SEED SIZE, GINNING RATE, AND NET GINNING ENERGY REQUIREMENT IN UPLAND COTTON

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Abstract

Not much information is available in the literature on the effect of seed size on ginning efficiency in upland cotton. In 2015, nine diverse upland cotton cultivars and germplasm were planted at two locations in Stoneville, MS to test the above relationship. Two of the cultivars (Ark 9317-26 and DP 555 BG/RR were classified as 'small' because they have seed index (SI) of < 10 gm. FM 832, FM 966, and MD 15, had SI ranging from 10-12 gm and were classified as having 'intermediate' seed size. TAM 182-34 ELS and three other breeding lines from Stoneville, MS (201-2, 107-1, and 152-1) had 'large' seeds with SI of > 12 gm. The materials were planted in three replications each at two sites in Stoneville, MS. Data were collected on ginning energy requirement (Wh kg^{-1} lint), ginning rate (g lint s^{-1}), fibers/seed, seed surface area, fuzz %, gin turnout, HVI and AFIS quality parameters. Statistical analyses of all properties associated with the genotypes were performed using Proc ANOVA. Simple Pearson's correlation test and regression analyses were conducted to test the relationship between traits. Result indicated that small and intermediate seeded genotypes have significantly higher ginning rate than large seeded genotypes. However, larger seeded genotypes required significantly higher ginning energy. Seed size was positively and significantly correlated with net ginning energy, seed index, fuzz %, and seed surface area but negatively and significantly correlated with lint turnout and fiber uniformity. Relationships with ginning rate and fibers/seed were negative but not statistically significant.

Introduction

Differences in ginning performance of several seed cottons were described as early as 1879 by Watson. He stated that the difference shown to exist between the several varieties of cotton in respect to the power consumed in their ginning can be associated with differences in the strength of the attachment of the fibers to the seed and differences in the degree of fuzziness of the seeds. Watson further reported that the time required for ginning was affected by the percentage of fuzz, lint percentage, and seed size, in that order. Net ginning required for ginning, on the other hand, depended on lint percentage, amount of fuzz, and seed size again in that order.

In 1943, Smith and Martin suggested that removal of the lint fibers from cotton seeds by means of gin saw is affected by the seed cotton processed. Varietal characteristics may influence the time and energy required to gin seed cotton. They found out that the larger and more fuzzy-seeded cottons required more time and energy to gin than the smaller and less fuzzy-seeded varieties. In cotton, it has been reported that large, high density seeds produced plants with greater seedling vigor than small low density seeds (Kreig and Kreig, 1975, Leffler and Williams, 1983). Snyder et al. (2014) pointed out that it is generally accepted that large seeded species produce more competitive seedlings that are larger, have deeper root systems, can more effectively utilize natural resources, and withstand environmental stresses better than smaller seeded species. Stewart (2015), however, pointed out that growers typically desire smaller seed because of the increased number of seeds per pound but he indicated that it is generally believed that larger seed are desired because of perceived increased in seed vigor that accompany larger seed size. According to Main et al (2013), varieties with medium sized seed produced higher yields in response to N application than did larger and smaller seeded varieties. Varieties with larger seeds had lower and stronger fibers, high fiber length uniformity than small seeded varieties and decreased micronaire. Hughs et al. (2003) found out that large seeded variety DP 451 had fewer neps. The small seeded variety DP 555 BG/RR made yarn whose properties were as good as or better than that made from DP 451. DP 555 had significantly shorter length, had higher short fiber and neps. DP 555 produced significantly stronger and more uniform yarn than did DP 451.

Snyder et al. (2016) reported that seed size was negatively associated with lint yield.

Available literature indicates that not much work has been conducted on the relationships of cotton seed size and ginning efficiency. The objective of this research was to investigate the effect of seed size on ginning energy and ginning rate in upland cotton.

Materials and Methods

Plant Material and Study Site

In 2015, nine diverse upland cotton cultivars were planted in Stoneville, MS to study the effects of seed size on ginning efficiency of upland cotton. Two of these cultivars, AR 9317-26 and DP 555 BG/RR were classified as 'small' seeded based on their seed index (weight of 100 fuzzy seeds in grams) (<10 gm). FM 832 okra, FM 966, and MD 15 okra were classified as 'intermediate' and has seed index ranging from 10 to 12 gm. Entries 201-2, 107-1 and 152-1 are breeding lines at Stoneville, MS with seed indexes >12 gm. ('Large'). TAM 182-34 ELS (PI 654362, Smith et al., 2009) was also a large seeded cultivar. Ark 9317-26 is a semi-naked seed breeding line from the University of Arkansas. It was derived from a cross of 'H1330' (Bourland, 1996) by N-143-6. N-143-6 is a naked seed line developed by B.A. Waddle, a former UA cotton breeder. Fiber Max 832 (okra) (PVP 9800258) and FM 966 (PVP 200100209) are varieties developed by the Commonwealth Scientific and Industrial Research Organization. MD 15 is another okra breeding line (Meredith 2006, PI 642769). DP 555 BG/RR (PVP 200200047) a transgenic variety developed by Delta and Pine Land Company.

The experiment was conducted in a randomized complete-block design with three replications at two locations during 2015 and 2016 (but only data from 2015 is reported here) at Stoneville, MS. The two locations differed in soil type. One location had Bosket fine sandy loam soil that was very deep, wee drained, and moderately permeable. The soil at the second location was coarse-loamy, mixed and fine loam. Single-row, 12.2 m. plots with 1.0 m between rows, was used. Planting was carried out in the fourth week in April at the first location but was delayed until the first week of May at the second location. Three inches of irrigation water was applied three times with poly-pipe in furrows. One-hundred thirty four kg/ha of K_2O and 112 kg/ha of nitrogen were applied. Prowl (at 26.4 kg/ha0 and Valor (at 2.2 kg/ha) were pre-plant incorporated for weed control. At planting, a fungicide, Terraclor and an insecticide, Temik, were applied at the rates of 11.2 kg/ha and 5.6 kg/ha, respectively, in the furrows. A pre-emergence herbicide, Dual Magnum, was applied at the rate of 0.56 kg/ha. Insecticides were also applied for thrips (Radiant at the 0.11 kg/ha) and other plant bugs (Trimax, Centric, orthane, etc.). GINSTAR (thidiazuron and diuron) (Bayer CropScience, NC) at the rate of 0.63 kg/ha and SUPER BOLL (ethephon) (DuPont, DE) at the rate of 1.54 kg/ha were applied as defoliants.

Ginning Energy and Ginning Rate Measurements

Fifty bolls/rows were hand-picked from all plots. These bolls were used to measure net ginning energy, ginning rate, fuzz percentage and other quality attributes. The seed cotton was weighed before ginning and the lint was weighed after ginning to determine the lint turnout. Fuzz percentage was calculated as ((fuzzy seed weight – delinted seed weight)\fuzzy seed weight) X 100. The cotton was ginned using a 10-saw Continental Eagle laboratory gin (Bajaj ConEagle, LLC, Prattville, AL). All samples were ginned by the same person to reduce variability caused by different feeding techniques. Electrical power used by the gin stand motor was measured and recorded at 1-s interval with a Yokogawa CW121 power meter (Yokogawa Corp. of America, Newnan, GA). Resolution of the power meter was 10 W. Ginning efficiency was described by two parameters calculated from the gin stand power data- ginning rate and net ginning energy per unit mass. The gin stand motor was started before cotton was fed into the stand. A 30 W increase in gin stand power indicated the start of ginning. The gin stand motor was stopped when ginning of the sample was completed. The elapsed time was used to calculate the ginning rate. The total energy used by the gin stand motor was determined by integrating the recorded power over the time that cotton was ginned. The power used by the gin stand when idling was defined as the median value of data collected for 10 s before the start of ginning (or all data if less than 10 s from starting the motor to the start of ginning). The idling energy while ginning was equal to the idling power multiplied by the ginning time. Net ginning energy was calculated by subtracting the idling energy from the total energy. The net ginning energy 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 mechanical components of the gin stand.

Fiber Quality Measurements

High-volume instrument (HVI) quality analyses generated data on MIC, FS, FL and UN. HVI was performed by the Fiber and Biopolymer Research Institute, Texas Tech University. Fiber bundle strength (kN m kg^{-1}) was measured as the force required to break a bundle of fibers. MIC, which is the degree of cotton fiber wall development relative to the diameter of the fiber, was measured in micronaire units.

Statistical Analysis

Statistical analyses of all properties associated with the genotypes were performed using Proc ANOVA (SAS, 2004). Simple Pearson's correlation test was used to estimate the level of relationships between traits.

Results and Discussion

A one year, two locations preliminary data indicated that:

- Larger and intermediate sized seeds had higher seed index than smaller seeds
- Intermediate and small seeded genotypes have significantly higher ginning rate than larger seeded genotypes
- Larger seeded genotypes required significantly higher gin energy to gin and have higher fuzz % than smaller seeded genotypes.
- Smaller seeded genotypes had significantly higher lint yield and gin turnout than intermediate and larger seeded genotypes.
- In general, medium and large seeded genotypes had higher fiber strength, longer fiber length, lower short fiber content, lower fineness, and higher maturity ratio than the smaller seeded genotypes. However, the smaller seeded genotypes required less net ginning energy to gin but the ginning rate was smaller than the medium and large seeded genotypes.
- The smaller and intermediate seed size group had higher fiber length uniformity than the large seeded group.
- In terms of correlations – Seed size was positively and significantly correlated with net ginning energy, seed index, fuzz %, and seed surface area but negatively and significantly correlared with turnout and uniformity. The relationship with ginning rate and fibers/seed were negative but not significant.
- Note – The second year data which is currently being analyzed, and not included here, might change some of these conclusions**.**

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Table 1. Mean square values for ginning rate, ginning energy, agronomic and quality parameters

Source	Ginning Rate	Ginning Energy	TO	Lint Yield	Fuzz %	Seed Index	Mic	Length	Unif.	Strn	Fibers/ Seed
Cultivars	0.16**	2.1**	36.7**	5.1 x 10^{5}**	14.6**	10.7**	0.3**	0.04**	6.6**	37.6**	2.3 x 10^{9}**
Location	0.03	2.5	36.6**	1.5 x 10^{5}**	7.1**	2.2**	0.02**	0.002*	0.6	32.5**	1.9 x 10^{9}**
Rep.	0.03	0.6	8.5**	7.6 x 10^{4}**	1.9**	0.9**	0.04**	0.0008*	0.8	7.1**	6.9 x 10^{9}**
Seed Size	0.24**	3.7**	18.4**	9.6 x 10^{5}**	18.7**	21.0**	0.63**	0.02**	11.4**	75.9**	1.3 x 10^{9}**

* Significant at 0.05 level of probability

**Significant at 0.01 level of probability

Table 2[†]. Performance of some cotton genotypes for ginning efficiency and some quality parameters

Cultivar	Seed Size*	NE**	GR***	Lint %	Fuzz %	Fibers Seed^{-1}	Strength (cN tex^{-1})	Length (mm)	Nep-Um^{2}	SFC_w	Fine (millitex)	MR
DP 555 BG/RR	Small	9.9	2.96	0.45	12.8	13273	20.1	28.7	620.9	7.5	172.8	0.94
AR 9317-26	Small	7.5	3.1	0.35	6.4	10436	18.7	28.4	612.3	4.6	183.7	0.93
MD 15 (Okra)	Int.	10.0	3.4	0.38	10.6	13494	29.0	31.5	626.4	3.4	165.3	0.98
FM 832 (Okra)	Int.	10.5	3.15	0.39	12.4	13733	24.7	31.2	628.7	4.5	169.7	0.98
TAM 182-34-ELS	Large	12.0	3.11	0.35	11.3	13325	25.2	35.3	672.7	4.4	161.7	0.97

[†]Adapted from 'Bechere, E., J. Clif Boykin, and W. R. Meredith. 2011. Evaluation of Cotton Genotypes for Ginning Energy and Ginning Rate. Journal of Cotton Sci. 15:11-21.'

*Based on seed index (small=<10 grams/100 fuzzy seeds, Intermediate=10-11 grams/100 fuzzy seeds, and >12 grams/100 fuzzy seeds.

** Net Ginning Energy (Wh kg^{-1} lint)

*** Ginning Rate (g lint s^{-1})

Table 3. Performance of cultivars in the test during 2014 and 2015 at Stoneville, MS.

		2014		2015				
Cultivar	Seed Size†	Seed Index‡	Fibers/ Seed	Seed Index	Seed Surf. Area	Fibers/ Seed	GE±	GR¶
AR 9317-26	Small	10.00	9952	9.8	109.5	148574	7.1	2.86
DP 555 BG/RR	Small	9.13	13288	9.4	97.4	197401	8.0	3.05
FM 832 (Okra)	Int.	10.9	12957	--	--	--	--	--
MD 15 (Okra)	Int.	11.1	12389	12.0	117.5	144858	8.2	3.11
FM 966	Int.	11.9	13725	11.9	121.9	166517	8.5	3.15
TAM 182-34-ELS	Large	12.8	12808	12.1	113.4	148997	8.6	2.97
201-2, Plant # 49	Large	15.6	--	--	--	--	--	--
107-1, Plant # 45	Large	14.6	--	13.0	122.4	160683	8.7	2.72
152-1, Plant # 49	Large	14.0	--	--	--	--	--	--
LSD (0.05)				0.2	0.5	14978	0.1	0.5

†Based on seed index (small=<10 grams/100 fuzzy seeds, Intermediate=10-12 grams/100 fuzzy seeds, and >12 grams/100 fuzzy seeds.
‡ Weight (gm) of 100 fuzzy seeds
± Net Ginning Energy (Wh kg^{-1} lint)
¶ Ginning Rate (g lint s^{-1})

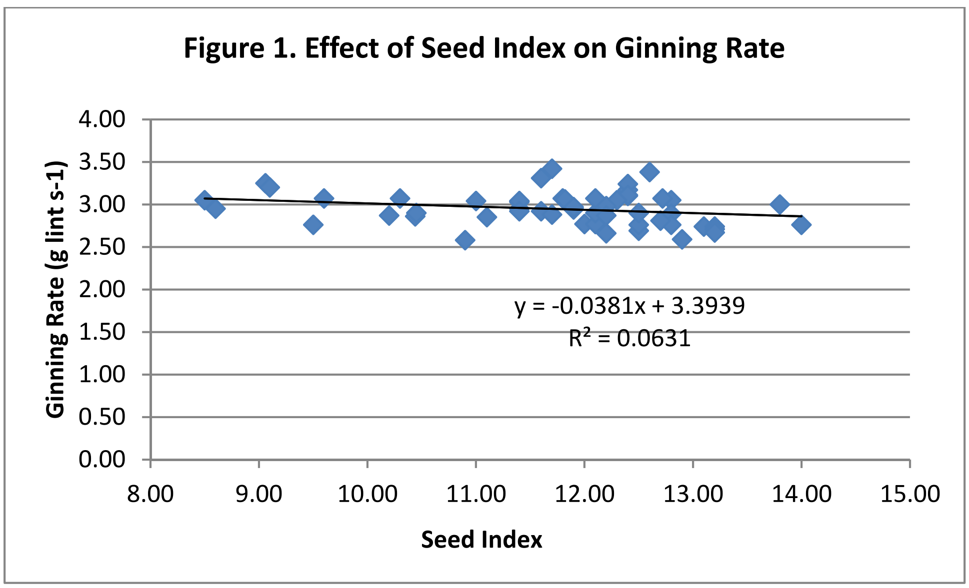
Table 4. Correlations of Seed size with ginning energy, ginning rate and other indices.

	Ginning Energy	Ginning Rate	Seed Index	Turnout	Fuzz %	Fibers/ seed	Seed sur. Area	Uniformity
Seed Size	0.63**	-0.21	0.68**	-0.37*	0.59**	-0.29	0.59**	-0.38*

*Significant at 0.05 probability level
**Significant at 0.01 probability level

Table 5. Performance for various indices Summarized by Seed Size

Ginning Rate	Ginning Energy	Turnout	Fuzz %	Seed Index	Fibers/Seed	Seed Surf. Area	Uniformity
3.13 a (Int.)	8.64 a (Large)	38.7 a (Small)	8.68 a (Large)	12.4 a (Int.)	172987 a (Small)	119.7 a (Int.)	85.3 a (Int.)
2.95 b (small)	8.38 b (Int.)	37.2 b (Int.)	7.44 b (Int.)	12.3 a (Large)	155687 b (Int.)	117.9 b (Large)	84.7 a (Small)
2.85 c (Large)	7.58 c (Small)	36.2 c (Large)	6.17 c (small)	10.1 b (Small)	154840 b (Large)	103.5 c (Small)	83.4 b (Large)



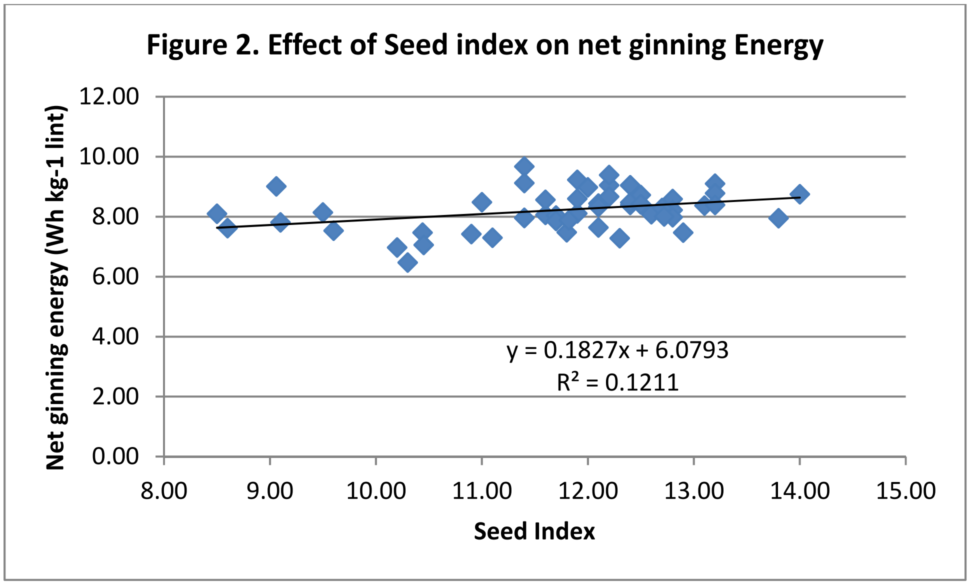


Figure 2. Effect of Seed index on net ginning Energy
Net ginning energy (Wh kg-1 lint)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
Seed Index
y = 0.1827x + 6.0793
R² = 0.1211