COMPARISON OF THE UGA MICROGIN, A LABORATORY GIN, AND COMMERCIAL GINS IN GEORGIA: SECOND YEAR STUDY

Changying Li[1], Andy Knowlton[1], Scott N. Brown[2]
[1]Biological and Agricultural Engineering, University of Georgia, Tifton, GA
[2]University of Georgia Cooperative Extension Office, Colquitt County, GA

Abstract

Previous studies have shown that small sampling methods and lab gin stands could not accurately predict the true fiber lint quality and lint yield. The UGA Microgin was built to simulate the performance of commercial gins and to gin cotton samples from the whole research plot. The goal of this study was to investigate whether the UGA Microgin can accurately estimate fiber properties of lint ginned from commercial gins. Six commercial gins in south GA were selected and compared with the UGA Microgin and a Continental Eagle 10-saw laboratory gin stand. Five cotton varieties (DPL 555, DPL 0935, FM 1740, ST 5458, and PHY 370) from non-irrigated and irrigated land were ginned in this study. Same cotton varieties from the same location were ginned across the three types of gin in order to have a fair comparison. Both the lint yield and HVI fiber quality data were compared among three types of gin. Nine HVI quality properties were analyzed by the one-way ANOVA test. The lab gin had zero success rate in estimating the performance of commercial gins in color grade and leaf grade. In contrast, the Microgin successfully predicted the color grade and leaf grade of lint ginned by commercial gins in 53% and 65% of times, respectively. The UGA Microgin had 77% and 82% success rates in estimating commercial gin performance for staple and uniformity, respectively; the lab gin stand only achieved 35% and 18% success rates in these two measures. These data confirmed that the UGA Microgin did a far superior job to the lab gin stand in estimating the fiber length and uniformity from commercial gins. The Microgin and lab gin stand did an equally good job in estimating commercial gins in micronaire and strength with a success rate of 65% in micronaire and 77-88% in strength. Given the large intra-sample variations in cotton samples and variations between commercial gins, these data provided strong evidence that the UGA Microgin performs better than the lab gin stand in estimating lint yield and most fiber quality properties obtained from commercial gins. This study proved that the UGA Microgin is a valuable tool for cotton research.

Introduction

Cotton researchers generally use small research plot trials to evaluate fiber quality from certain varieties, different field treatments, as well as various growing conditions (Boykin, 2008). These small research plots cannot generate enough cotton samples for a commercial gin to separate the lint from seeds, which is a necessary step for fiber lint quality evaluation. Researchers typically use laboratory gin stands to gin a small amount of cotton samples collected from research plots by sub-sampling methods such as boll sample or grab sample (Calhoun et al., 1996). However, sub-sampling methods invariably leads to the biases due to lack of true representation of the whole research plot (Boykin, 2008). Indeed, it has been well documented that gin machinery has a significant impact on fiber quality including length, color, trash content (Anthony, 1990; Anthony, 1994; Anthony, 2002). Therefore, the selection of the right gin is critical in estimating the true fiber quality of lint ginned from commercial gins.

The University of Georgia Microgin facility was built to address this issue. The UGA Microgin was designed to simulate commercial gins with all standard machinery and procedures typically used in commercial gins such as drying, seed cotton cleaning, and lint cleaning. However, as its name suggests, the UGA Microgin is in a much smaller scale than a typical commercial gin. All machine parts in the UGA Microgin is one foot wide compared to 8-10 feet wide in most commercial gins. The Microgin was designed to overcome limitations in small lab gins. It enables researchers to gin cotton samples harvested from the whole research plot for up to 2500 lbs, far exceeding the limit in laboratory gin stands. Nevertheless, one question still remains unanswered: whether the Microgin can better estimate lint yield and cotton fiber quality of lint ginned from commercial gins than lab gin stands? Although a few previous studies were attempted to fill this knowledge gap (Brown et al., 2004; Li et al., 2009), these studies had limitations by selecting only one commercial gin for comparison or not providing adequate sample replicates in fiber quality data for statistical analysis. The overall goal of this study was to investigate whether the UGA Microgin can outperform a laboratory gin stand in estimating lint yields and HVI fiber quality properties of lint ginned from the same seed cotton in commercial gins.

Materials and Methods

The UGA Microgin was made by Lummus (Lummus Inc., Savannah, GA) and Cherokee (Cherokee Fabrication Inc., Salem, Alabama), and it uses the same equipment layout as used in a typical commercial gin. The major difference between the UGA Microgin and a commercial gins is that all the machines in the Microgin are one foot instead of 8-10 feet wide in most commercial gins. The equipment is arranged in the standard configuration for spindle picked cotton. Unlike the laboratory gin, the UGA Microgin provides full drying as well as seed cotton and lint cleaning. The schematic diagram of the UGA Microgin is illustrated in Figure 1.

Six commercial gins in southern Georgia were identified in this study. For the purpose of confidentiality, their names were coded by letters from A to F. The six gins had similar setup with cylinder seed cotton cleaner, dryer, stick machine, cylinder cleaner, extractor feeder, gin stand, and saw type lint cleaner. All six gins used the Samuel Jackson “moisture mirror” (Samuel Jackson, Inc., Lubbock, TX) to monitor the moisture content in cotton and to determine the dryer temperature. However, minor differences in setup existed. For instance, some gins were older than the others; two gins (A and B) were equipment with the Intelligen (Uster Technology, Knoxville, TN); one gin (E) by passed the stick machine; one gin (F) used two lint cleaners instead of one.
The lab gin stand used in this study is a 10 saw lab gin made by Continental (Continental Eagle Corporation, Pratville, AL). It does not have any drying, seed cotton cleaning, and lint cleaning equipment.

Cotton sample collection

Cotton was grown in Colquitt County in Georgia and harvested in October and November, 2009. Five cotton varieties, i.e., DPL 555, DPL 0935, FM 1740, ST 5458, and PHY 370, were selected in this study due to their popularity and wide availability in Georgia. Some varieties were grown in non-irrigated and some were in irrigated land. In order to compare the performance of the three types of gin with the same cotton variety grown in the same field, cotton samples for the Microgin and lab gins stand were collected in the field from the boll buggy as the cotton was unloaded into the module builder. Five 30-lb seed cotton samples of each cotton variety were collected in mesh bags for the Microgin and five 1-lb cotton samples were collected in paper bags for lab gin use. These cotton samples in mesh bags and paper bags were put under the shelter immediately after the collection and were stored for about two months before they were ginned at the UGA Microgin facility. The modules stayed in the field mostly just for a few days before they were sent to one of six commercial gins for ginning. The number of cotton varieties ginned at each of the six commercial gins were not uniform due to logistic challenges. As shown in Table 1, commercial gin C ginned all five cotton varieties grown in irrigated land, while other gins ginned 2 or 4 varieties grown in either dry land or irrigated land.

Cotton conditioning and ginning procedures

Cotton samples ginned by the Microgin and the laboratory gin stand were processed using a set standard operating procedure consisting of conditioning, weighing, ginning, and fiber sample collection. No conditioning procedure was performed in the six commercial gins, in which cotton moisture was monitored by moisture sensors and was controlled by dryers during the ginning process. Turnout at the commercial gins was obtained where available. Since commercial gins ran in a continuous mode, it was challenging to completely stop the commercial gin after one module was ginned, clean the gin, and measure the net lint weight. With our effort, seven varieties in two commercial gins (C and A-only for irrigated cotton) did this for us. Therefore, the turnout rates of these 7 varieties were accurate. For the other two commercial gins, the lint weight was estimated by the bale weight and seed weight, which was not as accurate as in the former case. In the other 6 cases, no turnout rate was recorded. Therefore, there were only 11 turnout rates provided by four commercial gins (A, C, E, and F), to which the turnout of the Microgin and the lab gin stand could be compared. HVI fiber quality data of each bale coming out of the module in the six commercial gins were presented in a standard USDA Classing Office report.
Fiber quality was evaluated by HVI (Uster Technologies, Knoxville, TN) at the USDA Cotton Classing Office in Macon, GA. Nine fiber quality parameters were selected for the purpose of comparison: staple length, uniformity, micronaire, strength, leaf grade, HVI trash, Rd, +b, and color grade.

Statistical analysis

The one-way analysis of variance (ANOVA) was conducted to test equal means across three types of gins in nine quality parameters. Tukey's LSD (least significant difference) was chosen to determine the significant difference among treatments in ANOVA. ANOVA tests were evaluated at a significance level of 0.05. Standard error was used to depict the measurement variation. The SAS statistical software (SAS Institute, Cary, NC) was used for statistical test and data analysis. Since only one module of each variety was used for turnout rate calculation in the six commercial gins, the variation of turnout rates was not presented in the commercial gins.

Results and Discussion

Gin turnout rates

Figure 2 compares the lint yields (gin turnout) of three types of gins. Standard error was not shown in commercial gin data due to only one turnout rate was calculated from one module. From this figure, it is crystal clear that the turnout rates from the laboratory gin are consistently higher than those from Microgin and four commercial gins in all ten cases. The minimum difference between the lab gin stand and the Microgin is 1.5% and the maximum difference between these two gins is 4%. The differences between the lab gin stand and commercial gins range from 1% to 3.7% in ten cases.

Lint yields of cotton ginned from Microgin and commercial gins were comparable in the majority of ten comparisons. The differences between these two types of gins range from 0.1% to 1.9%, which are much smaller than those between the lab gin stand and the commercial gins. A comparison between the Microgin and commercial gin revealed that three commercial gins (A, C, E) had consistently higher or equivalent lint yields than the Microgin across all varieties, while the commercial gin F had lower lint yields than Microgin in the two varieties it ginned.

This result is in agreement with previous studies which reported that lab gins usually have 4-5% higher lint yield than commercial gins (Calhoun et al., 1996), due to the cleaning in the commercial gins. The UGA Microgin has similar machinery layout as most commercial gins, therefore, its turnout rates were comparable to those of commercial gins. However, difference exists between the Microgin and commercial gins and among commercial gins. The UGA Microgin has two saw type lint cleaners, while commercial gins A, C, and E had only one lint cleaner, which contributed to their general higher lint yield than that of Microgin. Instead, commercial gin F had two lint cleaners and usually lint cleaners from commercial gins are more aggressive than those from Microgin, which explains why commercial gin F had a lower lint yield than Microgin. Given the same ginning condition, lint yields should reflect the genetic nature of different cotton varieties. In general, all three types of gin showed similar relative difference among different varieties of cotton. However, the Microgin and the lab gin stand showed almost the exact same pattern across all 10 cotton sources. Commercial gins did not reflect the same relative difference among cotton varieties as the lab gin stand, partly due to the large variation within and between different commercial gins. Another reason that caused this discrepancy is perhaps because the method to calculate turnout rate in some commercial gins were inaccurate.

Tables 2 and 3 show the fiber quality data obtained from three types of gin for dry land cotton and irrigated cotton, respectively. As shown in Tables 2 and 3, the HVI trash measurement of lint ginned by the Microgin and commercial gins did not show significant difference in 16 out of 17 comparison cases when dry land and irrigated cotton were considered together. The HVI trash of lint ginned by the lab gin stand is significantly higher (dirtier) than either Microgin or commercial gins in all 17 cases. Although measured by classers, leaf grade reflects the same trend as measured by the instrument: in none of these 17 cases, leaf grade from the lab gin agreed with either Microgin or commercial gins. The lab gin stand consistently had 2-4 grades lower (dirtier) in leaf grade than either the Microgin or commercial gins. In contrast, Microgin agreed with commercial gins in leaf grade in 11 out of 17 cases. Among those 6 cases that they did not agree, lint ginned by the Microgin was usually one grade higher (cleaner) than that ginned by commercial gins.

These results confirmed that seed and lint cleaning have significant impact on the trash content and leaf grade in the final lint. As reported previously, HVI trash decreased from about 6 to 4.9, 4.3, and 3.9 when one, two and three stages of lint cleaning were used, respectively (Anthony, 1990; Anthony, 1994). The cleaning machines removed significant amount of trash out of lint, which resulted in much cleaner lint. HVI trash measurement from the Microgin and commercial gins were almost identical and they were significantly lower than that from the lab gin stand. It proved that the seed cotton cleaner and lint cleaner in the Microgin achieved a similar effect as those in commercial gins, although the minor difference between these two types of gin suggest that the Microgin tended to provide cleaner lint than commercial gins. This discrepancy is largely because the Microgin had two saw type lint cleaners while most commercial gins (4 of 5) selected in this study had only one lint cleaner.

In Tables 2 and 3, among 17 cotton sources grown in both non-irrigated and irrigated land, the reflectance of cotton lint ginned at UGA Microgin and commercial gins did not show significant difference in 12 cases, in which lint ginned by these two types of gin showed significantly higher reflectance than that from the lab gin stand. In all 17 comparisons, lint ginned at the lab gin stand showed significantly lower reflectance than that ginned at commercial gins. In those 5 cases in which the Microgin and commercial gins did not agree (A1, F1, A2, C3, and C5), it was observed that the lint reflectance of the Microgin were always higher than that of commercial gins.
Although Rd is an indicator of lint reflectance which is determined by cotton genetic nature, trash content did affect HVI measurement of the Rd. As reported by Thomasson (1990), trash particles on the surface of lint have a negative effect on Rd measurement, i.e., two lint samples with identical color may have different Rd values due to different trash content on the their surface. Cotton lint ginned by the lab gin stand has more trash content and therefore it appears to be darker than that ginned by Microgin and commercial gins. Cotton lint ginned by the Microgin and commercial gins were cleaned

by seed cotton cleaner and lint cleaner, therefore, their reflectance seem to be comparable. Lint from the Microgin showed higher reflectance in five comparisons and it might suggest that the Microgin with 2 lint cleaners tend to have cleaner and brighter lint than the commercial gins that had single lint cleaners.

In both dry land and irrigated cotton samples, yellowness of lint ginned by the UGA Microgin was not significantly different from that ginned by commercial gins in 12 out of 17 comparisons. In contrast, the lab gin stand and commercial gins only agreed in 3 cases. Fiber yellowness from the Microgin and the commercial gins was significantly higher than that from the lab gin stand. Yellowness measured by HVI could also be affected by trash content in lint.

Considering dry land and irrigated cotton samples together, color grade of lint ginned by Microgin did not show significant difference from that ginned by commercial gins in 9 out of 17 comparison cases. Color grade from lint ginned by the lab gin stand (51 or 41) is significantly lower than that ginned by both commercial gins and the Microgin (41 or 31) in all 17 cases. This result is in accordance with the aforementioned differences in brightness and yellowness.

When comparing all samples, the staple length of lint ginned by the Microgin was not significantly different from that of the commercial gins in 14 of 17 cases, while the staple length of lint ginned by the lab gin stand was significantly higher than that of commercial gins in 11 cases. There are four cases in which all three types of gin showed no significant difference in staple length. As shown in Tables 2 and 3, the Microgin and commercial gins did not show significant difference in uniformity of lint in 14 cases; while in contrast, the lab gin stand only agreed with commercial gins in uniformity in 3 cases. For the rest of 14 cases, lint ginned by the lab gin stand has shown significantly higher uniformity than that ginned by commercial gins. The mean values of uniformity showed that lint ginned by the lab gin stand always had highest uniformity, while lint ginned by commercial gins had lowest uniformity in most cases.

The length and uniformity data agree with each other very well and they reflected the same fact that the ginning method has a significant impact on fiber length and uniformity. As reported by Anthony (1990), HVI length could be reduced about 0.05 cm (0.02 in) when lint cleaners were added to the gin equipment sequence. Microgin and commercial gins tend to have shorter fiber with lower uniformity than the lab gin stand because the seed cotton cleaner and lint cleaner tend to break more fiber and more fiber fractions in the final lint result in a shorter staple length and lower uniformity. The lab gin stand does not have any cleaning machineries that may damage the fiber in addition to the ginning itself and therefore longer staple and shorter uniformity was observed in samples ginned at lab gin stand. It seems that the Microgin, although in a much smaller scale, has the similar effect in creating fiber fraction as in most commercial gins. However, minor differences between the Microgin and commercial gins were also observed. The mean values of the fiber length and uniformity of lint ginned by the Microgin appeared to be slightly higher than those by commercial gins. This suggests that the commercial gins tend to be more aggressive than Microgin.

Another possible reason is that the commercial gins used higher heat to heat for drying purposes during the ginning process, which results in a dryer cotton that is more prone to damage and fraction.

Micronaire

As shown in Tables 2 and 3, micronaire of lint ginned by all three types of gin did not show any significant difference among each other in majority of cases (10/17). In the remaining 7 cases, micronaire of lint ginned by the commercial gins is higher than that ginned by the Microgin and lab gin stand in 4 cases, and in the other 3 cases, it is either at the same level as in the lab gin stand or the Microgin. Given the large variation in cotton samples, this may indicate that the micronaire difference among three types of gin is just caused by random variation. The results clearly supported the previous studies that micronaire should not be affected by ginning methods. Micronaire is only dependent on fiber variety, maturity, and growing conditions.

Strength

A similar pattern is observed in strength comparison. There are 11 cases in which all three types of gins did not show significant differences in strength, which suggests that fiber strength is not a quality property that can be easily affected by ginning methods. However, minor difference was observed between gins. The Microgin and commercial gins had the same strength statistically in 15 cases, while the lab gin stand agreed with commercial gins in 13 cases. A closer look at the mean values of strength data revealed that the Microgin and commercial gins had slightly lower strength values than lab gin stand in majority of these cases.

These data showed that strength is not affected significantly by ginning methods in general. However, a minor difference did show that the strength estimated by the Microgin was slightly closer to that obtained from commercial gins than that from the lab gin due to the similarity of ginning equipment set up between these two types of gin. Previous literature reported that strength of lint ginned by commercial gins tend to be smaller than that of lab gin stand due to the heat added to cotton samples in commercial gins and dryer lint tends to be more brittle in strength tests. This pattern was observed in the data collected from this study.

Summary

A comparison of success rates between the lab gin stand and Microgin in predicting fiber quality of lint ginned by commercial gins were depicted in Figure 3. It is striking that the lab gin had zero success rate in estimating the performance of commercial gins in color grade and leaf grade. In contrast, the Microgin successfully predicted the color grade and leaf grade of lint ginned by commercial gins in 53% and 65% of times, respectively.

The Microgin and lab gin stand did an equally good job in estimating commercial gins in micronaire with a success rate of 65%. For strength comparison, although both the Microgin and lab gin stand did good job in predicting the performance of commercial gins, the Microgin showed a slightly higher success rate with 88% versus 77%. Given the large intra-sample variation in cotton samples, these data indicate that micronaire and strength are less likely to be affected by ginning methods.

Staple length and uniformity are two indices to describe the fiber length and its distribution. UGA Microgin had 77% and 82% success rates in estimating commercial gin performance for staple and uniformity, respectively; the lab gin stand only achieved 35% and 18% success rates in these two measures. These data confirmed that ginning methods have a significant impact on fiber length and uniformity. The UGA Microgin did a far superior job to the lab gin stand in estimating the fiber length and uniformity from commercial gins. The fiber length and uniformity obtained from the lab gin stand could not be used to estimate these values from commercial gins if an accurate estimation is required.

The data displayed in this study confirm that the UGA Microgin performs better than the lab gin stand in estimating lint yield and fiber quality obtained from commercial gins and is a valuable tool for cotton research.

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References

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

Anthony, W. S. 1994. The effect of gin machinery on measurement of high volume instrument color and trash of cotton. *Trans. ASAE* 37(2): 373-380.

Anthony, W. S. 2002. Influence of cotton varieties and gin machinery on trash particles. *Trans. ASAE* 18(2): 183-195.

Anthony, W. S. and W. D. Mayfield. 1994. *Cotton Ginners Handbook*. USDA Agricultural Handbook 503. 348 pp.

Boykin, J., D. Whitelock, M. Buser, C. Armijo, G. Holt, T. Valco, D. Findley, E. Barnes and M. Watson. 2008. Comparison of Five Small-Scale Laboratory Gins to Seven Commercial Gins Sampled Across the Cotton Belt. *National Cotton Council Beltwide Cotton Conference.* , Nashville, Tennessee.

Boykin, J. C. 2008. Small sample techniques to evaluate cotton variety trials. *Journal of Cotton Science* 12(1): 16-32.

Brown, S. M., S. Jones and S. Ragan. 2004. Large block variety trials at southwest Georgia research and education center. In "Cotton Research-Extension Report 2004". ed. P. H. Jost, P. M. Roberts and R. C. Kemerait. The University of Georgia College of Agricultural & Environmental Sciences Cooperative Extension Service.

Calhoun, D. S., T. P. Wallace, W. S. Anthony and M. E. Barfield. 1996. Comparison of lint fraction and fiber quality data from hand- vs. machine-harvested samples in cotton yield trials. *Proceedings of the 1996 Beltwide Cotton Conference*, Nashville, TN.

Li, C., A. Knowlton and S. Brown. 2009. A Comparison Study of UGA Micro Gin, Commercial Gin, and Table Top Gin. *Proceedings of the 2009 Beltwide Cotton Conferences*, Memphis, TN.

Thomasson, J. A. (1990). Effects of nonlint material on HVI color measurements, ASAE paper No. 90-1031. St. Joseph, Mich.: ASAE.

USDA AMS. 2001. *The classification of cotton*. USDA, Washington, D.C.

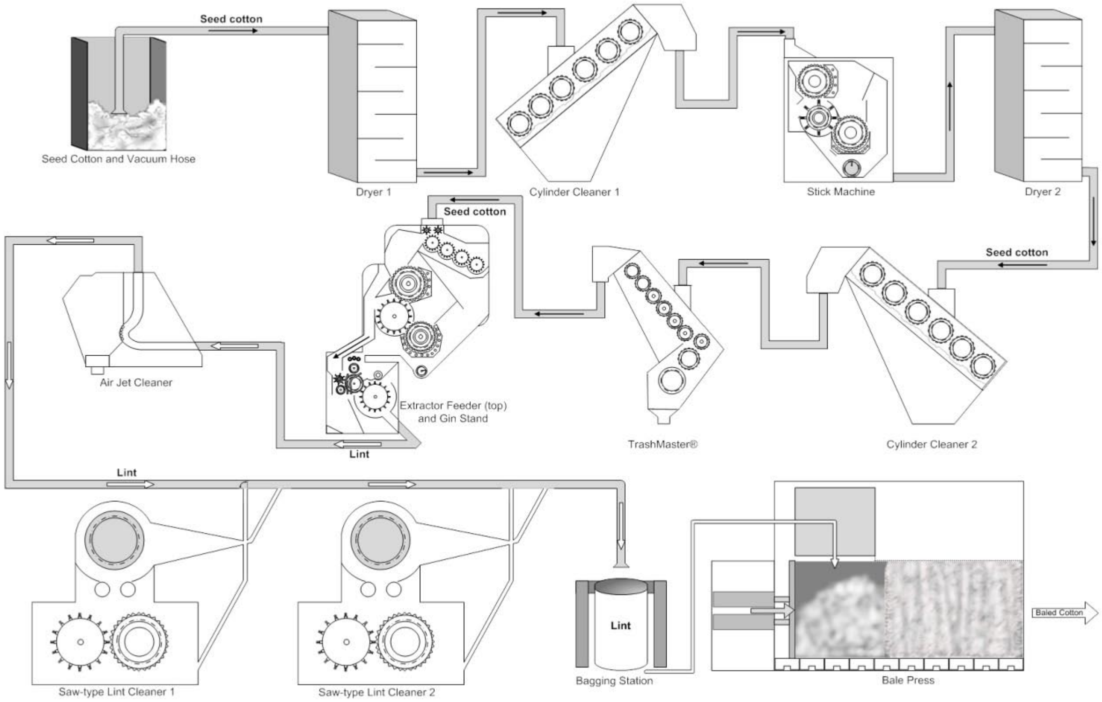

Figure 1. The schematic diagram of the UGA Microgin.

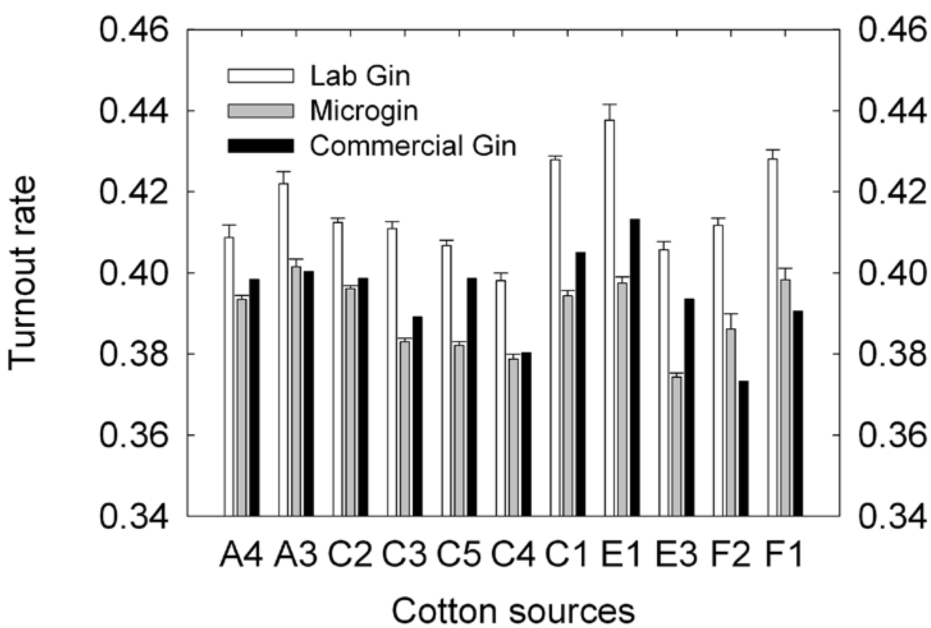

Figure 2. Gin turnout rate comparison among lab gin, UGA Microgin, and commercial gins.

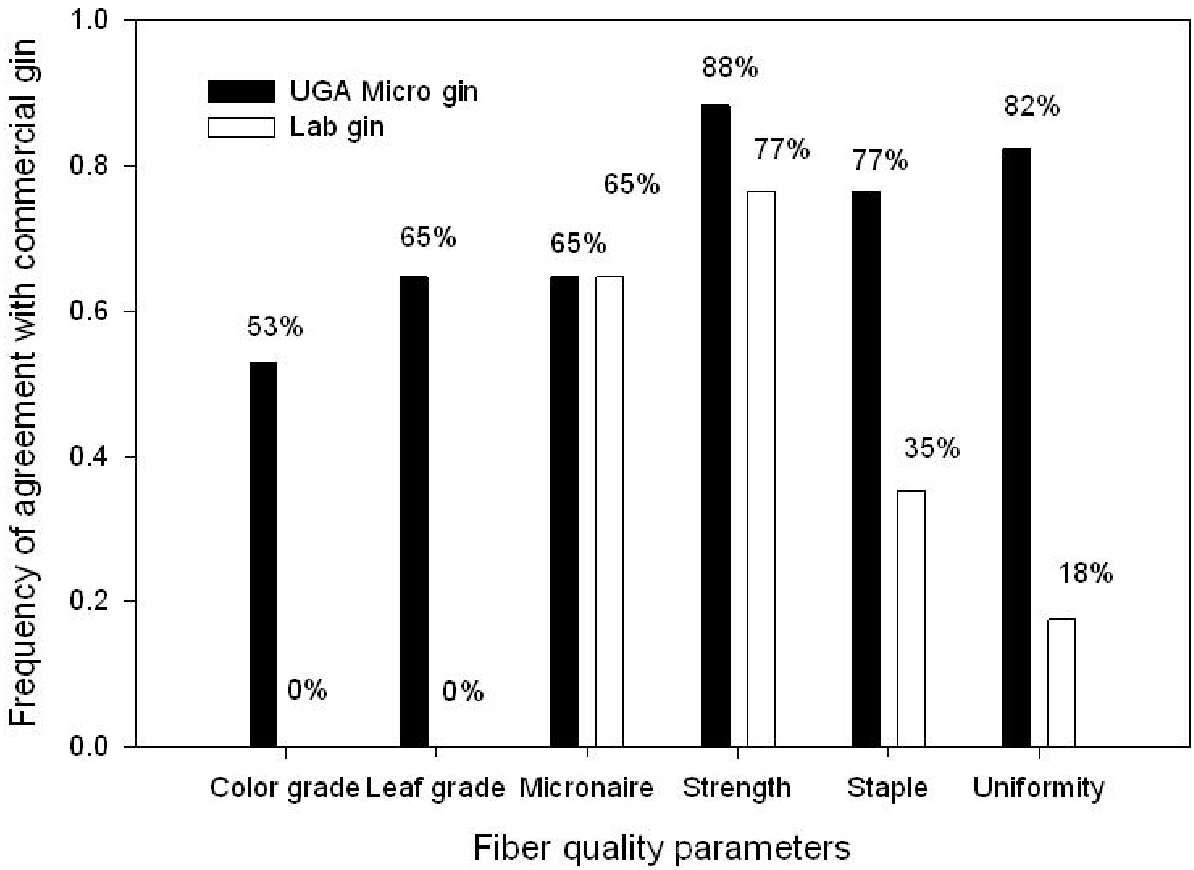

Figure 3. Comparison between the UGA Microgin and the lab gin in estimating commercial gins for six fiber quality parameters

Table 1. Dryland and irrigated cotton varieties ginned at six commercial gins.

Commercial gins	Cotton varieties	Dry land	Irrigated
A	1- DP555	1,5	2,4
B	2- FM1740	1,3	
C	3- PHY370		1,2,3,4,5
D	4- ST5458		3,5
E	5- DP0935		1,2
F		1,5	

Table 2. Fiber quality comparison among three types of gins for dry land cotton.

	Color grade	Rd	+b	Staple	Uniformity	Leaf grade	HVI trash	Micro	Strength
LG*	51	67.2 c	6.9 b	35 a	81.1 a	6	1.7 a	4.5 b	29.2 a
UM	41	76.4 a	7.7 a	35 a	80.4 ab	3	0.2 b	4.4 b	30.4 a
CM-A1	41	74.2 b	7.7 a	35 a	79.6 b	4	0.5 b	4.7 a	29.4 a
LG	51	72.5 c	6.3 b	36 a	81.7 a	5	1.5 a	4.6 a	29.8 a
UM	31	80.8 a	7.0 a	36 ab	81.2 ab	3	0.2 b	4.5 a	28.2 b
CM-F1	41	78.9 b	7.0 a	35 b	80.5 b	3	0.4 b	4.6 a	29.3 a
LG	51	69.7 b	6.9 b	36 a	82.2 a	6	1.2 a	4.3 b	29.6 a
UM	31	76.8 a	7.9 a	35 a	80.8 ab	3	0.3 b	4.4 b	29.2 a
CM-B1	31	76.6 a	7.7 a	34 b	80.0 b	3	0.4 b	4.6 a	28.9 a
LG	51	68.7 b	7.9 c	36 a	83.1 a	6	1.2 a	4.5 b	30.3 a
UM	31	74.4 a	8.5 a	35 b	82.5 ab	3	0.2 b	4.6 b	29.7 ab
CM-B5	41	75.2 a	8.3 ac	34 b	81.6 b	3	0.3 b	4.9 a	28.8 b
LG	51	68.0 c	7.7 b	35 a	81.3 a	6	1.4 a	4.8 a	28.8 a
UM	31	75.3 a	8.3 a	35 a	81.2 a	3	0.2 c	4.7 a	29.0 a
CM-A2	41	71.9 b	8.4 a	35 a	80.3 a	4	0.5 b	4.9 a	28.7 a
LG	41	72.9 b	7.1 b	37 a	82.6 a	6	1.4 a	4.3 a	29.3 a
UM	31	77.4 a	8.1 a	36 ab	81.9 a	3	0.3 b	4.5 a	29.5 a
CM-F2	31	78.2 a	7.8 a	36 b	80.3 b	3	0.4 b	4.4 a	28.1 a

*LG=lab gin; UM=UGA Microgin; CM=commercial gin. Letters A, B, F represent commercial gins; numbers 1, 2, 5 represent cotton varieties DP 555, FM1740, and DP0935, respectively.

Table 3. Cotton fiber quality comparison among three types of gins for irrigated cotton

	Color grade	Rd	+b	Staple	Uniformity	Leaf grade	HVI trash	Micro	Strength
LG*	51	69.1 b	6.8 c	37 a	82.8 a	6	1.7 a	4.5 b	30.1 a
UM	41	76.2 a	7.8 a	35 b	80.8 b	3	0.2 b	4.7 a	29.0 a
CM-C1	41	76.9 a	7.3 b	35 b	79.7 b	3	0.4 b	4.7 a	29.2 a
LG	41	75.6 b	6.9 c	37 a	82.9 a	6	1.1 a	3.9 a	30.9 a
UM	21	81.1 a	7.6 a	36 a	81.7 b	2	0.4 b	3.8 a	29.0 b
CM-E1	31	80.0 a	7.3 b	35 b	80.6 c	3	0.4 b	3.8 a	28.8 b
LG	51	70.1 c	7.1 b	37 a	83.5 a	6	1.6 a	4.6 a	30.9 a
UM	31	77.4 a	7.9 a	36 b	82.1 b	3	0.2 b	4.7 a	29.9 a
CM-C3	41	75.6 b	7.8 a	36 b	81.8 b	3	0.4 b	4.7 a	30.1 a
LG	51	73.7 b	6.4 c	37 a	83.7 a	6	1.4 a	4.1 a	31.4 a
UM	31	79.2 a	7.8 a	36 a	82.3 a	3	0.2 b	4.18 a	30.4 a
CM-E3	31	79.3 a	7.0 b	37 a	82.4 a	3	0.5 b	4.26 a	30.5 a
LG	51	69.8 b	8.2 a	36 a	83.4 a	6	1.3 a	4.8 a	30.9 a
UM	31	78.3 a	8.1 ab	36 a	82.4 ab	2	0.3 b	4.5 b	30.7 ab
CM-A3	31	77.8 a	7.7 b	35 a	82.2 b	4	0.4 b	4.7 a	29.9 b
LG	51	68.9 c	7.6 b	36 a	83.5 a	6	1.2 a	4.7 c	30.2 a
UM	31	76.3 a	8.5 a	35 b	82.1 b	3	0.2 b	4.9 a	28.1 b
CM-C5	41	74.5 b	8.3 a	35 ba	82.3 b	4	0.3 b	4.8 b	29.4 a
LG	51	68.4 b	7.2 c	36 a	83.3 a	7	1.4 a	4.8 a	31.0 a
UM	31	77.6 a	8.3 a	35 ba	81.8 b	3	0.2 b	4.8 a	28.4 b
CM-D5	31	76.9 a	8.1 b	35 b	81.5 b	3	0.3 b	4.8 a	28.3 b
LG	51	70.6 b	7.1 c	37 a	83.2 a	6	1.4 a	4.6 b	30.2 a
UM	32	74.2 a	9.0 a	35 b	81.4 b	3	0.2 b	4.6 b	30.1 a
CM-A4	41	75.0 a	8.4 b	35 b	81.6 b	3	0.4 b	5.0 a	30.9 a
LG	51	68.8 b	7.8 b	37 a	82.6 a	7	1.5 a	4.9 a	30.5 a
UM	31	75.3 a	8.7 a	36 ba	81.1 ba	3	0.2 b	4.9 a	29.8 a
CM-C4	41	73.8 a	8.5 a	35 b	80.1 b	3	0.5 b	5.0 a	28.7 a
LG	41	70.4 b	7.9 b	36 a	81.5 a	7	1.3 a	4.4 a	28.4 a
UM	31	74.9 a	9.0 a	35 b	81.1 a	3	0.2 b	4.4 a	29.0 a
CM-C2	31	75.5 a	8.4 ba	36 ba	81.8 a	3	0.4 b	4.6 a	28.1 a
LG	41	72.2 b	7.6 a	36 a	82.7 a	5	1.1 a	4.6 a	29.6 a
UM	31	77.2 a	8.1 a	35 a	81.2 b	2	0.3 b	4.6 a	29.1 a
CM-D2	31	77.0 a	8.1 a	34 b	79.8 c	3	0.3 b	4.7 a	27.6 a

*LG=lab gin; UM=UGA Microgin; CM=commercial gin. Letters A to F represent six commercial gins; numbers 1 to 5 represent cotton varieties DP 555, FM1740, PHY370, ST5458, and DP0935, respectively.