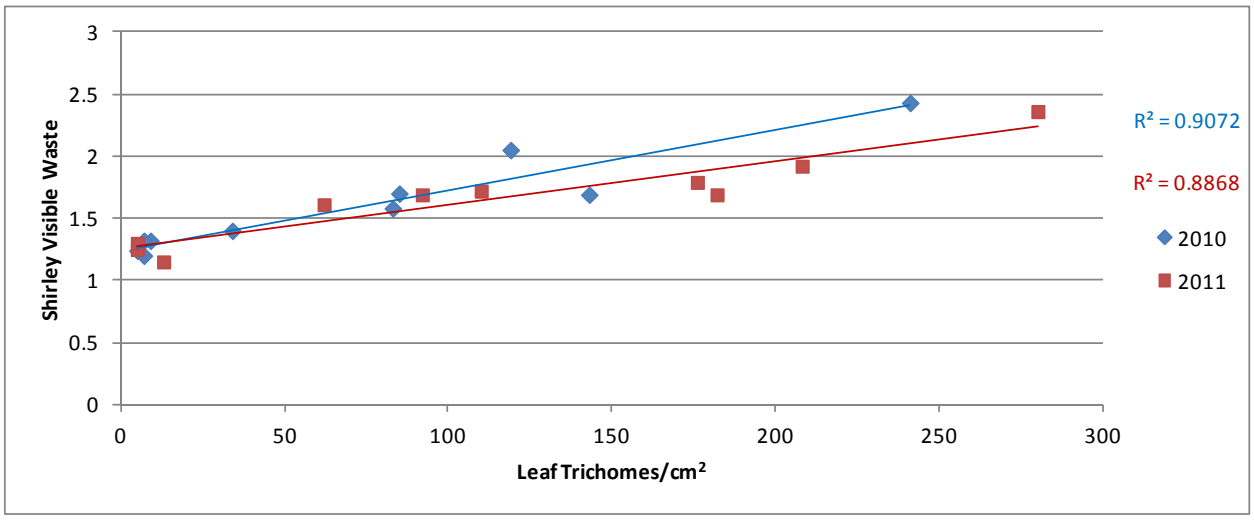

Figure 7. Shirley analyzer visible waste vs. leaf trichome density for 10 varieties grown in 2010, and 10 varieties grown in 2011.

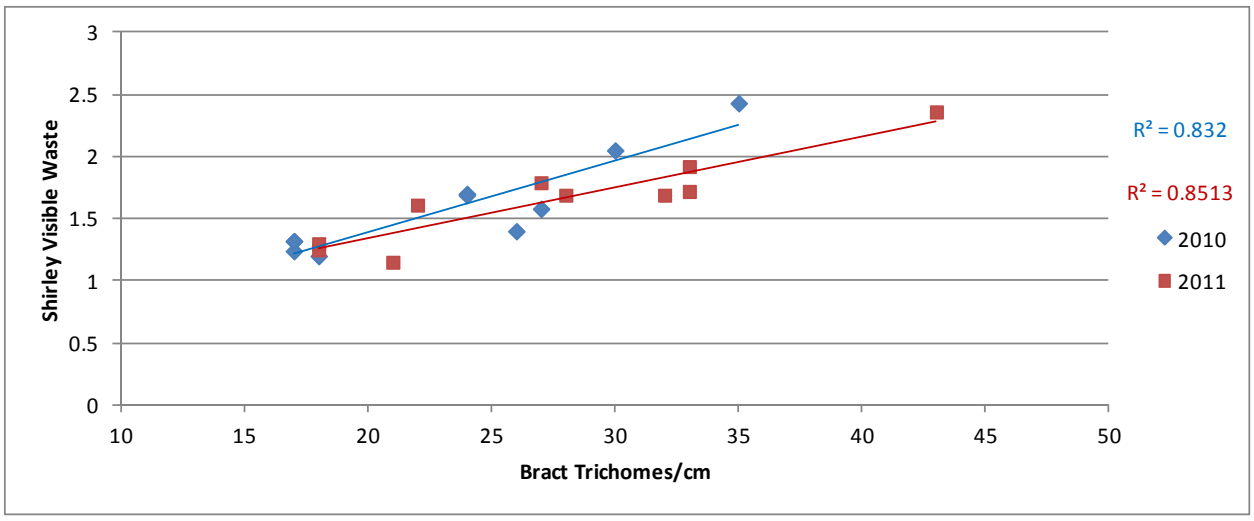

Figure 8. Shirley analyzer visible waste vs. bract trichome density for 10 varieties grown in 2010, and 10 varieties grown in 2011.

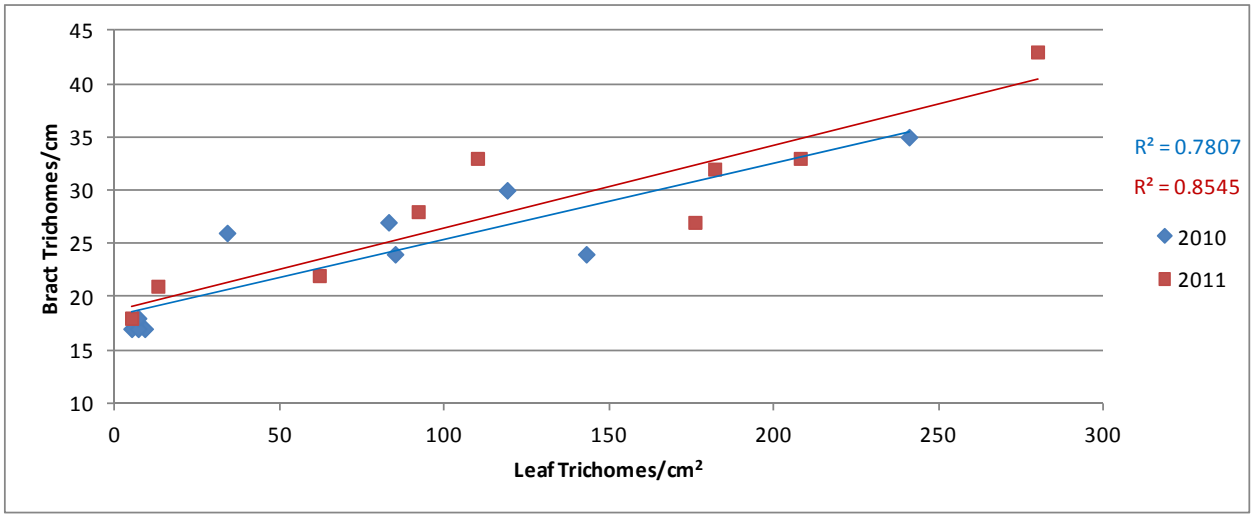

Figure 9. Bract trichome vs. leaf trichome density for 10 varieties grown in 2010, and 10 varieties grown in 2011.

Summary

Ten varieties were grown in seven locations in 2010, and five locations in 2011, to relate leaf and bract trichome density to lint trash content. Large differences in leaf and bract trichome density were found among varieties. Lint trash content of commercially harvested cotton ginned in the microgin was determined by HVI, AFIS, and Shirley Analyzer. Overall, leaf trichome density was more strongly correlated with lint trash measurements, but bract trichomes were also highly correlated. Results did not reveal any additive effect or additional value of predicting lint trash content with both leaf and bract trichome density. In other words, no evidence was found that leaf and bract trichome density were independently related to lint trash content, but this may have been due to the high correlation between bract and leaf trichome density for the varieties included in this study. These findings are significant in that high HVI leaf grades (and other measures of lint trash) are associated with densely populated trichomes of the leaves and bracts of certain varieties. These results should encourage breeders to select against hairy leaves and bracts. These results also show that variety information for leaf and bract hairiness should help ginners make management decisions and gin researchers develop new and improved technologies to increase the cleanliness of lint and thus bale value.

Disclaimer

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U. S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

References

Anthony, W.S. 1990. Performance characteristics of cotton ginning machinery. *Trans. ASAE* 33(4): 1089-1098.

Anthony, W.S. and O.L. McCaskill. 1974. Development and evaluation of a small-scale cotton ginning system. ARS-S-36. New Orleans, La.: USDA Agricultural Research Service.

Bourland, F.M. and J.M. Hornbeck. 2007. Variation in marginal bract trichome density in upland cotton. *Journal of Cotton Science.* 11: 242-251.

Morey, P.R. 1979. Botanically what is raw cotton dust? *American Ind. Hygiene Assoc. J.* 40(8): 702-780.