# EFFECT OF CLEANING TREATMENT AND COTTON CULTIVAR ON TEXTILE YARN QUALITY

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## Abstract

Textile yarn quality can be affected by ginning processes and cotton cultivars. The overall goals of this study were to utilize a microgin to evaluate the effect of seed cotton cleaner and lint cleaner on yarn quality, and to benchmark FiberMax 1740 and Phyto Gen 370 against Deltapine 555 grown in Georgia. Six cleaning treatments in a microgin were arranged by varying seed cotton cleaners (stick machine, cylinder cleaner, and Trashmaster®) and one saw-type lint cleaner. Ring yarn quality was measured in terms of spinning efficiency, tensile, hairiness, defects, and waste. As for the ring yarn quality, cotton lint with less cleaning processes exhibited lower defects, lower hairiness (irregular CV), but more waste than that with more cleaning processes. Given the waste can be cleaned during the carding process and easily manageable, the less ginning options could be beneficial to spinning process. Among the three cultivars, PHY 370 generated the highest quality yarn suggesting that DP 555 can be replaced by other cultivars with improved yarn quality. This study shed light on cleaning and cotton varietal effect on the spinning performance of the cotton fiber. The information could be useful to improve the profitability of cotton growers, ginners, and spinners alike.

## Introduction

Cotton fiber quality can be affected by a variety of factors, such as cotton cultivar, growing environment, planting practice, harvesting method, and ginning procedures (Brown et al., 2004). Cleaning during the ginning process significantly affects fiber quality properties like fiber length and trash (Boykin et al., 2010; Li et al., 2011). Under-cleaning could lead to excessive trash and potential price penalization to cotton growers, while over-cleaning could lower cotton fiber quality such as creating short fibers (Anthony, 1990). To achieve the maximum profitability, ginners must preserve the quality of cotton fiber while remove as much trash from the lint as possible when they set up their ginning procedures (Mayfield et al., 1994). On the other hand, cotton fiber quality determines yarn quality which is important to textile consumers. Cotton with a higher short fiber content may lead to excessive breakage of yarn, more defects, and less efficient spinning (Thibodeaux et al., 2008), which could result in discounts paying to growers. Therefore, it is important to understand how cleaning during the ginning process affects the fiber quality and yarn quality, a primary concern for ginners and spinners alike.

In this study, a detailed investigation was conducted to evaluate the effect of cleaning treatments via a microgin and cotton cultivar (DP 555, FM 1740, and PHY 370) on yarn quality. The microgin at the University of Georgia (UGA) uses the same equipment used in a typical commercial gin but with flexible arrangement while machine parts are only one-foot wide (Li et al., 2011). By varying seed cotton cleaners and a saw-type lint cleaner, this study provides insight into how individual cleaning process affects the fiber and yarn quality. The information could be used to optimize the ginning setup that minimizes fiber damage and ensures adequate trash removal in the microgin. In 2010, DP 555, the long dominant cotton cultivar in Georgia, was no long available in the market. Therefore, it is important for cotton growers to understand how other alternative cotton cultivars perform compared to DP 555. This study evaluates the cotton varietal effect on fiber and yarn quality by benchmarking DP 555 against other two abundant Georgia cotton cultivars. The overall goal of this study was to utilize the UGA microgin to delineate the effect of seed cotton and lint cleaners on cotton fiber (length and trash) and yarn quality (ends-down, tensile, hairiness, defects, and wastes) using three common cotton cultivars in Georgia.

## Cotton samples

All cotton samples were harvested by a spindle cotton harvester in a commercial farm in Colquitt County, Georgia in October and November in 2009. Three cotton cultivars (Deltapine 555 BG/RR (DP 555), FiberMax 1740 B2F (FM 1740), and Phyto Gen 370 WR (PHY 370)) were grown in one irrigated field with similar growing conditions. Cotton samples were stored in trailers and ginned at the University of Georgia microgin facility.

## UGA microgin and cleaning treatments

The University of Georgia microgin is a smaller scale gin compared to a typical commercial gin, but has the same equipment layout as a typical commercial gin for spindle picked cotton. During the ginning process in the microgin, seed cotton was cleaned using a six cylinder incline cleaner and a stick machine (defined as seed cotton cleaner 1 in this study), followed by an additional six cylinder incline cleaner feeding into a Trashmaster® cleaner (defined as seed cotton cleaner 2). After the seed cotton cleaning process, the cotton entered an extractor feeder and a 24-saw Lummus gin stand in which lint and seeds were separated. Upon exiting the gin stand, the lint was cleaned by one air jet lint cleaner and one saw type lint cleaner(Li et al., 2011). In this study, the air jet cleaner was used in all treatments while the saw type lint cleaner was bypassed or used in different treatments. The saw type lint cleaner was referred to as the lint cleaner throughout this paper. Six cleaning treatments were created by varying the number of seed cotton cleaners and lint cleaner used (Table 1).

**Table 1. Six cleaning treatments used in the microgin**

| | Seed cotton cleaner 1 | Seed cotton cleaner 2 | Saw type lint cleaner |
|---|---|---|---|
| **Treatment 1** | Used | Used | Used |
| **Treatment 2** | Used | Used | Bypassed |
| **Treatment 3** | Used | Bypassed | Used |
| **Treatment 4** | Bypassed | Used | Used |
| **Treatment 5** | Used | Bypassed | Bypassed |
| **Treatment 6** | Bypassed | Used | Bypassed |

During the ginning process, seed cotton samples from the trailer were continuously collected by the vacuum pipe and ginned by the microgin. The sample size was controlled by the ginning time: roughly 13-14 minutes were used to gin cotton samples before the vacuum pipe was shut off, which was equivalent to 36-45 kg (80-100 lbs) of lint for each sample. Samples of the ginned lint were compressed into bales for cotton fiber quality measurement and spinning tests. A total of 54 cotton samples were used (three replicates for each of the three cultivars and six treatments).

## Spinning process

All fiber was processed through the same modern Truetzschler Opening and Cleaning line (American Truetzschler Inc., Charlotte, NC) and card to produce a 70 grain sliver at 45 kg/hour (100 lbs/hour). All fiber was processed through the following sequence: blending hoppers in a Fiber Controls Synchromatic Blending System (M & M Electric Service Inc., Gastonia, NC), Axi-Flo cleaner (American Truetzschler Inc., Charlotte, NC), GBRA blending hopper (American Truetzschler Inc., Charlotte, NC), a RN cleaner (American Truetzschler Inc., Charlotte, NC), RST cleaner (American Truetzschler Inc., Charlotte, NC), DUSTEX fine dust remover (American Truetzschler Inc., Charlotte, NC), and chute fed Truetzschler DK-803 card (American Truetzschler Inc., Charlotte, NC). Ring spinning sliver (70 grain/yard) was processed through two passes of drawing first on a Rieter SB-951 draw frame (Rieter Corp., Spartanburg, SC) followed by a Rieter RSB-51 draw frame with leveler (Rieter Corp., Spartanburg, SC). Finisher drawing sliver was processed into roving on a Zinser 660 roving frame (Saurer Group, Charlotte, NC) producing a 1.00 hank roving at a flyer speed of 850 RPM. Yarn (20/1 Ne) was subsequently spun from the roving on a Zinser 321 ring spinner (Saurer Group, Charlotte, NC) at a spindle speed of 14,000 RPM and with a twist multiple α of 4.1. Complete sets of yarn production, spinning efficiency, and yarn quality measurements were collected in the manufacture of ring 30/1 yarns.

## Yarn quality

Processing efficiency was determined by physically counting and recording the number of ends down for the duration of processing. Ring spinning ends down was recorded and calculated for 1000 spindle hours, respectively. The grading of yarn for appearance was performed according to standard test methods (ASTM, 2004). Tensile properties of produced yarns from spinning were evaluated for single end yarn strength on the Statimat-M (Lawson-Hemphill, Central Falls, RI) using standard test methods (ASTM, 1994). Yarn evenness, regular and irregular occurring yarn faults (thick places, thin places, and neps) were determined using the Uster UT-5 (Uster Technologies, Knoxville, TN) using standard test methods. Classifying and counting faults was determined using a Classimat II (Uster Technologies Inc., Knoxville, TN) using standard test methods (ASTM, 2005).

## Data analysis

The one-way analysis of variance (ANOVA) was conducted to test equal means across six cleaning treatments, among three cotton cultivars, and their interactions in all quality properties. Tukey's LSD (least significant difference) was chosen to determine the significant difference between treatments with a significance level of 0.05. The SAS statistical software (v9.2, SAS Institute, Cary, NC) was used for statistical test and data analysis.

## Results and discussion

Ends-down measures the number of ends down during spinning, which reflects the spinning efficiency. No significant difference was observed among the six cleaning treatments in ends-down (Table 5). Although it is generally believed that higher trash content and higher short fiber content could reduce the ginning efficiency, this effect was not observed in our study. McAlister (2001) found no significant difference in ends-down between the Intelligin and a commercial gin as well.

Good tensile properties are desired for textile applications (McCreight et al., 1997). In this study, no significant difference was observed among the six cleaning treatments in the two tensile properties (elongation and strength). Tensile strength is not only related to cotton lint strength but also related to the short fiber content of the lint. Yarn made from shorter fibers is more likely to have lower tensile values (Perkins and Bargeron, 1982). Although statistically insignificant, the average values of elongation of the yarn from treatments 2, 5, and 6 were slightly higher than those from treatments 1, 3, and 4, which attributes to the higher fiber length in the first group of cleaning treatments (2, 5, and 6) due to less cleaning.

Hairiness and irregular CV measure the appearance of the yarn. Although hairy yarn could provide desirable properties for the final textile product, such as good heat retention, it also has detrimental effect on spinning process due to the contamination by loose lint (Hussein et al., 2009). In this study, although no significant difference was observed in hairiness, treatments 5 and 6 showed significantly lower irregular CV than treatments 1, 3, and 4. It clearly suggests that irregular CV is positively related to the amount of cleaning performed in the microgin: more cleaning leads to higher irregular CV. Treatments 2 and 3 did not show significant difference, suggesting that seed cotton cleaner 2 and lint cleaner might have similar effect in affecting irregular CV.

Three defect properties of the yarn were considered: neps, thicks, and thins. All three defect properties showed significant differences among the six treatments. For neps, a clear trend was observed that treatments 2, 5, and 6 had lower neps than treatments 1, 3, and 4, indicating that more mechanical processes during the cleaning leads to higher neps in yarn, which is consistent with the pattern observed in cotton fiber neps measured by AFIS. A similar pattern was observed in the data from both thins and thicks: less cleaning had lower defects. It can be confirmed by the fact that treatment 5 as the least cleaned treatment consistently exhibited the lowest defect values in all three properties.

Waste in the spinning mill is determined by the trash level in the cotton lint. A clear-cut pattern was observed that the least cleaned treatments (5 and 6) showed significantly higher waste values than treatments with more cleaning operations (treatments 2, 1, 3, and 4). This result clearly indicates that spinning waste is a direct result of the trash level in the cotton fiber: less cleaning leads to higher trash level in lint and more waste in the spinning mill. The result is in consistent with the data from HVI™, AFIS, and Shirley analyzer. Previous studies showed that larger trash particles are easier to manage than smaller trash particles caused by excessive ginning (McAlister, 2001). Therefore, reduced cleaning during the ginning process could be beneficial to the yarn quality.

Other than ends-down, all other yarn properties showed significant differences among the three cultivars. PHY 370 had the best elongation property among the three cultivars, while DP 555 showed the lowest elongation. As for strength, PHY 370 and DP 555 showed significantly higher strength values than FM 1740. Overall, PHY 370 seemed to be the cultivar with the best performance in yarn tensile properties. As for hairiness and irregular CV, DP 555 and FM 1740 showed higher values than PHY 370. If we consider hairiness an unfavorable yarn property, the data suggest that PHY 370 is the best cultivar among the three in hairiness measurement. In all three defect measurements, PHY 370 consistently had significantly less defects than the other two cultivars. DP 555 and FM 1740 were similar in thicks and thins measurement, but FM 1740 showed higher neps than DP 555. In waste, a consistent pattern was observed that PHY 370 showed the lowest waste values than the other two cultivars. In general, the data suggest that PHY 370 seems to be the best cultivar among the three in most yarn quality properties. DP 555 was once the dominant cotton cultivar in Georgia in the past decade due to its high yield. However, as this study demonstrates that DP 555 has less desirable quality properties compared to the other two cotton cultivars. Therefore, replacing DP 555 with other cotton cultivars such as PHY 370 would lead to beneficial effect in yarn quality.

The F-values indicate that although cleaning treatments had significant impact on some of the yarn quality properties such as defects and waste, the dominant effect in determining the most yarn quality properties is from the cotton cultivar. No significant interaction between the ginning treatment and cotton cultivar was found across the yarn quality properties.

**Table 5. ANOVA test of ring yarn quality in comparison of six cleaning treatments, three cotton cultivars, and their interactions.**

| Yarn quality | Ends-down | Elongation | Strengths | Hairiness | Irregular CV | Neps | Thicks | Thins | Waste |
|---|---|---|---|---|---|---|---|---|---|
| **Cleaning Treatment** | | | | | | | | | |
| Treatment 1 | 3.33 | 5.32 | 14.37 | 5.55 | 16.70 a | 169.22 abc | 393.60 ab | 18.57 ab | 1.75 c |
| Treatment 2 | 6.44 | 5.41 | 14.50 | 5.52 | 16.45 bc | 154.07 bcd | 362.31 bc | 15.92 bc | 3.45 b |
| Treatment 3 | 2.67 | 5.31 | 14.21 | 5.53 | 16.67 ab | 173.93 ab | 394.98 ab | 19.99 a | 1.89 c |
| Treatment 4 | 5.89 | 5.32 | 14.15 | 5.55 | 16.73 a | 178.58 a | 403.74 a | 20.08 a | 1.92 c |
| Treatment 5 | 6.22 | 5.43 | 14.41 | 5.53 | 16.35 c | 144.41 d | 352.38 c | 14.48 c | 3.70 a |
| Treatment 6 | 4.11 | 5.36 | 14.30 | 5.57 | 16.41 c | 150.56 cd | 358.54 bc | 15.66 bc | 3.88 a |
| LSD | 8.49 | 0.27 | 0.43 | 0.18 | 0.22 | 22.06 | 38.38 | 3.88 | 0.18 |
| **Cotton cultivar** | | | | | | | | | |
| DL555 | 4.89 | 4.89 C | 14.62 A | 5.72 A | 16.82 A | 172.52 B | 419.48 A | 19.78 A | 2.84 A |
| FM 1740 | 5.83 | 5.36 B | 13.71 B | 5.60 B | 16.85 A | 195.81 A | 432.69 A | 19.53 A | 2.78 AB |
| PHY 370 | 3.61 | 5.83 A | 14.64 A | 5.31 C | 15.98 B | 117.06 C | 280.60 B | 13.03 B | 2.67 B |
| LSD | 4.88 | 0.16 | 0.43 | 0.10 | 0.13 | 12.67 | 22 | 2.23 | 0.11 |
| **Factor** | | | | F-value | | | | | |
| Treatment | 0.66 | 0.68 | 1.71 | 0.19 | 10.22 | 7.23 | 6.08 | 6.96 | 546.81 |
| Cultivar | 0.62 | 106.27 | 55.54 | 48.52 | 179.62 | 121.73 | 174.54 | 35.14 | 8 |
| Treatment* cultivar | 0.51 | 0.42 | 1.19 | 0.79 | 0.72 | 0.87 | 0.53 | 1.75 | 1.53 |

1. Same lower case letters indicate no significant difference between treatments.
2. Same upper case letters indicate no significant difference between cotton varieties.
3. No letters indicate no significant difference across treatments or varieties.

## Conclusions

This comprehensive study investigated the effect of six cleaning treatments in a microgin and three cotton cultivars grown in Georgia on yarn quality. The six cleaning treatments did not affect ends-down and yarn tensile properties, but exhibited significant effect on hairiness, yarn defects, and waste. Fewer cleaning processes tended to produce the yarn with lower defects, lower hairiness (irregular CV), and more waste. Cotton cultivar PHY 370 seemed to be the best among the three cultivars in most yarn quality properties. As far as the fiber quality and yarn quality are concerned, therefore, replacing DP 555 with other promising alternatives such as cultivar PHY 370 should be beneficial to textile mills and consumers.

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