THE IMPACT OF VARIETY AND LOCATION ON THE QUALITY OF GEORGIA COTTON

Devron P. Thibodeaux
USDA-ARS-CQRS
Clemson, SC
Jared R. Whitaker
University of Georgia
Statesboro, GA
Andy Knowlton
Phillip M. Roberts
Glen Ritchie
Guy Collins
University of Georgia
Tifton, GA
Richey Seaton
Georgia Cotton Commission
Perry, GA

Abstract

The purpose of this study was to cooperate with Georgia cotton producers to find a variety to replace DP555 having equal or better yield with outstanding fiber, and spinning performance. Based on previous field trials, six promising varieties of cotton were planted in six counties in Georgia. After harvesting, all seed cottons were delivered to the UGA Tifton MicroGin for processing under identical conditions. The ginned lint was then baled and sent to the USDA Cotton Quality Research Station, Clemson for pertinent fiber tests and both ring and rotor spinning trials. Results of the tests were quite satisfactory especially in light of the significant rainfall prior to harvest. Overall yield was good with no significant differences between the varieties averaged over the six counties. In general, fiber quality was good to excellent with a large number of instances of premiums and only very few discounts. Yarn quality was quite good, especially in the case of the carded ring yarns. Four of the six cottons performed well in both ring and rotor, it being noteworthy that these had the lower short fiber content.

Introduction

The purpose of this study was to cooperate with Georgia cotton producers to find a variety to replace DP555 having equal or better yield with outstanding fiber, and spinning performance. Based on variety trials, six promising varieties were planted in six counties in Georgia. After harvest, all seed cottons were brought to the Tifton MicroGin where they were ginned under identical conditions. Thirty-four of the thirty-six lots were successfully produced and sent to CQRS for pertinent fiber tests and spinning trials. Our understanding is that there was considerable rain on all the entries after defoliation. The protocol used at the Cotton Quality Research Station (CQRS) was similar to those used to evaluate the impact of variety (Foulk, et al., 2009), cultural practice (McAlister, et al., 2005), breeding (Bauer, et al., 2006), and short fiber content (Thibodeaux, et al., 2008) on fiber and yarn quality. This approach consisted of in depth testing of relatively large lots (at least 100 pounds) of the cotton being studied to extensive fiber testing and spinning trials of in some cases both ring and rotor yarns accompanied by thorough statistical analysis.

Materials and Methods

The candidate varieties that were chosen included: DP0935, D9555, DP0949, FM1740, ST5458, and PHY375. The counties chosen included: Burke, Candler, Coffee, Colquitt, Early, and Worth. Candler, Coffee, and Colquitt counties were dry land and Burke, Early, and Worth counties were irrigated. The cotton for each lot was processed through the opening and cleaning line at the Cotton Quality Research Station (CQRS), USDA-ARS, Clemson, SC at a throughput rate of 100 lbs/hr. The processing equipment consisted of three tandem opening hoppers, an Axi-Flo opener/cleaner, a GBRA hopper, an RN coarse cleaner, a RST multi-roll cleaner, a DX de-duster, and a DK-803 card (all from Truetzschler; Monchengladbach, Germany). In the case of ring spinning, after carding, six cans of 70 grain sliver were processed through a Rieter RSB 951 breaker drawing frame (Rieter; Winterthur, Switzerland) to form 60 grain sliver. This was then taken to a Rieter RSB 51 frame with leveled finisher drawing that produced 55 grain sliver. This was then creeled to a Zinser 660 Roving frame producing 1.0 hank roving. The roving bobbins

were creeled onto a Zinser 321 ring spinning set to produce 30/1 Ne yarn with 4.1 TM. . In the case of rotor spinning, after carding, six cans of 70 grain sliver were processed through a Rieter RSB 51 frame with leveled finisher drawing that produced 55 grain sliver. This was then creeled to a Schlafhorst SE-11 (Schlafhorst; Monchengladbach, Germany) rotor spinning frame to spin a 20/1 Ne yarn. Raw cotton was characterized on the Uster 900 HVI and AFIS Pro. Processed fiber, sliver, and roving studied on the AFIS Pro. Ring and rotor yarns were sampled and studied with the Uster UT-5 and Statimat M.

Results and Discussion

Results for lint yield were available from 33 of the 34 lots and are shown in Table 1. Yield values ranged from a low of 832 lbs/ac (PHY375, Coffee county) to a high of an impressive 1727 lbs/ac (FM1740, Worth County). Considering an average of the yields for each of the counties over each of the varieties, the highest yielding was Colquitt (1400 lbs/ac) and the lowest was Coffee (890 lbs/ac). Considering an average of the yields for each of the varieties over each of the counties, the highest yielding variety was FM1740 (1419 lbs/ac) and the lowest was DP0949 (1114 lbs/ac). DP555 which was included as a reference was only available from four of the counties exhibited a range of yields from 1384 lbs/ac down to 858 lbs/ac.

Table 1. Yield (lbs./acre) for each variety grown in each county.

COUNTY	DP0935	DP555	DP0949	FM1740	ST5458	PHY375	MEAN
Colquitt	1434	1273	1430	1418	1491	1354	1400
Candler	1369	1384	1118	1444	1269	1172	1293
Coffee	932	858	874	974	867	832	890
Early	898		950		894	989	933
Worth	1130		1169	1727	1363	1299	1338
Burke	1305	1357	1145	1535	1293	1197	1305
MEAN	1178	1218	1114	1419	1196	1140	

Results from the Macon Classing Office for HVI values are summarized on Table 2. The properties are shown here for each of the cottons averaged over the six counties. The average values for Micronaire, strength, Rd, +b, and trash are all within normal, acceptable levels. The values of length range between 1.10 and 1.15 inches. Length uniformity values are all quite acceptable ranging between 81.56% and 82.88%. More specifically, considering the most recent listings of premiums and discounts, of the 34 total lots harvested:

- 15 lots received premiums for strength.
- 18 lots received premiums for micronaire.
- 5 lots were premium for high uniformity.
- only 3 lots received discounts for low micronaire.
- All varieties averaged over 2 bales/acre.

Table 2. HVI Properties of the Six Cottons Averaged over Counties

Cotton	Micronaire	Strength	Rd	+b	Trash	Length	Uniformity
DP0935	3.88	28.62	77.52	7.14	0.34	1.10	81.56
DP555	4.00	29.03	76.55	7.90	0.53	1.15	82.52
DP0949	3.95	29.78	77.42	7.18	0.40	1.15	82.88
FM1740	4.16	30.32	74.57	8.05	0.52	1.14	81.48
ST5458	4.17	28.75	75.72	7.67	0.42	1.13	81.90
PHY375	3.88	28.62	77.52	7.14	0.34	1.10	81.56

Results of testing fiber samples on the AFISPro at CQRS are summarized in Table 3. Again, the properties are shown here for each of the cottons averaged over the six counties. Nep counts per gram range from 292 for FM1740 to 387 for DP0935. Ideally one would like these values for raw stock to be closer to 200, but they are not totally unreasonable. The upper quartile length by weight (UQL(w)) ranges from 1.16 in to 1.20 in. These lengths are quite acceptable and should yield satisfactory spinning results. The short fiber content by weight (SFC(w)) ranges from a low of 8.5% (DP0949) to a high of 11.2% (DP0939). Four of the varieties had average short fiber values below 10%. Total trash particles ranged between 400 and 600 counts per gram; while the visual foreign matter (VFM (%)) was between 1.89% and 2.59%; and seed coat neps (SCN) ranged between about 20 and 30 counts per gram. It may not be a coincidence that the two varieties with the smallest levels of short fiber (DP0949 and PHY375 have the largest levels of VFM which could go with reduced cleaning intensity. Finally, the cottons have moderate levels of fineness and good maturity.

Table 3. AFIS Properties of the Six Cottons Averaged over Counties

Cotton	Neps/ gm	UQL (w) [in]	SFC (w) [%]	Trash [cnt/g]	VFM [%]	SCN [cnt/g]	Fine [mTex]	Mat Ratio
DP0935	387	1.16	11.2	464	1.88	28	158.8	0.86
DP555	319	1.17	9.3	410	1.88	19	157.4	0.88
DP0949	338	1.20	8.5	608	2.55	25	158.8	0.88
FM1740	292	1.20	9.3	419	1.87	32	165.0	0.88
ST5458	305	1.20	10.3	480	1.96	26	170.7	0.90
PHY375	332	1.17	8.9	558	2.59	25	157.7	0.87

One of the chief tools for judging yarn quality is the Uster UT-5 Evenness Tester. The UT-5 employs dielectric and optical sensors to totally characterize the mass and shape uniformity of the yarn. Some of the factors measured include: a) the coefficient of variation of the yarn's mass per length (*CVm*); b) the number of thin places (*Thins*) per thousand yards; the number of thick places (*Thicks*) per thousand yards; the number of neps (*neps*) per thousand yards; and an index representing the relative degree of hairiness (*H*) of the yarn. Over the last several decades Zellweger Uster Technologies (now Uster Technologies) has collected fiber and yarn quality data from the world-wide textile industry. This data base now constitutes a benchmark to allow rating of textile products being produced by the industry. The UT-5 is programmed such that the parameters it measures (as seen above) are presented along with their Uster statistic. The statistics are presented as percentages relative to historical production data. In this system any grade between 25% and 50% is considered good and any grade less than 25 is premium. For the purposes of obtaining relative rankings of the candidate entries we developed a composite quality index based several of the UT-5 indices that we weighted as to perceived importance. The composite index (CI) is calculated from:

$$CI(RING) = 0.4 \times CVm + 0.2 \times Thins + 0.2 \times Thicks + 0.1 \times Neps + 0.1 \times H \quad (1)$$

The *CI(RING)* values for each of the cottons and counties are included in Table 4. Also included are the indices for each county averaged over the varieties as well as the indices for each variety averaged over the each county. The single best performing variety was DP375 which performed in the premium range for four of the six counties and was good (below 50%) in the other two. The overall best yarn came from Burke County at 16% for PH375. The next best performing variety was DP0949 which produced yarns in good range in four of the six counties. The two varieties with the lowest performance were DP0935 and ST5458. DP555 and FM1740 produced yarns ranked at least good in two of the counties. Averaging values for the yarns for each of the counties showed that four of the six counties (Coffee, Early, Worth, and Burke) had average quality indices less than 50%,

Table 4. A compilation of ring yarn evenness quality indices (*CI(RING*)).

COUNTY	DP0935	DP555	DP0949	FM1740	ST5458	PHY375	MEAN
Colquitt	90	62	58	59	95	41	67
Candler	100	89	61	71	96	47	77
Coffee	62	47	29	69	71	24	50
Early	61	58	31		69	24	49
Worth	66		38	30	64	22	44
Burke	59	41	26	28	58	16	38
MEAN	73	59	40	51	75	29	

The Statimat M yarn tensile tester measures the stress/strain characteristics of the yarns being tested. Twenty bobbins of yarn for each spinning lot are selected for testing. Twenty breaks are carried out on each bobbin giving a total of four hundred breaks per lot. The Statimat measures the force to break, the elongation to break as determined as a percentage of the gauge length of the break (24 cm), and the yarn count. From these are calculated the yarn tenacity (g/Tex), elongation to break, and their product the yarn toughness. Yarn toughness is probably the best predictor of the yarn performance especially in weaving. Table 5 is a summary of the ring yarn toughness values for each of the cottons and counties. Also included are the toughness values for each county averaged over the varieties as well as the values for each variety averaged over the each county. The single best performing variety was DP0949 which toughness values greater than 100 g.cm for three of the six with the other three counties exceeding values of 90 g.cm. The yarn toughness for DP0949 was 100 g.cm when averaged over all six counties. The next best performing variety was PHY375 which produced yarns greater than 100 g.cm in two of the six counties with toughness values greater than 90 g.cm in three other counties. The yarn toughness for PHY375 was 96 g.cm when averaged over all six counties. The overall best yarn came from Candler County at 107 g.cm for DP0949. The two varieties with the lowest performance were DP0935 and ST5458. DP555 and FM1740 produced yarns in Burke County that were of the order of 100 g.cm (97 and 101, respectively. Averaging values for the yarns for each of the counties showed that three of the six counties (Coffee, Worth, and Burke) had average quality indices less than 50%,

Table 5. Ring Yarn Toughness (g•cm)

COUNTY	DP0935	DP555	DP0949	FM1740	ST5458	PHY375	MEAN
Colquitt	75	76	91	76	72	94	81
Candler	81	86	107	82	69	96	87
Coffee	90	86	104	88	104	81	92
Early	82	74	97		69	93	83
Worth	81		99	92	72	106	90
Burke	88	97	104	101	85	104	96
MEAN	83	84	100	88	78	96	

The 360 ring spindles were run for two doffs each requiring approximately two hours for a full doff of approximately 0.1 pounds of 30/1 Ne yarn. Data on the number of yarn breaks during the ring spinning thus encompasses in excess of 1400 spindle hours. The number of ends down corrected for one thousand spindle hours is shown in Table 6 for each variety from each county. The maximum number of ends down per thousand spindle hours was 28 for DP0949 from Early County. Nine of the thirty four lots of cotton had zero ends down per thousand spindle hours. The two best performing varieties relative to ends down were PHY375 and FM1740 with 2.5 and 3.0 ends down, respectively. The two poorest performing varieties relative to ends down were DP0949 and ST5458 with 9.8 and 19.0 ends down, respectively. Averaging over the varieties the best performing counties relative to ends down were Candler, Coffee, and Burke.

Table 6. Yarn Ends Down per Thousand spindle Hours

COUNTY	DP0 935	DP555	DP0949	FM1740	ST5458	PHY375	MEAN
Colquitt	19	7	9	6	19	0	10.0
Candler	6	3	0	0	13	3	4.2
Coffee	0	13	13	3	0	0	4.8
Early	6	9	28		25	0	13.6
Worth	0		3	3	38	6	10.0
Burke	0	0	6	3	19	6	5.7
MEAN	5.2	6.4	9.8	3.0	19.0	2.5	

In a similar fashion to the way we treated the ring yarn (Eq. 1) we developed a composite quality index for rotor yarns based on several of the UT-5 indices that we weighted as to perceived importance. The rotor yarn composite index (CI) is calculated from:

$$CI(ROTOR) = 0.4 \times CVm + 0.2 \times Thins + 0.2 \times Thicks + 0.1 \times Neps + 0.1 \times H \qquad (2)$$

The *CI(ROTOR)* values for each of the cottons and counties are included in Table 7. We have also included the indices for each county averaged over the varieties as well as the indices for each variety averaged over the each county. The single best performing variety was PHY375 which performed in the premium range for three of the six

counties and had an average value of 49 for all six counties. The overall best yarn came from Burke County at 16% for PH375. As was the case for ring yarn, the next best performing variety was DP0949 which produced yarns in good range in three of the six counties with an average value of 53 for all six counties. Once again, the two varieties with the lowest performance were DP0935 and ST5458. DP555 produced yarns ranked at least good in four of the counties and FM1740 produced good yarns in Worth and Burke counties. Averaging values for the yarns for each of the counties showed that three of the six counties (Early, Worth, and Burke) had average quality indices less than 50%,

Table 7. Rotor Yarn Quality Indices (based on Uster Statistics)

COUNTY	DP0935	DP555	DP0949	FM1740	ST5458	PHY375	MEAN
Colquitt	92	84	76	91	95	83	87
Candler	83	78	68	76	91	73	78
Coffee	47	35	64	74	67	68	59
Early	80	44	36		55	24	48
Worth	51		39	42	67	22	44
Burke	49	39	36	37	50	16	38
MEAN	67	56	53	64	71	48	

Table 8 is a summary of the yarn toughness values for each of the cottons and counties. Also included are the toughness values for each county averaged over the varieties as well as the values for each variety averaged over the each county. The single best performing variety was PHY375 with a toughness value of 75 g.cm averaged over the six counties. PHY 375 had toughness values greater than 80 g.cm for two of the six with three other counties exceeding values of 70 g.cm. The next best performing variety was FM0949 with a toughness value of 71 g.cm averaged over the six counties. FM0949 produced the single toughest yarn (82 g.cm) in Coffee County. The two varieties with the lowest performance were DP0935 and FM1740. Averaging values for the yarns for each of the counties showed that three of the six counties (Coffee, Worth, and Burke) had average toughness values greater than 70 g,cm.

Table 8. Rotor Yarn Toughness (g•cm)

COUNTY	DP0935	DP555	DP0949	FM1740	ST5458	PHY375	MEAN
Colquitt	60	63	68	62	64	72	65
Candler	62	68	70	55		74	66
Coffee	68	81	82	67	73	81	76
Early	63	64	70		73	78	70
Worth	50	54	77	50	53	62	58
Burke	65	73	60	68	73	82	70
MEAN	61	67	71	61	67	75	

We have now considered all factors of our evaluation including lint yield and both ring and rotor uniformity and strength for all six cotton varieties grown in the six Georgia counties. We will now summarize the findings by ranking the varieties for their overall performance as averaged over the counties. In Table 9 we present the relative rankings of the varieties for all of these factors and then present a single "Overall Ranking" based on averaging the four spinning factors along with relative yield ranking where we have assigned a double weighting factor for yield. The issue is somewhat complicated by the fact that the two highest spinning performers (PHY375 and FM0949) had the lowest composite yields. The highest yielding variety (FM1740) was on average the third highest spinning performer. Applying our weighting calculation the top four are: 1) PHY375; 2) FM1740; and 3) DP0949 and DP555 (tied).

Table 9. Ranking of varieties based on spinning performance and yield

Cotton	Uniformity Ring	Strength Ring	Uniformity Rotor	Strength Rotor	Yield	Overall Ranking*
DP0935	5	4	5	5	4	**4**
DP555	3	5	3	4	2	**3**
DP0949	2	2	2	1	6	**3**
FM1740	4	3	4	3	1	**2**
ST5458	6	6	6	6	3	**5**
PHY375	1	1	1	2	5	**1**

*Ranking based on averaging four spinning factors with yield (with yield ranking giving a double weight).

Summary and Conclusions

- The results of the tests were quite satisfactory especially in light of the rainfall prior to harvest.
- Overall yield was good with no significant differences between the varieties averaged over the six counties.
- In general, fiber quality was good to excellent with a large number of instances of premiums and only very few discounts.
- Overall yarn quality was quite good, especially in the case of the carded ring yarns.
- Four of the six cottons performed well in both ring and rotor, it being noteworthy that these had the lower AFIS SFC(w).
- Considering the fiber properties (both HVI and AFIS) one would not predict the wide disparity in yarn performance. Perhaps the difference lies in differences in length distribution.

References

Bauer, P.J., D.D. McAlister, III, and J. R. Frederick. 2006. A Comparison of Bollgard/Glyphosate Tolerant Cotton Cultivars to Their Conventional Parents for Open End Yarn Processing Performance. J. Cotton Sci. 10:168-174.

Foulk, J., W.Meredith, D. McAlister, III, and D. Luke. 2009. Fiber and Yarn Properties Improve with New Cotton Cultivar. J. Cotton Sci. 13:212–220.

McAlister, III, D.D. and C.D. Rogers. 2005. The Effect of Harvesting Procedures on Fiber and Yarn Quality of Ultra-Narrow-Row Cotton. J. Cotton Sci. 9:15–23.

Thibodeaux, D., H. Senter, J. L. Knowlton, D. McAlister, and X. Cui. 2008. The Impact of Short Fiber Content on the Quality of Cotton Ring Spun Yarn. J. Cot. Sci. 12: 368-377.