The *Journal of Cotton Science 20:31–39 (2016)*
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BREEDING AND GENETICS

Relationships of Lint Yield and Fiber Quality with Ginning Rate and Net Ginning Energy in Upland Cotton (*Gossypium hirsutum* L.)

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ABSTRACT

The use of cultivars that gin faster and require lower net ginning energy have been suggested to improve ginning efficiency. The objectives of this study were to investigate the relationships of lint yield and fiber quality with ginning rate and net ginning energy, and also determine the effects of semi-naked seed, fuzzy seed, okra leaf, and the presence or absence of nectaries on ginning rate and net ginning energy. Thirteen cotton genotypes were evaluated in a randomized complete block design with four replications for ginning rate, net ginning energy, fuzz percentage, lint yield, and fiber quality at Stoneville, MS across four environments during 2013 and 2014. Ginning rate was positively related to lint yield (0.27, $p < 0.001^{***}$), fiber strength (0.22, $p < 0.01^{**}$), and fiber length (0.41, $p < 0.001^{***}$). Ginning rate, however, was negatively correlated with net ginning energy (-0.28, $p < 0.001^{***}$) fuzz percent (-0.06, ns), and micronaire (-0.38, $p < 0.001^{***}$). Higher lint yield appeared to be associated with higher net ginning energy. Net ginning energy was positively correlated with fiber length (0.26, $p < 0.001^{***}$), fiber strength (0.23, $p < 0.001^{***}$) and fuzz percent (0.50, $p < 0.001^{***}$). The okra-leaf group had higher ginning rate than the normal-leaf group ($p < 0.05^{*}$). The semi-naked-seed group had higher ginning rate than the fuzzy-seeded group ($p < 0.05^{*}$). The fuzzy-seeded group required higher net energy to gin. Cotton breeders should consider these relationships before embarking on a program to improve ginning efficiency.

Energy costs are the second largest source of variable costs for cotton gins, with electricity accounting for 18% of the variable costs (Valco et al., 2012). It has been suggested that a significant opportunity exists to improve gin profitability by reducing energy use. Higher energy costs emphasize the importance of improved energy efficiency at gins by increasing conservation measures (Hardin and Funk, 2012). An additional factor affecting gin electrical energy use is the cotton cultivar. Many researchers have found significant differences in power demand, energy use, and ginning rate among cotton cultivars (Griffin, 1984; Anthony, 1989; Boykin, 2007; Bechere et al., 2011). Various researchers have also reported genetic differences in fiber-seed attachment forces among different cotton cultivars and concluded that gin stand energy was likely related to the fiber-seed bond strength (Fransen et al., 1984; Griffin, 1984; Porter and Wahba, 1999 and Boykin, 2007). Griffin (1984) indicated that separation force of individual fibers for less fuzzy seeds was 17% lower than the fuzzy control and ginned 23% faster. Griffin further pointed out that the energy required to gin a bale (227 kg lint) was significantly lower for the semi-naked-seed strain resulting in 31% energy reduction for fiber seed separation. Bechere et al. (2009) reported that two seminaked-tufted cotton lines developed through chemical mutagenesis required less energy to gin when compared to the fuzzy genotype ‘FiberMax 958’ (PVP 200100208).

Genotypes with high fiber-seed attachment strength tend to reduce gin productivity by increasing power requirements at the gin stand, thus reducing ginning rate. Higher fiber-seed attachment force also increases fiber damage as measured by short fiber content (SFC) and neps. On the other hand, cultivars with reduced fiber-seed attachment force have the potential to be ginned faster with less energy and less fiber damage (Boykin, 2007; Fransen et al., 1984; Griffin, 1984; Porter and Wahba, 1999).

Ginning efficiency includes both reduced net gin stand energy usage (that above idling) and increased ginning rate. The most efficient ginning lines will require less ginning energy and gin faster. Before designing a sound breeding program to breed higher ginning rate and reduced net ginning energy into good quality and high yielding cotton germplasm, it is imperative to understand the genetics of these

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traits and their associations with other agronomic and fiber effects. To this end, Bechere et al. (2014) reported that genotypic variances contributed 88, 27, and 60% to the total phenotypic variations for fuzz percent, ginning rate, and net ginning energy, respectively. Furthermore, their data show high broad-sense heritability and genetic advances from selections for these traits that make them easier to transfer in crosses.

Trait associations are useful tools for plant breeders because they can indicate predictive relationships that can be exploited in practice. Selection for one characteristic will result in progress for all positively correlated traits and regress for all negatively correlated characteristics. In this regard, relationships of agronomic and other fiber traits with ginning rate and net ginning energy requirements can provide the cotton breeder with some valuable information. The relationships of fiber length, fiber strength, and fuzz percent with ginning rate and ginning energy requirements have been investigated by various researchers (Chapman, 1969; Boykin, 2007; Bechere et al., 2011). But the results have not always been consistent.

The objectives of this study were (1) to quantify the relationships of lint yield and fiber quality traits with ginning rate and net ginning energy and (2) attempt to determine the relationships of seed fuzziness, leaf type, and the presence or absence of nectaries on ginning rate and net ginning energy within a selected group of genotypes.

MATERIALS AND METHODS

Genotypes and Field Practices. A set of 13 diverse genotypes were included in the study (Table 1). The genotypes included in the study fall into: semi-naked seed (3 genotypes), fuzzy seeded (10 genotypes), nectaried (10 genotypes), nectariless (3 genotypes), okra-leaf type (2 genotypes), and normal-leaf type (11 genotypes). Most upland cotton have seed that is completely covered with linters, while other cultivars have very sparse linters (semi-naked) or completely naked seeds. Normal-leaf cotton has either wider leaf lobes and/or less indentation between the major lobes than do the okra types. Sub-okra is a less extreme type than okra or super-okra in terms of indentation. All genotypes were evaluated for ginning rate, net ginning energy requirement, fuzz percent, lint yield, and fiber quality traits at the Jamie Whitten Delta States Research Center, Stoneville, MS, across two environments, each during 2013 and 2014, with four replicates at each environment. The experiment was conducted in randomized complete block design. Plants were grown in single-row plots 12.2 m X 1.0 m in size. The environments were distinguished by soil type and planting date. The different soil types were Beulah fine sandy loam (a coarse-loamy, mixed active thermic Typic Dystrochrept) in environments 1 and 3, and Bosket fine sandy loam (a fine-loamy, active thermic Mollic Hapludalf) in environments 2 and 4. Environment 1 was planted on 23 April 2013, environment 2 was planted on 5 May 2013, environment 3 was planted on 2 May 2014, and environment 4 was planted on 13 May 2014.

Table 1. Genotypes included in the study with their specific traits and sources

Genotype	Traits			Source
	Nakedness	Nectar	Leaf type	
AR 9317-26	Seminaked	nectaried	normal	University of Arkansas
Coker 413	fuzzy	nectaried	normal	Stoneville Pedigreed Seed Comp.
DP 4-910	fuzzy	nectaried	normal	Delta and Pine Land Comp.
FM 832	fuzzy	nectaried	okra	FiberMax, PVP 9800258
JJ 1145ne	fuzzy	nectariless	normal	JAJO Genetics
MD 15	fuzzy	nectaried	okra	Meredith, 2006, PI 642769
MD 25	fuzzy	nectaried	normal	Meredith & Nokes, 2011, PI 659508
Phy 72	fuzzy	nectaried	normal	Phytogen, PVP 200100115
SG 747	fuzzy	nectaried	normal	Sure-Grow Seed Inc., PVP 9800118
SC 9023 NS	Semi-naked	nectaried	normal	EMS mutant, Texas Tech Univ.
SP 103ne	fuzzy	nectariless	normal	Zeng et. al. 2007.
TAM 98-99ne	fuzzy	nectariless	normal	Thaxton et al., 2005, PI 636491
Tejas NS	Semi-naked	nectaried	normal	EMS mutant, Texas Tech Univ.

Standard conventional field practices were used during the experiment. All plots received a total of 134 kg ha^{-1} of K_2O and 112 kg ha^{-1} N, applied pre-plant. Herbicides, fungicides, and insecticides were applied on as-needed basis. GINSTAR® (thidiazuron and diuron) (Bayer Crop Science, Research Triangle Park, NC, U.S.A) at 0.63 kg ha^{-1} and SUPER BOLL® (ethephon, DuPont, Wilmington, DE, U.S.A) at 1.54 kg ha^{-1} were applied as defoliants in all environments. Harvest was done on 28 September in environments 1 and 3, and 1 October in environments 2 and 4.

Ginning and Energy Measurements. One hundred randomly selected bolls were hand-picked from each plot. Data on net ginning energy requirements, ginning rate, fuzz percent, lint percent, lint yield, and high-volume instrument (HVI) fiber quality traits were collected. Seed cotton was ginned on a 10-saw laboratory gin stand (Continental Eagle, Prattville, AL, U.S.A) in order to evaluate ginning energy requirements and ginning rate. A total of approximately 400 g seed cotton was fed into the gin by hand. The same operator was used throughout the process to avoid variation due to feeding method. Electrical power consumed by the gin stand was measured and recorded at 1-s intervals with a Yokogawa CW121 power meter with 10 W resolutions (Yokogawa Corp. of America, Newnan, GA, U.S.A).

Ginning efficiency was based on measurement of ginning energy per unit mass (Wh kg^{-1} lint) and ginning rate (g lint s^{-1}). Total ginning energy has two components, idle and net. Total ginning energy is the power consumption of the gin stand integrated over the time required to gin. The start of ginning was defined by a 30W increase in gin stand power and the end of ginning was identified when the 5-s moving average of power decreased by 2 W or less. Idle energy is the power consumption of the gin stand without the presence of cotton multiplied by the time required to gin the cotton. Idle power was the median value of power data collected for 10 s before the start of ginning. Net energy is the difference between total and idle energy and reflects the energy used to remove fiber from the seed and turn the seed roll, as opposed to the energy used to overcome friction of the commercial components of the gin stand. Ginning energy might be significantly affected y by factors such as lint moisture content, seed moisture content, ambient temperature, and relative humidity (Anthony, 1989). Therefore, attempts were therefore made to standardize these before and during testing. The cotton samples were stored in the greenhouse at about approximately 90° F for about a week to equilibrate the moisture content before ginning

Fuzz percent was calculated by weighing the fuzzy seed, delinting the sample, and reweighing the seed. The difference in weight was then divided by the weight of the fuzzy seed and multiplied by 100 to get the fuzz percent.

Quality Measurements. High-volume instrument (HVI) testing generated data on micronaire, uniformity, fiber length, and fiber strength. HVI was performed by the Fiber and Biopolymer Research Institute, Texas Tech University, Lubbock, TX. Fiber bundle strength (kN m kg^{-1}) was measured as the force required for breaking a bundle of fibers. Micronaire, which is the degree of cotton fiber wall development relative to the diameter of the fiber, was measured in micronaire units. The staple length provided a measure of the length of the bulk of the long fibers in a sample. Length uniformity is the ratio of the mean length and the upper-half mean length of the fibrograph and is expressed as a percentage.

Statistical Analysis. Analysis of variance was performed using the ANOVA procedure in SAS (SAS Institute, Inc., Cary, NC). A mixed model was used in the procedure. Genotype was considered a fixed effect and environment and replicate within environments were considered random effects. Mean separations among genotypes and among different groups were performed using the LSD test. The correlations between all traits were calculated by PROC CORR in SAS using data averaged across locations and years.

RESULTS AND DISCUSSION

The specific traits of each genotype and its sources are given in Table 1. Mean square values for the 13 genotypes, the four environments, and the interaction of genotype X environment are presented in Tables 2 and 3. Highly significant statistical differences were observed between genotypes for lint percent, lint yield, fuzz percent, ginning rate, net ginning energy, micronaire, fiber length, and fiber strength. The environment had highly significant effect on all traits including ginning rate and net ginning energy. The genotype X environment effects followed the same pattern except for lint percent and net ginning energy. To address these significant GXE interactions, the relationships of the traits within environments are explored (Tables 5 and 6). Environment 2 had significantly higher lint yield, fuzz %, ginning rate, fiber length, and strength than the other 3 environments (Table 5). The relationships between the different traits were in general, different from one environment to another. Exceptions to this are the similar relationships between turnout and net ginning energy; fuzz percentage and net ginning energy; fuzz % and fiber strength; micronaire and fiber length; micronaire and fiber strength; fiber length and uniformity; and fiber length and fiber strength. The relationships between these traits remained similar across the four environments (Table 6).

Table 2. Mean squares for lint percent,lint yield, fuzz percentage, ginning rate, and net ginning energy for 13 diverse cotton genotypes grown in four environments (N = 208)

Source	DF	Lint percent	Lint yield	Fuzz percent	Ginning rate	Net ginning energy
Genotype (G)	**12**	**60.9*****	**11.5 X 10^{5***}**	**23.4*****	**0.56*****	**10.1*****
Environment (E)	**3**	**76.4*****	**11.1 X 10^{5***}**	**9.11*****	**18.3*****	**6.7*****
G X E	**36**	**2.30**	**17.0 X 10^{4**}**	**1.03****	**0.13***	**0.40**
Reps	**3**	**1.31**	**33.3 X 10^{4**}**	**1.71***	**0.18**	**0.31**
Error	**153**	**1.78**	**72.7 X 10^{3}**	**0.58**	**0.08**	**0.30**

***, **, *** Significant at 0.05, 0.01, and 0.001 probability level, respectively**

Table 3. Mean squares for HVI fiber traits for 13 cotton genotypes grown in 4 environments

Source	Df	Micronaire	Fiber length	Uniformity	Fiber strength
Genotype (G)	**12**	**0.93*****	**0.02*****	**3.78****	**46.2*****
Environment (E)	**3**	**3.63*****	**0.06*****	**33.5*****	**62.1*****
G X E	**36**	**0.16*****	**0.01*****	**2.12*****	**5.30****
Rep	**3**	**0.05**	**0.001**	**0.11**	**1.65**
Error	**153**	**0.05**	**0.001**	**0.80**	**2.52**

****, *** Significant at the 0.01 and 0.001 probability levels, respectively.**

Table 4. Mean ginning rate, net ginning energy, lint yield, and fiber length, and strength by genotype

Genotype	Ginning rate (g lint s^{-1})	Net ginning energy (Wh kg^{-1} lint)	Lint yield (Kg ha^{-1})	Mic	Fiber length (mm)	Fiber strength (kNmkg^{-1})	Fuzz %	Lint %
AR 9317-26	**3.05**	**7.12**	**1249**	**4.9**	**29.2**	**296.2**	**4.4**	**37.2**
Coker 413	**2.64**	**8.39**	**1635**	**4.8**	**28.5**	**293.2**	**6.4**	**43.4**
DP 4-910	**2.64**	**8.16**	**1153**	**5.4**	**27.9**	**299.1**	**6.7**	**43.5**
FM 832	**2.61**	**9.03**	**1161**	**4.5**	**30.2**	**317.8**	**7.1**	**40.3**
JJ 1145ne	**3.02**	**8.84**	**1571**	**4.7**	**30.2**	**311.9**	**6.2**	**43.3**
MD 15	**2.56**	**8.47**	**1285**	**4.6**	**29.2**	**326.6**	**6.4**	**41.2**
MD 25	**2.88**	**9.06**	**1745**	**4.6**	**31.2**	**338.3**	**6.3**	**41.4**
Phy 72	**2.55**	**10.11**	**1157**	**4.9**	**29.7**	**322.7**	**6.7**	**41.9**
SG 747	**2.66**	**8.72**	**1630**	**5.2**	**29.0**	**292.3**	**8.1**	**43.8**
SC 9023 NS	**2.81**	**7.80**	**1094**	**4.8**	**27.9**	**297.2**	**5.1**	**38.3**
SP 103ne	**2.45**	**9.79**	**954**	**4.6**	**30.2**	**324.6**	**8.4**	**37.2**
TAM 98-99ne	**2.67**	**8.90**	**1335**	**4.9**	**30.0**	**336.4**	**7.0**	**40.6**
Tejas NS	**2.90**	**7.87**	**696**	**4.7**	**29.0**	**324.6**	**4.4**	**36.5**
LSD (0.05)	**0.19**	**0.38**	**188**	**0.2**	**0.02**	**1.11**	**0.53**	**0.93**
CV (%)	**10.1**	**6.4**	**23.6**	**4.6**	**2.7**	**5.0**	**11.9**	**3.3**
R^2	**0.85**	**0.77**	**0.69**	**0.79**	**0.79**	**0.71**	**0.80**	**0.87**

Table 5. Lint turnout, lint yield, fuzz percent, ginning rate, and quality traits performances within environments

Environment	Year	Field	Soil type	Turnout	Lint yield	Fuzz %	Ginning rate	Mic	Fiber length	Fiber strength
1	2013	6	Belulah Fine Sandy Loam	39.2 c†	1128 b	6.4 b	3.1 b	4.6 c	1.16 b	31.8 b
2	2013	9	Bosket Fine Sandy Loam	39.4 c	1354 a	7.0 a	3.3 a	4.5 d	1.20 a	33.3 a
3	2014	6	Belulah Fine Sandy Loam	42.3 a	1067 b	6.4 bc	2.0 d	5.0 b	1.13 c	30.6 c
4	2014	9	Bosket Fine Sandy Loam	41.8 b	1027 b	6.0 c	2.4 c	5.1 a	1.13 c	32.3 b
CV (%)				3.3	23.6	11.9	10.1	4.6	2.7	5.0
R^2				0.87	0.69	0.80	0.85	0.79	0.79	0.71

† Numbers within a column followed by similar letters are not significantly different from each other.

Table 6. Pearson correlation coefficients between various traits within 4 environments

	Environment	Fuzz percent	Ginning rate	Net ginning energy	Micronaire	Fiber length	Uniformity	Fiber strength
Turnout	1	0.3451*	0.0980	0.1047	0.3346*	-0.2371	-0.3264*	-0.3864*
	2	0.0813	-0.0857	0.2450	0.0410*	-0.1776	-0.0563	-0.2896
	3	0.3783*	-0.2421	0.1807	0.3542*	0.0136	-0.2791	0.0047
	4	0.3759*	-0.0951	0.2509	0.2029	-0.3108	-0.3194	-0.2510
Fuzz percent	1		-0.3483	0.4705**	-0.1567	0.0692	-0.1338	0.2212
	2		-0.1179	0.3263*	-0.0883	0.2494	-0.0447	0.2217
	3		-0.6414**	0.6305**	0.0724	0.3042	0.0544	0.1610
	4		-0.5206**	0.6269**	-0.0861	0.3168*	0.1041	0.2415
Ginning rate	1			-0.1907	0.2159	0.0609	0.2213	-0.1144
	2			-0.2556	-0.1538	0.4639**	0.3725*	0.1089
	3			-0.6642**	0.0435	-0.1520	0.1874	-0.1139
	4			-0.4314**	0.1871	-0.2937	-0.1455	-0.0033
Net ginning energy	1				-0.1129	0.3661*	0.0395	0.4938**
	2				0.0667	0.2614	0.3086	0.0516
	3				-0.1031	0.4219**	0.1461	0.5027**
	4				-0.2624	0.3270*	-0.0161	0.1925
Micronaire	1					-0.6179**	-0.1838	-0.5432**
	2					-0.5676**	0.0379	-0.7130**
	3					-0.3826*	-0.1321	-0.3943*
	4					-0.4887**	-0.2761	-0.3982*
Fiber length	1						0.5258**	0.6366**
	2						0.3745*	0.6359**
	3						0.3344*	0.5719**
	4						0.5968**	0.6399**
Uniformity	1							0.3381*
	2							0.1400
	3							0.2093
	4							0.5182**

*,**,*** Significant at the 0.05, 0.01 and 0.001 probability levels, respectively

Table 4 presents the ginning rate, net ginning energy, lint yield, fiber length, and strength values for all 13 genotypes. AR 9317-26, JJ 1145ne, Tejas NS, and MD 25 had the highest ginning rate values. The three seminaked-seed genotypes, AR 9317-26, SC 9023 NS, and Tejas NS had the lowest amount of net ginning energy requirements. MD 25, Coker 413, and SG 747 had the highest lint yield. In addition to having a high ginning rate and the highest lint yield, MD 25 also had the longest fiber and the highest fiber strength. This genotype, interestingly, appears to have overcome the negative correlation between lint yield and fiber strength, a phenomenon that has been a major problem of cotton improvement in the U.S. in the past few decades (Meredith, 1977; Culp et al., 1979; Culp, 1992; May, 1999). Thaxton (2008) and Meredith and Nokes (2011) also reported excellent yield (1714 Kg/ha), and quality (length of 31.2 mm and strength of 400 kNmkg^{-1}) for MD 25. Bechere et al. (2015) also reported high general combining ability effect of MD 25 for ginning rate and recommended it to be included in crosses to improve ginning efficiency in upland cotton.

Relationships Between Traits. Pearson's correlation coefficients between the different traits in the study are given in Table 7. In addition to correlations among all genotypes, correlations among genotypes in the absence of the semi-naked-seed group also were calculated. The yield and energy use are significantly lower and the ginning rate is higher for the naked seed group (Table 8).Ginning rate was significantly and positively related to lint percentage, micronaire, fiber strength, fiber length, and uniformity. Micronaire represents a combined measure of cotton fineness and maturity. High micronaire fibers are normally coarse and have high wall thickness (Montalvo, 2005). The relationship of micronaire with net ginning energy is negative, but not significant. Ginning rate, however, was negatively correlated with net ginning energy, lint yield, and fuzz percent. The higher the fuzz percent and lint yield, the lower were the ginning rate of a genotype. Net ginning energy requirement was positively, but not significantly, associated with lint yield. Net ginning energy requirement was highly significantly and positively correlated with fiber length, and fiber strength, and fuzz percent. Bechere et al. (2011) reported similar results. Longer fibers require a greater force per fiber due to greater frictional forces (more entanglement with other fibers and a longer time attached to the saw before removal from the seed). Although a longer fiber will have greater mass (if the cross-sectional area is the same), the energy/mass is still greater for longer fibers. Because the fiber is longer and has greater mass, the ginning rate increases as well. With stronger fibers, ginning energy is increased because more energy will be used to remove fibers that would be broken at the gin stand with weaker cotton. The fiber breaks when the force applied by the saw is more than the breaking strength of the fiber. If a greater force can be applied before the fiber breaks (either along the length or at the seed), the ginning energy will increase. This is just a theory and needs to be supported with further investigation. Chapman (1969) and Boykin (2007), however, reported that fiber length did not appear to influence ginning energy and furthermore they stated that ginning energy increased as HVI strength decreased. These researchers also found out that fuzz percent had a strong and positive relationship with net ginning energy. The relationship of micronaire with ginning rate and net ginning energy was negative, but not significant. Relationships between traits remained fairly constant when the semi-naked-seed group was not involved in the analyses. This was mostly true when ginning rates were considered. Exceptions to this are the relationships between net ginning energy and fuzz percent and net ginning energy and lint percent. When all genotypes are considered, fuzz percent was positively and significantly correlated with ginning energy. However, when the seminaked-seed group is left out from the analyses, this significant relationship disappears. The seminaked-seed group has much less fuzz on their seeds. The relationship between net ginning energy and lint percent also changed dramatically when the semi-naked-seed group was not considered. The positive and significant relationship changes into a negative and significant relationship in the absence of the semi-naked-seed group (Table 7). The lower amount of lint on the naked-seed group might be responsible for altering this relationship.

Table 7. Pearson correlation coefficients between ginning rate, net ginning energy, lint yield, and fiber traits in all cotton genotypes (first row) and among genotypes excluding the semi-naked seed genotypes (second row)

		Net ginning energy	Fuzz %	Lint %	Lint yield	Micronaire	Fiber length	Uniformity	Fiber strength
Ginning rate	All genotypes (N = 208)	-0.28***	-0.06	0.27***	-0.38***	0.41***	0.48***	0.22**	0.22**
	Without seminaked seed (N = 160)	-0.19*	0.11	0.36***	-0.37***	0.45***	0.49***	0.21**	0.21**
Net ginning energy	All genotypes (N = 208)		0.50***	0.22**	0.05	-0.06	0.26***	0.07	0.23***
	Without seminaked seed (N = 160)		0.15	-0.21*	-0.15	-0.07	0.24**	0.16	0.24**
Fuzz %	All genotypes (N = 208)			0.18**	0.17*	-0.15*	0.28***	0.11	0.21**
	Without seminaked seed (N = 160)			-0.36***	-0.05	-0.16*	0.23**	0.25**	0.10
Lint %	All genotypes (N = 208)				0.35***	0.47***	-0.30***	-0.40***	-0.30***
	Without semi-naked seed (N = 160)				0.28***	0.55***	-0.52***	-0.46***	-0.49***
Lint yield	All genotypes (N = 208)					0.05	0.15*	0.06	-0.07
	Without seminaked seed (N = 160)					0.09	0.05	0.06	-0.17*

*, **, *** Significant at 0.05, 0.01, and 0.001 probability level, respectively.

Table 8. Comparisons of okra leaf versus normal leaf, semi-naked versus fuzzy seed, and nectaried and nectariless plants for ginning rate, net ginning energy, fuzz percentage, and lint yield

Groups	Ginning rate (g lint s^{-1})	Net ginning energy (Wh kg^{-1} lint)	Fuzz %	Lint yield (Kg ha^{-1})
Okra leaf (2)†	2.75*	8.75	6.77	1299
Normal leaf (11)	2.59	8.63	6.32	1225
Seminaked seed (3)	2.92*	7.66	4.62	1013
Fuzzy seed (10)	2.67	8.95*	6.92*	1363*
Nectaried plants (10)	2.73	8.49	6.16	1281
Nectariless plants (3)	2.72	9.18*	7.17*	1286

*Significantly different at $p < 0.05$.

† Comparisons were made by using data averaged across four environments.

† Numbers of genotypes with the trait.

Comparisons Between Different Genotype Groups. Comparison of okra leaf versus normal leaf, semi-naked seed versus fuzzy seeds, and the presence or absence of nectaries with ginning rate, net ginning energy, and other traits is presented in Table 8. These comparisons should be viewed with care because the number of genotypes in each group is not equal. In addition, in comparing the different genotype groups for ginning efficiency, the development of near isogenic lines for each trait in each genotype would have given a more accurate comparison between each group of genotype. The okra-leaf group had significantly ($p < 0.05$) higher ginning rate than the normal-leaf group. The semi-naked-seed group had significantly higher ($p < 0.05$) ginning rate than the fuzzy seed group. On the other hand, ginning rate did not appear to be influenced by the presence or absence of nectaries. The fuzzy-seeded group required higher net energy to gin when compared to the semi-naked-seed group. Bechere et al. in (2011) reported that the semi-naked-seed group in their study had lower net ginning energy and higher ginning rates than the fuzzy genotypes. Genotypes with no nectaries required higher net ginning energy to gin than the nectaried genotypes. The fuzzy seeded and nectariless genotypes had significantly higher fuzz percentage than the semi-naked seeded and nectaried genotypes, respectively. No difference in fuzz percent was observed between the okra-leaf and normal-leaf groups. For lint yield, differences were observed only between the semi-naked and fuzzy-seeded genotypes. The fuzzy-seeded genotypes yielded significantly higher than the semi-naked-seeded genotypes.

CONCLUSION

Even though the number of genotypes in the study is not large, a high level of genetic diversity for ginning efficiency was observed. Ginning rate had significant negative correlation with lint yield, but positive and significant relationships with micronaire, fiber length, uniformity, and fiber strength. These relationships hold true even when the semi-naked-seed group was taken out of the analyses. Lint yield appears to have no impact on ginning energy requirement. Fiber length and fiber strength, on the other hand, had positive and significant relationships with net ginning energy. The semi-naked-seed group appears to have no impact on these relationships. When comparing the different genotype groups, the most dramatic differences occurred between the semi-naked and fuzzy-seeded genotypes, where the semi-naked-seed genotypes had significantly higher ginning rate, but significantly lower net ginning energy, fuzz percent, and lint yield. These results should be taken with caution because there were only three semi-naked-seed genotypes as compared to 10 fuzzy genotypes in the study.

ACKNOWLEDGEMENT

This research is part of the National Program 301 (Plant Genetic Resources, Genomics and Genetic Improvement) and is funded through ARS Project Number 6066-21000-051-00D.

DISCLAIMER

Mention of trade names or commercial products in this 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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