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ENGINEERING AND GINNING

Cotton Genotype Differences in Fiber-Seed Attachment Force

J. Clif Boykin*, Efrem Bechere, and William R. Meredith, Jr.

ABSTRACT

Cotton genotypes with reduced fiber-seed attachment force have the potential to be ginned faster with less energy and fiber damage. The objective of this paper was to evaluate 15 genotypes to determine how net gin stand energy usage (that above idling), ginning rate, and fiber quality relate to fiber-seed attachment force. Attachment force was measured with a pendulum-type tester for tufts of fiber on each side of the seed oriented towards the chalazel (rounded) end of the seed, micropyle (pointed) end of the seed, or in between (middle); and two sample preparation techniques were evaluated. Genotypes exhibited a wide range of net gin stand energy (7.5 to 12.0 Wh/kg lint) and ginning rate (2.5 to 3.3 g lint/sec) on a 10-saw lab gin stand, and fiber-seed attachment force range from 36.1 to 64.1 cN*cm/mg fiber. There was a strong correlation (r = 0.87) between net gin stand energy and fiber-seed attachment force, and a slight correlation (r = -0.38) between ginning rate and fiber-seed attachment force. Increased fiber-seed attachment force and increased fiber length both together increased net gin stand energy, though fiber-seed attachment force was the dominant component of the relationship. Net gin stand energy measurements can predict genotype differences in fiber-seed attachment force, but it might be important to consider effects of fiber length. These findings are important as net gin stand energy can be determined much more quickly than fiber-seed attachment force and might be used as an effective breeding tool.

Cotton in the U.S. is mechanically harvested and ginned to produce bales of cotton fiber. Cotton gins dry and clean seed cotton, separate fiber from seed, clean fiber, and bale fiber. Cotton bales are typically owned by growers, and cotton gins are paid per bale for their services. To remain profitable cotton gins must continue to reduce costs. Valco et al. (2012) surveyed cotton gins in 2010 and found total variable costs to average $20.95 per bale. Three components of variable costs: electric ($3.79 per bale), dryer fuel ($1.39 per bale), and seasonal labor ($7.04 per bale), can be reduced by increasing ginning rate (bales per hour). Additionally, electrical costs can be reduced by ginning cotton that requires less energy from gin machinery such as the gin stand.

During saw-type ginning, gin stand saws separate fiber from seed by pulling fibers through ginning ribs, which retain seed in the seed roll. Lint is doffed from saws and pneumatically conveyed to lint cleaners, while ginned seed are dropped or forced out of the seed roll as more seed cotton enters the seed roll. Most fibers tend to be ginned (removed or broken) from the seed without additional breakage due to a weakened area in the fiber at the surface of the seed; the force required to break an individual fiber equals 1.8 times the force required to remove it from the seed (Anthony and Griffin, 2001). However, the gin stand is known to break some fibers in multiple places or with fragments of fiber left on the seed, and this leads to reduced fiber length and increased short fiber content (Fransen and Verschraege, 1985; Sui et al., 2010). Increased neps (fiber entanglements), seed coat neps (neps containing fragments of the seed coat), and seed fragments are also attributed to the gin stand (Sui et al., 2010). Long fiber and low short fiber, nep, seed coat nep, and seed coat fragment contents are desirable qualities for processing fiber into yarn, so it is important to avoid excessive breakage and other damage caused by the gin stand (Fransen and Verschraege, 1985; Krifa et al., 2001; Pearson, 1955; Tallant et al., 1960).

Cotton genotypes are well known to differ in yield and fiber quality. Genotypes also differ in how strongly fibers are attached to seed (Fransen et al., 1984; Porter and Wahba, 1999; Verschraege and Kiekens, 1987); and gin stand energy consumption and ginning rate have been shown to differ among genotypes (Anthony et al., 1982; Bechere et al., 2011; Boykin, 2007) with differences presumably related to fiber-seed attachment force. Genotypes with reduced fiber-seed attachment force have the potential to be

J.C. Boykin*, USDA-ARS, Cotton Ginning Research Unit, 111 Experiment Station Road, Stoneville, MS 38776; E. Bechere and W.R. Meredith, Jr., USDA-ARS, Crop Genetics Research Unit, 141 Experiment Station Road, Stoneville, MS 38776.
*Corresponding author: clif.boykin@ars.usda.gov

ginned faster with less energy (reducing the electrical costs required to operate the gin stand) and less fiber and seed damage given that all other properties are the same. The overall objective of this project was to investigate the potential for developing a breeding program for improved ginning efficiency. Improved ginning efficiency as defined in this study included both reduced net gin stand energy usage (that above idling) and increased ginning rate. Initial results for 46 genotypes including six semi-naked seeded genotypes ginned on a 10-saw gin stand showed significant variation in net gin stand energy usage, ginning rate, and other fiber properties (Bechere et al., 2011); so the specific objective of this paper was to determine how these properties related to fiber-seed attachment force measured with a pendulum-type tester.

MATERIALS AND METHODS

A subset of the 46 genotypes comprised of 15 genotypes (two semi-naked seeded genotypes) was tested in this experiment, which included a wide range of net gin stand energy (7.5 to 12.0 Wh/kg lint) and ginning rate (2.5 to 3.3 g lint/sec) as shown in Table 1. The two semi-naked seeded genotypes that had the least net gin stand energy were SC9023ns 57-13-5-1 (a naked-tufted seed coat mutant developed at Texas Tech University, Bechere et al., 2009) and AR9317-26 (a semi-naked seed breeding line developed by the University of Arkansas).

For analysis of fiber-seed attachment force, these genotypes were grown and hand-picked from one field in 2009 with two replications per genotype. Fiber-seed attachment force was measured for one or two tufts of fiber on each side of the seed. Tufts were oriented towards the chalazel (rounded) end of the seed, towards the micropyle (pointed) end of the seed, or in between (middle) so that on one side of a seed either two tufts (one chalazel and one micropyle) or one tuft (middle) were tested. Tufts were tested from different locations on the seed because fiber-seed attachment force has been shown to vary across the seed (Fransen et al., 1984). The chalazel and micropyle tufts were tested either with preparation (combing and trimming to standard length) or without preparation. Middle tufts were only tested with preparation. Preparation involved gently combing tufts to align fibers before testing. Fiber tufts were grasped by hand close to the seed to help prevent fibers from being pulled from the seed as they were combed. Preparation also involved trimming tufts after shearing from the seed to 1.2 cm (the width of the fiber clamp) to standardize fiber length before weighing. This preparation followed the instructions outlined in the attachment tester's user manual. Tufts tested without preparation were not combed or trimmed. It was suspected that combing the fibers could bias the sample by breaking fibers or removing them from the seed. Because the uncombed tuft fibers were not aligned, they were not trimmed to the width of the clamps so that the whole bundle weight was obtained.

Table 1. Net gin stand energy and ginning rate for genotypes processed on a 10-saw lab gin (Bechere et al. 2011)

Genotype	PVP, PI, or Source	Citation (if found)	Net gin stand energy, Wh/kg lint	Ginning rate, g lint/sec
TAM182-34-ELS	PI 654362	Smith et al., 2009	12.0	3.11
PHY72	PVP 200100115		11.8	2.72
STV4554B2RF	PVP 200700046		10.6	2.54
ST474	PVP 9400152		10.6	2.97
FM832	PVP 9800258		10.5	3.15
JJ1145ne	USDA ARS		10.3	3.12
MD15OP(MD15)	PI 642769	Meredith, 2006	10.0	3.21
DP555BR	PVP 200200047		9.9	2.96
TAM98-99ne	PI 636491	Thaxton et al., 2005	9.8	3.02
SG747	PVP 9800118		9.7	3.02
FM960B2R	PVP 200500109		9.6	3.32
STV5599BR	PVP 200300279		9.3	3.18
AR9608-08-03ne	PI 651854		9.1	2.84
SC9023ns57-13-2-1	Texas Tech Univ.	Bechere et al., 2009	9.0	2.89
AR9317-26	Univ. of AR		7.5	3.09
LSD			0.4	0.37

Fiber-seed attachment force was measured with a modified SDL2 Cotton Seed Attachment Tester (Shirley Developments Limited, Didsbury, Manchester, UK). To measure fiber-seed attachment force, a pendulum was raised and locked into position with a known amount of potential energy (Fig. 1). A cartridge was placed in the path of the pendulum, which held the seed in place behind a slotted plate on one side of the pendulum path and the tuft of fibers retained by clamps on the alternate side of the pendulum path (Fig. 2). The pendulum was released to pass through the fiber bundle between the seed plate and fiber clamp, thus shearing the tuft of fiber from the seed. Data were deleted if the bundle was not sheared by the pendulum or if a portion of the fiber bundle remained on the seed; 5% of data were deleted for these reasons. The instrument was modified with an inclinometer and computer to measure and record the peak position (angle) of the pendulum swing after shearing ("sample peak position"). Blanks were also run without sample to measure the peak position (angle) of the pendulum blank ("blank peak position"). The difference in the blank peak position and sample peak position was used to calculate the fraction of energy removed from the pendulum swing. This was multiplied by the potential energy of the pendulum to determine the energy required to shear the fiber bundle from the seed. The fiber bundle was weighed, and fiber-seed attachment force (cN*cm/mg fiber) was determined by dividing the energy for shearing the bundle (cN*cm) by the fiber weight (mg fiber).

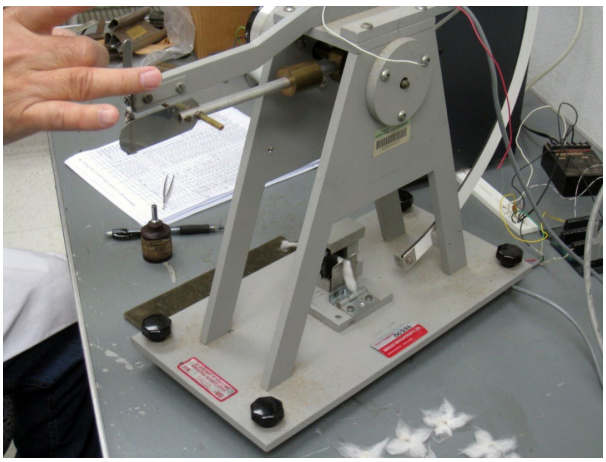

Figure 1. Fiber-seed attachment force tester just before releasing the pendulum. Pendulum arm locked in raised position and sample cartridge in place. Note the prepared seed with four bundles (two chalazel and two micropyle) in the lower portion of the picture. Seed including middle tufts are not shown.

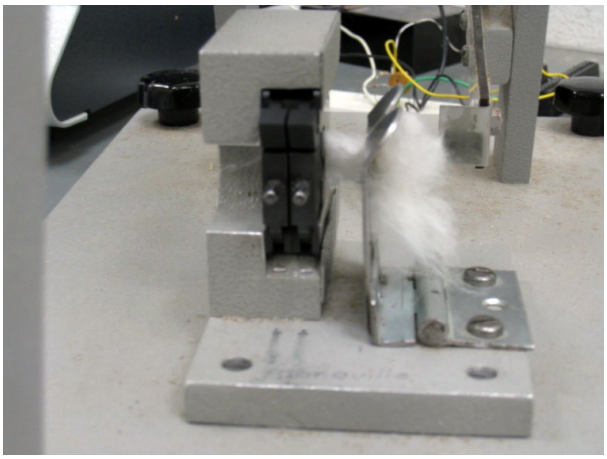

Figure 2. Sample cartridge holding seed behind slotted seed plate (right side of pendulum path) and fiber bundle in clamps (left side of pendulum path).

For testing, a single lock of cotton typically including seven to nine seed was taken from a sample. All seed were tested sequentially alternating tuft location (micropyle and chalazel or middle) and preparation (with or without prep) on each side of each seed as described above. As discussed earlier, either two tufts (micropyle and chalazel) or one tuft (middle) was formed on a side of the seed. All 30 samples (15 genotypes with two replications) were tested in this manner. Then, the entire procedure was repeated in the same way four additional times so that there were five repeated test sequences done for each sample.

The experimental design was a split plot with the main unit being 15 Genotypes and two field replications (Rep). The main unit design was a randomized complete block. The five sub-unit treatments consisted of chalazel tufts without prep, chalazel tufts with prep, micropyle tufts without prep, micropyle tufts with prep, and middle tufts with prep. There were several levels of subsampling. Multiple Seed for each Rep x Genotype were considered subsamples for the Genotype main unit treatment and replication for the sub-unit treatments. The five repeated tests (Run) of the samples were also considered subsamples of the main unit treatment and replication for the sub-unit treatments. Statistical analysis was done with Proc Glimmix (SAS v9.2, Cary, NC, 2008). Fixed effects included Genotype, sub-unit treatments, and interactions between Genotype and sub-unit treatments (Table 2). Random effects included Rep, Rep x Genotype, Run (Rep Genotype), and Seed (Rep Genotype Run). Preliminary analysis indicated further partitioning of these random effects did not improve the estimate of

sub-unit error. Therefore, additional components of error were combined in the residual error to simplify the analysis of variance. A set of four, single degree of freedom orthogonal contrasts were used to construct the ANOVA table for the sub-unit treatments as described in Table 2. Additional simplified statistics were obtained from this model using the "slice" option in the lsmeans statement to make specific comparisons (Table 3). Proc Reg (SAS v9.2) was used to correlate fiber-seed attachment force results for genotypes to net gin stand energy usage, ginning rate, and other fiber properties (Tables 4, 5, and 6).

Table 2. Statistical analysis of fiber-seed attachment force with F-values indicating the strength of treatment differences and *P*-values indicating the significance of treatment differences (significant if *P*-value < 0.05)

Main unit	DF	F-value	P-value
Genotype	**14**	**6.31**	**0.0002**
Sub-unit contrast			
Tuft1 [Z]	**1**	**1656.13**	**<0.0001**
Tuft2 [Y]	**1**	**190.85**	**<0.0001**
Prep [X]	**1**	**784.32**	**<0.0001**
Tuft2*Prep	**1**	**16.59**	**<0.0001**
Genotype*sub-unit contrast			
Genotype*Tuft1	**14**	**7.54**	**<0.0001**
Genotype*Tuft2	**14**	**1.32**	**0.1849**
Genotype*Prep	**14**	**1.13**	**0.3255**
Genotype*Tuft2*Prep	**14**	**0.67**	**0.8042**

[Z] Tuft1 contrast comparing average chalazel tuft treatments and average micropyle treatments.

[Y] Tuft2 contrast comparing middle tuft treatment to the average of chalazel and micropyle tuft treatments.

[X] Prep contrast comparing average without prep treatments to with prep treatments (excluding middle tufts).

Ginned seed fuzz and fibers per seed were analyzed in this study. Ginned seed fuzz weight was the difference in ginned seed weight and acid-delinted seed weight, and ginned seed fuzz was expressed as a percentage of ginned seed weight. The number of fibers per seed = Li*10/(stdfine/(1,000,000/Lw)) where Li = lint index (grams of lint/100 seed), stdfine = fineness/maturity ratio, and Lw = mean fiber length by weight (Bourland and Bird, 1983). These and other more common properties were discussed in this study, and actual genotype values as well as additional methodologies were reported by Bechere et al. (2011).

RESULTS AND DISCUSSION

Genotypes were found to vary statistically in fiber-seed attachment force (Table 2). The factors Tuft1, Tuft2, and Prep were also highly significant indicating an overall difference in fiber-seed attachment force between tuft locations on the seed (chalazel, micropyle, or middle) and whether or not the tufts were prepared by combing and trimming (with or without prep). Genotype*Tuft1 was highly significant indicating relative differences in genotypes for fiber-seed attachment force differed between chalazel and micropyle tufts (Fig. 3). Genotype*Tuft2 was not significant indicating relative differences in genotypes for fiber-seed attachment force were similar when comparing middle tufts to the average of chalazel and micropyle tufts. Genotype*Prep was not significant indicating that differenced in genotypes for fiber-seed attachment force was consistent between samples with and without preparation.

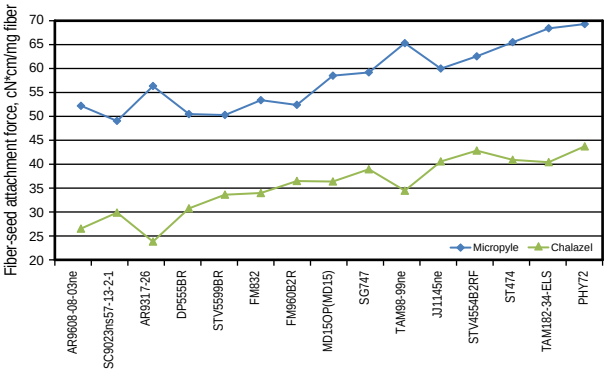

Figure 3. Fiber-seed attachment force measured for 15 genotypes for micropyle tufts (averaged over prep) and chalazel tufts (averaged over prep).

Across all tuft locations with and without preparation, fiber-seed attachment force was found to vary statistically among genotypes ranging from 36 cN*cm/mg fiber for AR9317-26 to 64 cN*cm/mg fiber for PHY72 (Table 3). These results were encouraging because AR9317-26 consumed the least amount of net gin stand energy and PHY72 consumed the second highest amount of net gin stand energy behind TAM182-34-ELS (Table 1). TAM182-34-ELS was an extra-long staple genotype. Fiber-seed attachment force was higher for this genotype than PHY72 when chalazel or micropyle tufts with prep were tested, but this was not true for middle tufts (Table 3). This indicated that trimming tufts to 1.2 cm increased fiber-seed attachment force measurements more for the longer staple genotype than other genotypes.

Table 3. Least square means for fiber-seed attachment force (cN*cm/mg fiber) for different tuft locations with and without preparation. Genotype means within a column are not significantly different if followed by same letter. Overall means differed between tuft locations with and without preparation as indicated by letters

Genotype	Chalazel no prep	Chalazel w/ prep	Micropyle no prep	Micropyle w/ prep	Middle w/ prep	All tufts
PHY72	37.1 A	50.7 AB	60.4 A	79.3 AB	74.9 A	64.1 A
STV4554B2RF	33.5 AB	52.5 A	50.9 ABCD	75.1 ABCD	73.3 AB	61.1 AB
ST474	32.8 AB	49.3 ABC	52.5 ABC	79.5 AB	68.5 ABC	59.1 ABC
TAM182-34-ELS	29.3 BC	51.8 A	55.7 AB	82.2 A	62.8 ABCD	56.8 ABCD
JJ1145ne	30.4 BC	51.0 A	50.1 ABCDE	70.7 ABCDE	62.5 ABCD	55.0 ABCD
SG747	29.9 BC	48.2 ABC	47.6 BCDEFG	71.6 ABCDE	59.6 ABCD	53.0 BCDE
TAM98-99ne	26.2 CD	42.8 ABCD	53.2 ABC	78.4 ABC	57.0 CDE	51.5 BCDE
MD15OP(MD15)	26.9 CD	46.0 ABC	48.6 BCDEF	69.2 ABCDEF	54.3 CDE	49.5 CDE
FM832	25.7 CD	42.3 ABCD	45.3 CDEFG	62.1 CDEF	58.3 BCDE	49.4 CDEF
FM960B2R	26.3 CD	46.8 ABC	40.7 FG	64.7 BCDEF	55.6 CDE	48.6 DEF
STV5599BR	26.9 CD	40.4 BCDE	42.3 DEFG	58.8 EF	50.4 DE	45.2 EF
DP555BR	22.4 DE	39.1 CDE	41.9 EFG	59.6 DEF	52.3 DE	44.9 EF
SC9023ns57-13-2-1	23.4 DE	36.3 DEF	43.2 DEFG	55.4 F	51.1 DE	43.9 EF
AR9608-08-03ne	19.7 EF	33.2 EF	39.4 G	65.6 ABCDEF	46.6 E	41.0 FG
AR9317-26	18.0 F	29.4 F	42.1 DEFG	71.3 ABCDE	36.8 F	36.1 G
Mean	26.8 E	43.4 D	47.2 C	69.1 A	56.7 B	48.6
F value	9.38	4.50	3.82	2.19	4.67	6.31
P value	<0.0001	<0.0001	0.0019	0.0180	<0.0001	0.0002

Table 4. Pearson correlations (r) between genotype fiber-seed attachment force (n = 15) for different tuft locations with and without preparation. All correlations significant at $p < 0.05$ ($r > 0.51$)

	Chalazel no prep	Chalazel w/ prep	Micropyle no prep	Micropyle w/ prep	Middle w/ prep	All tufts
Chalazel no prep	1.00	0.91	0.81	0.58	0.95	0.97
Chalazel w/ prep		1.00	0.73	0.58	0.90	0.93
Micropyle no prep			1.00	0.82	0.79	0.86
Micropyle w/ prep				1.00	0.57	0.67
Middle w/ prep					1.00	0.99
All tufts						1.00

Averaged across genotypes, fiber-seed attachment force for tufts with prep was highest for micropyle tufts (69.1cN*cm/mg fiber) followed by the middle tufts (56.7 cN*cm/mg fiber) then chalazel tufts (43.4 cN*cm/mg fiber) indicating fibers were more strongly attached to the seed moving from the chalazel end to micropyle end (Table 3). These measurements were standardized for fiber length, so differences were not related to potential differences in fiber weight with fiber length across the profile of the seed. These differences were also found for tufts without prep with fiber-seed attachment force averaging 47.2 cN*cm/mg fiber for micropyle tufts and 26.8 cN*cm/mg fiber for chalazel tufts. Sample preparation increased fiber-seed attachment force for chalazel tufts from 26.8 to 43.4 cN*cm/mg fiber with a similar increase observed for micropyle tufts. This increase was mostly due to the reduced fiber weight associated with prepared tufts trimmed to 1.2 cm.

Table 5. Pearson correlations (*r*) between genotype properties (n = 15). Values followed by "*" significant at $p < 0.01$ ($r > 0.64$), "**" significant at $p < 0.05$ ($r > 0.51$), and "*" significant at $p < 0.10$ ($r > 0.44$). Values followed by "x" indicate correlations that were significant and in the same direction (+/-) in the overall study of 45 genotypes by Bechere et al. (2011)**

	Chalazel no prep	Chalazel w/ prep	Micropyle no prep	Micropyle w/ prep	Middle w/ prep	All tufts	Net gin stand energy	Ginning rate	Ginned seed fuzz %
Net gin stand energy	0.79***	0.83***	0.79***	0.54**	0.86***	0.87***	1.00***	-0.23	0.63**
Ginning rate	-0.32	-0.11	-0.32	-0.24	-0.45*	-0.38	-0.23	1.00***	-0.37x
Ginned seed fuzz %	0.70***	0.72***	0.43	0.34	0.77***	0.73***	0.63**	-0.37x	1.00***
Seed index	0.27	0.39	0.35	0.21	0.18	0.25	0.33	0.47*	-0.20
Lint %	0.09	0.10	-0.21	-0.18	0.14	0.08	0.03	-0.11	0.59**
AFIS[Z] nep count	0.22	0.17	0.18	0.25	0.28	0.25	0.15	-0.65***	0.22x
AFIS nep size	0.59**	0.68***	0.70***	0.63**	0.60**	0.67***	0.82***	-0.07	0.37x
AFIS seed coat nep count	0.65***	0.67***	0.83***	0.70***	0.65***	0.72***	0.82***	-0.13	0.31
AFIS seed coat nep size	0.51*	0.40	0.59**	0.28	0.54**	0.53**	0.64***	-0.28	0.45*
Fibers / mm^2 seed	0.08	0.06	-0.25	-0.28	0.14	0.05	0.04	-0.20	0.55**
Fibers / seed	0.52**	0.60**	0.11	-0.10	0.43	0.42	0.41	0.38x	0.48*
AFIS UQLw[X]	0.06	0.30	0.31	0.23	0.11	0.18	0.54**	0.37x	-0.09
AFIS SFCw[W]	0.08	0.09	-0.31	-0.34	0.10	0.02	-0.06	-0.22x	0.41x
HVI[Y] strength	0.12	0.23	0.28	0.14	0.14	0.18	0.45*	0.28x	-0.07
HVI elongation	0.32	0.16	0.43	0.56**	0.27	0.31	-0.05	-0.55**	0.22
HVI micronaire	-0.14	-0.31	-0.21	0.02	-0.17	-0.18	-0.43	-0.14	0.12
AFIS fineness	-0.16	-0.29	-0.21	0.06	-0.23	-0.22	-0.51*	0.00	0.00
AFIS IFC	0.04	0.09	-0.14	-0.22	0.08	0.02	-0.07	-0.28	0.07
AFIS maturity ratio	-0.05	0.01	0.10	0.08	-0.04	-0.01	0.24	0.39x	-0.09

[Z] Advanced fiber information system.

[Y] High Volume instrument.

[X] Upper quartile length by weight.

[W] Short fiber content by weight.

Genotype differences in fiber-seed attachment force were most significant (statistically) for chalazel tufts without prep as indicated by the largest F-value (9.38, Table 3). Reduced significance was found for chalazel tufts with prep (F-value = 4.50) with a similar trend found for micropyle tufts. This indicated preparation reduced genotype variability, but it was uncertain why this occurred. It was either related to combing the tufts or trimming to 1.2 cm. Because most genotypes did not differ drastically in fiber length the reduced genotype variability was suspected to be related to combing, and further analysis of the data where the additional weight of fiber trimmed from the prepared samples was added back to the fiber weight confirmed this was the case (statistics not reported).

Correlations between genotype fiber-seed attachment force for different tuft locations with and without preparation showed that middle tufts with prep was most highly correlated with overall values (0.99, Table 4) followed by chalazel tufts without prep (0.97). The lowest correlations were between middle tufts with prep and micropyle tufts with prep (0.57) and between micropyle tufts with prep and chalazel tufts with or without prep (0.58). This agreed with the significant Genotype*Tuft1 interaction (Table 2), which indicated relative differences in genotypes for fiber-seed attachment force depended on tuft location.

Correlations between genotype fiber-seed attachment force for different tuft locations with and without preparation and other traits such as ginning energy, ginning rate, and other seed and fiber properties are reported in Table 5. Net gin stand energy was significantly and positively correlated with all fiber-seed attachment force measurements. The highest correlation was found for middle tufts with prep ($r = 0.86$) followed by chalazel tufts with prep ($r = 0.83$). Chalazel and micropyle tufts without prep were both correlated with net gin

stand energy with $r = 0.79$. These correlations indicated that genotype differences in net gin stand energy were strongly related to differences in fiber-seed attachment force. Fig. 4 illustrates the relationship between net gin stand energy and fiber-seed attachment force for chalazel and micropyle tufts without prep. Fig. 5 shows the relationship between net gin stand energy and fiber-seed attachment force for chalazel, middle, and micropyle tufts with prep. In these figures, net gin stand energy for AR9317-26, PHY72, and TAM182-34-ELS were extremely low or high relative to other genotypes, but these genotypes did not have extremely low or high values for fiber-seed attachment force relative to other genotypes.

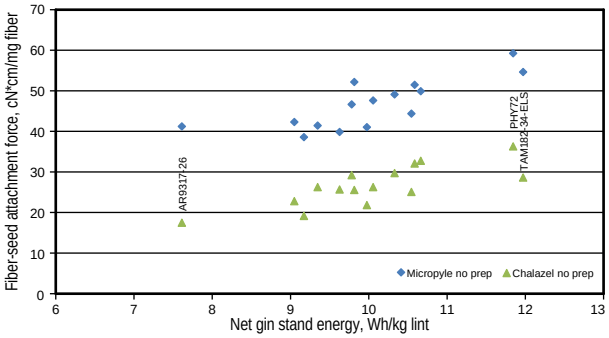

Figure 4. Net gin stand energy for 15 genotypes vs. fiber-seed attachment force measured for micropyle and chalazel tufts without prep.

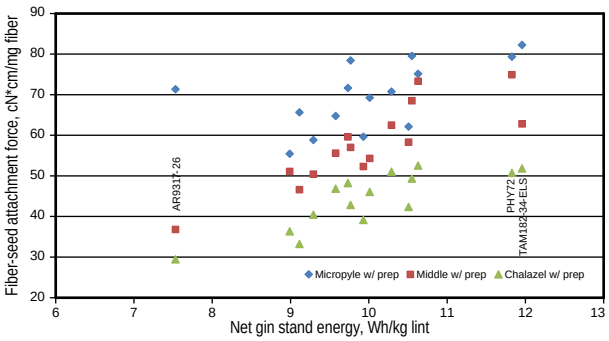

Figure 5. Net gin stand energy for 15 genotypes vs. fiber-seed attachment force measured for micropyle, middle, and chalazel tufts with prep.

There was a slight negative correlation between ginning rate and fiber-seed attachment force (Table 5), so genotype differences in ginning rate might have been slightly impacted by fiber-seed attachment force. It was suspected that ginning rate determined for small samples ginned on a 10-saw gin stand might not have been a good estimate of ginning rate for commercial ginning. Future studies should focus on this relationship by testing with commercial-type ginning machines. In commercial gins, ginning rate can be adjusted to maintain an optimal power (or amperage) loading on the gin stand, so it is reasonable to expect that genotypes with low net gin stand energy (and low fiber-seed attachment force) should gin faster.

Fiber-seed attachment force was positively correlated with ginned seed fuzz, but only for chalazel and middle tufts (Table 5). Seed fuzz has been shown to be positively correlated with net gin stand energy and was thought to be related to fiber-seed attachment force, and these results indicate this was true for chalazel and middle tufts but not micropyle tufts. Fiber-seed attachment force was not related to seed index or lint percent, and neither was net gin stand energy. The number of fibers per seed increased with fiber-seed attachment force, but only for chalazel tufts; but the number of fibers per seed surface area (mm^2) was not significantly related to fiber-seed attachment force or ginning energy indicating that the density of fibers on the surface of the seed was not related to the amount of energy required to gin the fiber. Fiber-seed attachment force and net gin stand energy both increased with nep size, seed coat nep count, and seed coat nep size indicating that fibers more strongly attached to seed pulled fragments of the seed coat from the seed during ginning. This was an important finding indicating that reduced seed coat contamination in lint (as well as reduced seed damage) can be achieved by breeding for reduced fiber-seed attachment force (or net gin stand energy).

Table 6. End results of step-wise regression models for genotype net gin stand energy (n = 15).

Independent variable	Intercept and significant factors	Slope	F-value	P-value	Model R-square
Net gin stand energy	Intercept	-10.51	4.21	0.0626	
	Att. force middle tuft w/ prep	0.36	120.98	<0.0001	0.94
	Upper quartile length	0.96	36.33	<0.0001	
Net gin stand energy	Intercept	-10.59	2.02	0.1805	
	Att. force chalazel tuft no prep	0.65	51.40	<0.0001	0.87
	Upper quartile length	1.05	20.98	0.0006	
Net gin stand energy	Intercept	-1.45	0.02	0.8775	
	Att. force chalazel w/ prep	0.45	26.93	0.0002	0.78
	Upper quartile length	0.69	5.04	0.0444	

Fiber length and strength increased with net gin stand energy, but this trend was not found with fiber-seed attachment force. It was suspected that a more complex relationship existed between fiber-seed attachment force and net gin stand energy. A stepwise regression procedure was used to model net gin stand energy with multiple factors such as fiber-seed attachment force for different tuft locations with and without prep, fiber length, strength, and fineness (Table 6). The best fit model (highest model R^2) showed that net gin stand energy increased with fiber-seed attachment force of middle tufts with prep (F-value = 121) and increased with fiber length (F-value = 36). This proved there was variability associated with both factors, and including both factors significantly improved the model. Fiber-seed attachment force of middle tufts with prep was likely an average of chalazel and micropyle tufts with prep, but the difference in chalazel and micropyle tufts might have varied between genotypes. The model was run again excluding fiber-seed attachment force of middle tufts with prep to see if both chalazel and micropyle tufts could be used to better model net gin stand energy relative to simple correlations shown in Table 5. The best fit for this model (highest model R^2) showed that net gin stand energy increased with fiber-seed attachment force of chalazel tufts without prep (F-value = 51) and increased with fiber length (F-value = 21), but fiber-seed attachment force on micropyle tufts did not significantly explain any additional variability. A final model was run that also excluded fiber-seed attachment force of chalazel and micropyle tufts without prep. Similar results were found with the best fit model (highest model R^2) showing that net gin stand energy increased with fiber-seed attachment force of chalazel tufts with prep (F-value = 27) and increased with fiber length (F-value = 5), but fiber-seed attachment force on micropyle tufts with prep did not significantly explain any additional variability.

SUMMARY

This experiment supported a larger study targeting improved genotype ginning efficiency as defined as both reduced net gin stand energy usage and increased ginning rate. The purpose of this experiment was to determine if gin stand energy usage was related to fiber-seed attachment force. There was a significant positive correlation between net gin stand energy (that above idling) and fiber-seed attachment force indicating that genotypes with fibers more strongly attached to the seed required more energy to gin. There was a slight (nonsignificant) negative correlation between ginning rate and fiber-seed attachment force. In this study, genotype differences in ginning rate determined for small samples ginned on a 10-saw gin might not have been a good estimate of genotype differences in ginning rate in a commercial gin. Evidence supports the expectation that genotypes with lower fiber-seed attachment force will gin faster and with less total energy per bale in a commercial gin, and future testing with commercial-type ginning machines will be conducted to confirm.

It was significant to note that including fiber length as a covariate strengthened the relationship between net gin stand energy and fiber-seed attachment force indicating that increased fiber-seed attachment force and increased fiber length both increased net gin stand energy, though fiber-seed attachment force was the dominant component of the relationship. Genotype difference were strongest (statistically) for fiber-seed attachment force for chalazel tufts without prep (combing and trimming) followed by middle tufts with prep, but all fiber-seed attachment force measurements differed significantly among genotypes. Genotype differences in fiber-seed attachment force for middle tufts with prep was most highly correlated with net gin stand energy followed closely by chalazel tufts with and without prep and micropyle tufts without prep. Step-wise regression models did not indicate that net gin stand energy could be better predicted with multiple fiber-seed attachment force measurements (i.e., chalazel and micropyle tufts). Another important finding of the study was that AFIS seed coat neps increased with fiber-seed attachment force and ginning energy indicating that fibers strongly attached to seed tended to remove fragments of the seed during ginning.

The results of this study validated the assumption that net gin stand energy measurements can be used to predict genotype differences in fiber-seed attachment force, but it is important to consider the effects of fiber length. Genotype differences in ginning rate determined on a lab-scale gin stand were not strongly related to fiber-seed attachment force. These findings are important in that net gin stand energy can be determined much more efficiently than fiber-seed attachment force. Future breeding programs might find reduced fiber-seed attachment force beneficial in reducing fiber damage during ginning, thus improving fiber quality parameters such as fiber length, short fiber content, nep content, and seed coat nep (or seed coat fragment) content.

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DISCLAIMER

Mention of a trade names or commercial products in the publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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