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ENGINEERING AND GINNING

Effects of Gin Machinery on Cotton Quality

Robert G. Hardin IV*, Edward M. Barnes, Thomas D. Valco,
Vikki B. Martin, and David M. Clapp

ABSTRACT

Ginning practices affect both economic returns to cotton producers and quality of fiber produced for textile mills and, ultimately, consumers. Because of the shift from a primarily domestic to an export market for U.S. cotton and the loss of textile market share to synthetic fibers, production of high-quality cotton is critical to maintaining the competitiveness of the U.S. cotton industry. The objectives of this review are to summarize the effects of ginning on cotton quality, focusing on recent research, and provide best practices for gin managers to maximize bale value and fiber quality. Higher fiber moisture content at the gin stand, with an optimum of 6 to 7%, better preserves fiber length and strength, but this moisture level reduces both seed cotton and lint cleaning efficiency; therefore, a fiber moisture content of 5 to 6% might be needed for efficient cleaning. Seed cotton cleaners are effective at removing larger foreign matter particles and cause minimal fiber damage. Lint cleaners are efficient cleaners and necessary for removing seed-coat fragments and other small particles created in the gin stand. However, lint cleaners break some fibers, create neps, and remove some good quality fiber. To maximize fiber quality, gins should encourage producers to grow high-quality cultivars and follow recommended harvesting practices. Modules need to be stored and handled properly. Gins should use the minimum amount of drying and lint cleaning that maximizes bale value. Avoiding contamination is vitally important to uphold the U.S. cotton industry's reputation as a supplier of high-quality cotton.

R.G. Hardin IV*[1] and T.D. Valco (retired), USDA/ARS, Cotton Ginning Research Unit, 111 Experiment Station Road, Stoneville, MS 38776; E.M. Barnes, V.B. Martin, and D.M. Clapp, Cotton Incorporated, 6399 Weston Parkway, Cary, NC 27513.
[1] Currently: Texas A&M University, Dept. of Biological and Agricultural Engineering, 207E Scoates Hall, College Station, TX 77843.
*Corresponding author: rghardin@tamu.edu

The primary objective of a cotton gin is to maximize the value of marketable lint for their customers, cotton growers. Gins should also strive to produce high-quality fiber for textile mills and, ultimately, consumers of cotton goods. Official USDA classing data, including High Volume Instrument (HVI, Uster Technologies, Inc., Charlotte, NC) measurements and the classer's determination of extraneous matter levels, is one set of measures used to describe fiber quality (for more details, see Cotton Ginners Handbook chapter on The Classification of Cotton [Moore, 1994]). Although USDA classing data is used to determine bale value, other measurements describing fiber quality are also important in textile processing. An example of another fiber testing system is the Advanced Fiber Information System (AFIS, Uster Technologies, Inc.), which is used by textile mills for quality control. Important cotton quality properties and their measurements are described in Table 1.

Many factors affect cotton quality, including cultivar, environmental conditions, and harvest and ginning practices. Fiber quality is best the day a cotton boll opens, and this maximum quality is governed by the genetics of that cotton plant (cultivar) and the environmental conditions during the growing season. Subsequent weathering of the cotton on the plant in the field, poor storage of seed cotton, or improper ginning practices can significantly decrease fiber quality.

Any mechanical processing of fiber will cause some reduction in quality due to fiber breakage and the creation of neps. With machine-harvested cotton, some cleaning of seed cotton and lint is necessary to produce marketable bales and remove material that is undesirable to the textile mill. Moisture content has a major impact on both fiber damage and cleaning efficiency during ginning. Therefore, the goals of the gin operation should be to (1) manage moisture content for minimum fiber damage and efficient cleaning and (2) perform the minimum amount of cleaning necessary to achieve satisfactory leaf grades and maximize revenue for the grower. Because cleaning machinery also removes fiber, unnecessary cleaning will reduce the weight of marketable lint.

Table 1. Fiber quality properties and measurements

Fiber Property	Gin Machinery Effect	USDA Classification Data		Selected AFIS Data	
		Measurement	Description	Measurement	Description
Length	Gin stand and lint cleaners break fibers-decreases length and length uniformity, increases short-fiber content; low moisture content increases fiber damage	Upper Half Mean Length (Staple – 1/32 in.)	Average length of the longest 50% of fibers	Upper Quartile Length (mm or in.)	Length exceeded by 25% of fibers, on a weight basis
		Length Uniformity (%)	Ratio of the mean length to the upper half mean length, equals 1 if all fibers are the same length	Short-Fiber Content (%)	Percent of fibers < 12.7 mm (0.5 in.), can be on a number or weight basis
Strength	Moisture history of fiber can affect strength	Strength (g/tex)	Force required to break a bundle of fibers		
Fineness/ Maturity	None	Micronaire	An indirect measure of maturity and fineness	Fineness (mtex = μg/m)	Fiber weight per length, estimated from fiber shape and form
				Maturity Ratio	Ratio based on degree of fiber wall thickness (cotton fibers are hollow tubes)
Color	Cannot directly be improved; lint cleaners can improve instrument measurement of color grade; storage at high moisture content has negative effect	Color Grade (e.g. 11, 21, 31, 41, etc.- 25 color grades and 5 categories of below-grade color)	Grade based on reflectance (Rd) and yellowness (+b) of fiber, 15 grades represented by physical standards		
Foreign Matter Content	Reduces	Leaf Grade (1-7 or below grade)	Grade based on % of sample surface area occupied by foreign matter particles and particle count, physical standards for all grades	Trash Count (count/g)	Number of foreign matter particles larger than 500 microns per gram of sample
				Visible Foreign Matter (%)	Calculation based on dust and trash count and size, intended to relate to mass-based methods, such as Shirley Analyzer
Neps	Increases, but gin stand and lint cleaners are largest source			Nep Count (count/g)	Number of fiber entanglements per gram of sample
Seed Coat Fragments	Can break seed coats, but lint cleaners can remove some	Extraneous Matter	Classer determines light (level 1) or heavy (level 2) presence of seed coat fragments	Seed Coat Nep Count (count/g)	Neps containing a portion of the seed coat per gram of sample

QUALITY NEEDS OF TEXTILE MILLS

During the past 25 years, domestic mill use of U.S. cotton has declined from a long-term average of 60% of production to approximately 25% (USDA-ERS, 2015)(Fig. 1). The growth of the export market for U.S. cotton has led to new mill customers who could have different expectations for fiber quality than domestic mills did in the past. Ring spinning is primarily used internationally and accounts for 75% of world spinning capacity, whereas domestic mills mostly use rotor spinning (ITMF, 2014b). Ring spinning is more sensitive than rotor spinning to fiber length, particularly short-fiber content. Furthermore, 60 to 65% of the world's cotton is still hand-picked, so extensive cleaning and drying are not required at the gin for this cotton (ICAC, 2011; USDA-FAS, 2018). Because of the shift from a domestic to an export market, U.S. cotton must compete with this hand-picked cotton. Gins need to preserve fiber quality so that U.S. cotton retains a favorable competitive position on the world market.

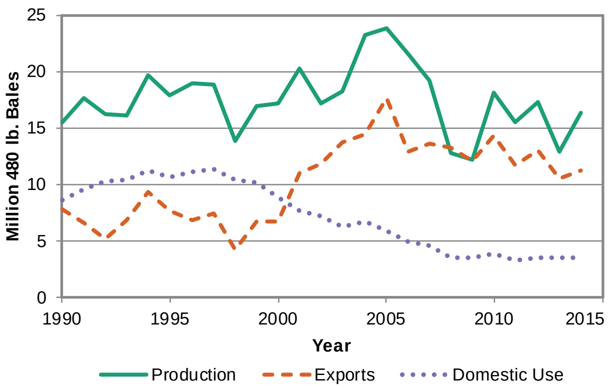

Figure 1. U.S. cotton production and use, 1990 to 2015 (USDA-ERS, 2015).

Cotton has lost textile market share to synthetic fibers, particularly polyester. From 1990 to 2015, cotton's share of the textile fiber market dropped from 49.1 to 27.6%, whereas the proportion of synthetic fibers used has risen from 39.3 to 65.4% (ITMF, 2014b). Although total world consumption of textiles increased significantly during this period, cotton consumption peaked in 2007 and decreased slightly since then due to its declining market share. With manmade fibers, there is little variation between individual fibers, unlike cotton, which has significant natural variability. Because of its uniformity, polyester is much easier for textile mills to spin efficiently. Synthetic fibers are also free of foreign matter. Spinning cotton efficiently requires careful blending of bales with different properties and more attention to machinery settings. To increase cotton's competitiveness with manmade fibers, gins need to maximize the quality and consistency of their product by maintaining length uniformity and minimizing short-fiber content by avoiding unnecessary fiber breakage.

QUALITY CHANGES DURING GINNING

Fiber quality is affected by every machine in the gin; however, the gin stand and lint cleaner apply the largest forces to individual fibers and are most likely to break fibers. Although gin dryers do not directly damage the fiber as long as maximum temperatures are kept below 350 °F (ASABE, 2007), the dryer can significantly impact fiber quality if cotton is processed through the gin at low moisture content.

Moisture Control. The individual fiber breaking force increases with fiber moisture content, although the fiber-seed separation force remains unchanged (Moore and Griffin, 1964) (Fig. 2). Therefore, higher fiber moisture content reduces fiber breakage and preserves fiber length throughout the ginning process. Tests have consistently shown that over a range of 3 to 7% moisture content (all moisture contents listed are wet basis, unless otherwise noted), HVI length increased approximately 0.2 mm (¼ staple length) and length uniformity increased 0.3 percentage points per percentage point increase in fiber moisture content (Anthony, 1990, 1996; Boykin, 2005; Byler and Boykin, 2006; Hughs and Price, 1998;). If the lint moisture content at ginning is increased only slightly, gins should have some bales classed with higher staple lengths. Other measures of fiber length, such as short-fiber content, are also improved by ginning at higher moisture content. The average reduction in AFIS short-fiber content by weight in several studies was 0.5 percentage points per percentage point increase in fiber moisture content (Byler, 2005b, 2008; Byler and Boykin, 2006).

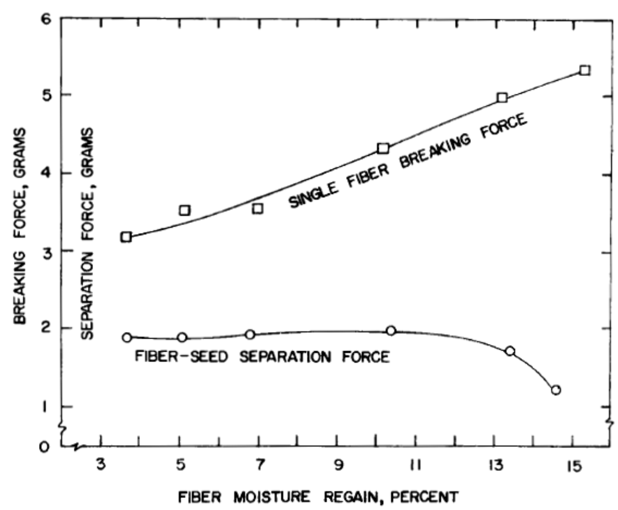

Figure 2. Effect of moisture content on fiber breaking force and fiber-seed separation force (Moore and Griffin, 1964).

Furthermore, ginning cotton at higher moisture content has been shown to increase fiber strength approximately 0.4 g/tex per percentage point increase in fiber moisture content, over a range of 3 to 7% (Anthony, 1990, 1996; Boykin, 2005; Byler and Boykin, 2006). HVI testing is done at standard conditions; however, processing cotton at lower moisture levels can damage some fibers without breaking them. Additionally, drying and rewetting fiber can alter the fiber structure and cause small changes in the equilibrium moisture content (Byler, 2005a; Griffin, 1974). Increasing moisture content during processing also reduces neps in lint. Studies have shown a reduction of approximately 20 neps/g per percentage point increase in lint moisture content (Anthony, 1996; Boykin, 2005; Byler, 2005b, 2008).

Although the fiber quality benefits of increased moisture content are clear, higher moisture levels can cause operational problems with gin machinery, and bale moisture content must be kept below 7.5%. Therefore, the recommended range for lint moisture content for ginning is 6 to 7%. However, lower fiber moisture increases cleaning efficiency of both seed cotton and lint cleaners. Decreasing the seed cotton moisture content from 11.4 to 7.2% increased the cleaning efficiency of the recommended sequence of seed cotton cleaning machinery for picker-harvested cotton (see Cotton Ginners Handbook chapter on Ginning Recommendations for Processing Machine-Picked Cotton [Anthony et al., 1994]) by 5.5 percentage points (Hardin and Byler, 2013). A survey of commercial roller gins indicated that seed cotton cleaning efficiency increased 3.4 percentage points for each percentage point decrease in seed cotton moisture content (Whitelock et al., 2007). The larger effect of moisture content on seed cotton cleaning efficiency observed at commercial roller gin plants could be due to the more extensive seed cotton cleaning machinery found in roller gins or differences in cultivars and foreign matter levels among the gin plants. Cleaning efficiency of a first-stage controlled-batt saw lint cleaner increased by 6.2 percentage points when the lint moisture content was reduced from 6.8 to 4.2% (Mangialardi and Griffin, 1966). The improved efficiency of seed cotton and lint cleaners at lower moisture contents results in an improvement of approximately one leaf grade over a decrease in moisture content of 3 to 4 percentage points (Anthony, 1990, 1996; Boykin, 2005).

Selecting the amount of drying needed is a compromise between efficient cleaning and operation with increased drying, and preserving fiber length and conserving fuel with less drying (Fig. 3). Drying cotton to a fiber moisture content of 5 to 6% might be necessary to attain the leaf grades that maximize bale value, although fiber quality might suffer; length, uniformity, and strength could be reduced slightly, whereas neps and short fiber could increase. Ginning and lint cleaning cotton at moisture levels lower than 5% should be avoided.

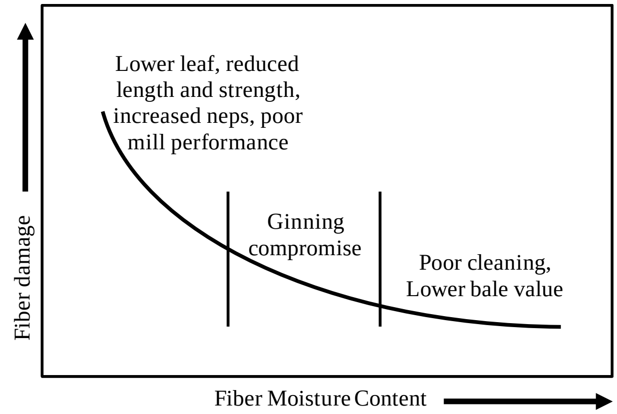

Figure 3. "Fiber damage and moisture content during ginning (adapted from Mayfield et al., 1994).

To maximize cleaning efficiency while preserving fiber quality, moisture can be added before the gin stand. Moisture can be added in the ductwork feeding cotton into the conveyor-distributor, in the conveyor trough, or in the ductwork between the conveyor-distributor and the extractor-feeder. Either humid air or water spray systems can be used before the gin stand, as moisture application at this location is self-limiting, because excess moisture will cause the gin stand to choke or require a significant reduction in ginning rate. Use of a moisture restoration system before the gin stand produces longer and stronger fiber and reduces neps (Boykin, 2005; Byler, 2008; Byler and Boykin, 2006). Similar quality effects are observed whether higher moisture levels are achieved by moisture restoration or reduced drying. Leaf grades were not significantly different when using a moisture restoration system before the gin stand, although AFIS trash counts increased slightly with higher moisture content, possibly due to the lower cleaning efficiency of the lint cleaners. A water spray system above the conveyor-distributor was tested in a commercial gin, resulting in an increase of 0.16 mm (0.2 staple lengths) in AFIS upper-quartile length and a decrease of 0.3 percentage points in AFIS short-fiber content by weight (Byler, 2008). This increased fiber length was due to an average increase in lint moisture content measured between the gin stand and first lint cleaner of 0.6 percentage points, with a maximum increase of 1.1 percentage points.

Moisture restoration systems at the lint slide have no positive impacts on fiber quality, but can improve the performance of the bale press. Increasing the lint moisture content at the lint slide reduces the packing force required at the press and bale tie forces (Anthony and McCaskill, 1976, 1978). However, if the bale moisture content is above 7.5%, fiber quality will likely decrease during storage, particularly color (Baker et al., 2008). Bales of cotton leaving the gin that have 7.5% or higher moisture content, at any location in the bale, are not eligible for the USDA Commodity Credit Corporation cotton loan program (Federal Register, 2006). Moisture restoration systems for lint must be managed properly to avoid over-application of moisture (Fig. 4). Ginners should exercise particular caution when ginning rates are reduced; the moisture application rate must decrease as well, or the bales produced might have unacceptably high moisture content. Although excessive moisture application at the lint slide is less likely with humid air than water spray systems, either type of system can apply too much moisture if not managed properly.

Figure 4. Wet bale after storage resulting from excessive moisture addition at the lint slide.

Seed Cotton Cleaners. Seed cotton cleaners are effective at removing large foreign matter particles (burs and larger pieces of leaf) and do not cause extensive fiber damage. Seed cotton cleaners tend to act more on the bulk of the seed cotton rather than pulling and combing individual fibers as with the gin stand and lint cleaners, thus causing less fiber damage. Research has shown that a second stage of lint cleaning can be replaced by additional seed cotton cleaning (Columbus and Anthony, 1991). Using three additional seed cotton cleaners with the recommended sequence of machinery for processing machine-picked cotton produced lint foreign matter levels and grades equivalent to using a second saw-type lint cleaner, and bale values increased due to higher turnout. Experiments using eight and nine seed cotton cleaners have shown no reduction in fiber length due to the additional seed cotton cleaning, when compared to the recommended machinery (Columbus and Anthony, 1991; Gillum and Armijo, 1997). Because any mechanical handling of fiber creates neps, seed cotton cleaners increase neps in fiber. However, the entire recommended sequence of seed cotton cleaning and drying machinery for machine-picked cotton creates a similar number of neps as a single stage of saw-type lint cleaning (Mangialardi, 1985; Sui et al., 2010).

Gin Stands. The gin stand applies the greatest forces to cotton fibers and likely causes the greatest damage. By comparing normally saw-ginned samples with fibers removed from the seed by hand, a study attributed half of the short-fiber content and a third of the neps in commercially produced lint (using one lint cleaner) to the gin stand (Sui et al., 2010). Although some fiber damage in the gin stand is unavoidable, some factors are known to influence fiber quality. Ginning at rates higher than recommended by the manufacturer has been shown to increase short-fiber content (Griffin, 1977; Griffin and Ramey, 1975). A larger number and greater weight of seed coat fragments were found in lint at higher ginning rates, although two stages of lint cleaning eliminated differences between ginning rates (Mangialardi et al., 1988).

Roller ginning is currently used in the western U.S. for Pima cotton, which has significantly longer fiber than upland cotton. The roller gin better preserves the inherent fiber length advantages of Pima cotton, although roller gins operate at lower rates per unit width than current models of saw gins and are costlier. With the development of the high-speed roller gin, more upland cotton in the western U.S. is roller ginned, and these producers receive a premium from textile mills. The USDA-AMS Visalia Cotton Classing Office reported that approximately 25% of upland cotton in California was roller ginned from 2013 to 2015; however, roller ginning was used for 40% of the upland cotton in 2016 and 2017 (G. Townsend, personal communication, 2018). Recent studies with upland cotton have shown that roller ginning typically increases fiber length at least one staple, improves uniformity index by one to two percentage points, decreases short-fiber content by two to three percentage points, and reduces neps compared to saw ginning (Armijo and Gillum, 2007, 2010; Armijo et al., 2013; Byler and Delhom, 2012; Hughs et al., 2013). Although the quality benefits of roller ginning upland cotton are evident, the economic benefits might not justify the additional cost, unless the market will pay a premium, similar to that received by California producers of roller-ginned upland.

Lint Cleaners. Flow-through air lint cleaners (also referred to as air-jet lint cleaners) remove significantly less material from lint, but create little, if any, fiber damage; therefore, the quality changes discussed during lint cleaning apply only to conventional saw-type lint cleaners. Saw-type lint cleaners are efficient cleaners, but do cause some fiber damage (Fig. 5). Samples collected from commercial gins across the U.S. indicated that the first stage lint cleaner reduced HVI length 0.4 mm (½ staple length), whereas the second stage lint cleaner decreased length by an additional 0.2 mm (¼ staple length) (Whitelock et al., 2011). Length uniformity decreased 0.7 percentage points and short-fiber content increased 0.8 percentage points at the first stage lint cleaner. The second stage lint cleaner resulted in smaller changes in these length measurements, as uniformity decreased 0.4 percentage points, and short-fiber content increased 0.2 percentage points (statistically not significant). Similar changes in fiber length over two stages of lint cleaning were found in another recent study conducted in the laboratory (Hughs et al., 2013).

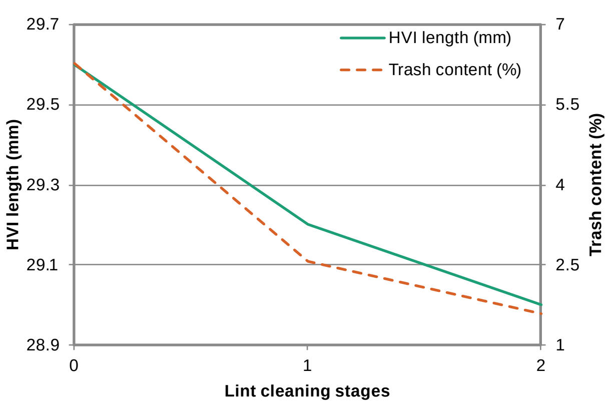

Figure 5. Effect of lint cleaning on fiber length and trash content (Whitelock et al., 2011).

Each stage of lint cleaning generates approximately the same number of additional neps (Anthony, 1996; Mangialardi, 1985; Whitelock et al., 2011). Each stage of lint cleaning creates approximately 40 AFIS neps/g lint, but this amount varies greatly with cotton cultivar. Lint cleaners remove seed-coat fragments, but also break fragments remaining in the lint (Anthony, 1990; Boykin, 2008; Whitelock et al., 2011). Therefore, the size and total weight of seed-coat fragments in the lint decreases, although the number of fragments can remain the same or decrease only slightly.

A decrease in fiber quality is not the only drawback of unnecessary lint cleaning. Marketable weight is lost from the bale, reducing the cotton producer's income. Studies of both picker- and stripper-harvested cotton processed through the recommended sequence of seed cotton cleaning machinery found that for every 227 kg (500 lb) of lint exiting the gin stand, the first lint cleaner removes an average of 8.9 kg (19.6 lb) of material and the second lint cleaner removes an additional 3.7 kg (8.1 lb), on average (Anthony, 1996; Baker, 1972; Mangialardi, 1972, 1981, 1993). However, the fiber content of the material removed increases with each stage of lint cleaning, averaging 25.5% for the first lint cleaner and 30.4% for the second lint cleaner with picker-harvested cotton (Mangialardi, 1972). Lint cleaning removes some good spinnable fiber along with objectionable shorter fibers (Hughs et al., 2013).

STRATEGIES TO PRESERVE QUALITY DURING GINNING

Understanding the impact each machine has on fiber quality is the first step to minimizing fiber damage at the gin. There are several operational practices that can be implemented to preserve quality prior to and during ginning.

Before Cotton Enters the Gin. As noted earlier, the gin is not solely responsible for final fiber quality. It is important to encourage your grower customers to:

1. Choose a cultivar that will have the potential to produce high-quality fiber.
2. Carefully defoliate the crop so that excessive leaf trash does not have to be removed by additional stages of lint cleaning or aggressive drying (see Cotton Ginners Handbook chapter on Harvesting [Williford et al., 1994]).
3. Harvest cotton at an appropriate moisture content—less than 12% seed cotton moisture content—to prevent a decrease in color grade and seed quality during storage (Abernathy and Williams, 1961; Curley et al., 1988). Although round module covers provide excellent protection from rain, they might not allow as

much moisture loss to the atmosphere as conventional module covers, which could cause ginning problems with modules near 12% seed cotton moisture.

4. Follow recommended practices for module construction, storage, and handling (see Cotton Ginners Handbook chapter on Seed Cotton Storage and Handling [Lalor et al., 1994]).

Regardless of module type (conventional, half-size, or round), module covers need to be in good condition, and modules should be properly transported and stored to avoid damaging covers. Conventional or half-size module covers should only be secured or tied down with cotton straps or rope. Plastic baling twine should never be used to secure module covers. Modules should be inspected regularly and after storms, so damaged or missing covers can be repaired or replaced. High moisture modules should be ginned as soon as possible to minimize quality losses.

Moisture Management in the Gin. The ginner's compromise shown in Fig. 3 is important to keep in mind, particularly when drying seed cotton. Cotton fibers are more likely to break during ginning at low moisture content, even though cleaning is improved. Spinning performance is decreased due to the increase in short-fiber content, and bale value can be reduced if over-drying is severe enough to cause a decrease in staple length. The target lint moisture for ginning should be 6 to 7% lint moisture content, if desirable leaf grades can be obtained and there are no issues with extraneous matter, such as bark, grass, seed-coat fragments, or preparation. If additional cleaning is needed, cotton can be dried to 5 to 6% lint moisture. Drying to lower moisture levels should be avoided, if possible.

Technology can assist the ginner in maintaining a proper moisture level in the cotton throughout the ginning process. Responding to rapid changes in moisture content from a wet spot in a module or changes in the feed rate of seed cotton into a gin is difficult or impossible for the ginner due to the high ginning rates currently used. Control systems for seed cotton dryers adjust fuel flow to the burner to maintain a more consistent lint moisture level. These systems can save fuel, improve efficiency, and improve fiber quality by providing the appropriate level of drying over a wide range of conditions of incoming seed cotton. Control systems should be used with moisture restoration systems at the lint slide, to prevent wet bales.

If cotton regularly enters the gin plant at low moisture levels, or is dried to lower moisture levels, gins should consider moisture restoration before the gin stand. Although lint cleaning efficiency will decrease slightly, fiber length will improve, and more desirable bale moisture levels can be achieved, reducing wear on the press.

Selecting the Appropriate Level of Cleaning. The gin's primary responsibility is to maximize the cotton producer's revenue from the seed cotton. Maximizing grower income primarily involves cleaning cotton to a level that balances the increase in value from improved leaf grades with the loss in marketable weight (reduced turnout). Length is the other fiber property that significantly affects value that gins can significantly impact. Minimizing cleaning will best preserve fiber length.

The primary decision the ginner makes regarding cleaning level is the number of lint cleaners to use. Numerous studies have demonstrated that one or two lint cleaners typically maximize producer revenue (Baker, 1972; Mangialardi, 1972, 1981, 1993, Wanjura et al., 2012). Because the lint cleaner removes seed cotton fragments and other small foreign matter created in the gin stand, blends cotton, and combs fiber (preventing rough preparation), at least one stage of lint cleaning should be used. Fiber value is generally maximized by cleaning upland cotton with middling (i.e., 31) color or better to a 3 leaf, or strict low middling (i.e., 41) color or lower to a 4 leaf. Large discounts occur for less desirable leaf grades than the target level, whereas premiums for improved leaf grades are small. For example, the base grade for upland cotton is 41 color, 4 leaf, and 34 staple. Improving the leaf grade to 3 results in a premium of only 0.99 ¢/kg (0.45 ¢/lb), whereas a leaf grade of 5 yields a discount of 4.30 ¢/kg (1.95 ¢/lb). Table 2 shows examples of how the number of lint cleaners affects producer income for varying color and leaf grades.

Several factors not listed in Table 2 will affect the optimum amount of lint cleaning required. The relative values of the lint weight lost by using a second lint cleaner and the premium for an improved leaf grade need to be considered. Shorter staple (34 and lower) cotton with 31 color might not benefit from cleaning beyond a 4 leaf grade, as well as some spotted grades of middling color (i.e., 32, 33) because the premium for improved leaf grades is small. If the lint is worth less, due to discount micronaire values or extraneous matter, for example, the additional value from an improved leaf grade could justify using a second lint cleaner. Conversely, if cotton prices increased significantly without a change in leaf grade premiums, using one lint cleaner to achieve 31-4 could maximize value, because the material lost in the second lint cleaner would be worth more.

Table 2. Number of lint cleaners and income for different color and leaf grades

Lint Cleaners	Leaf	2016 Loan Price ¢/kg (¢/lb)[z]	Weight kg (lb)	Value $[y]
		Color = 31		
1	4	120.70 (54.75)	217.7 (480)	262.80
2	*3*	*123.90 (56.20)*	*214.1 (471.9)*	*265.21*
1	*3*	*123.90 (56.20)*	*217.7 (480)*	*269.76*
2	2	124.89 (56.65)	214.1 (471.9)	267.33
		Color = 41		
1	5	115.08 (52.20)	217.7 (480)	250.56
2	*4*	*119.82 (54.35)*	*214.1 (471.9)*	*256.48*
1	*4*	*119.82 (54.35)*	*217.7 (480)*	*260.88*
2	3	120.92 (54.85)	214.1 (471.9)	258.84

[z] Prices calculated based on average values for 2015 U.S. crop of 36 staple, 30 strength, and 4.5 micronaire (USDA-AMS, 2016). A second lint cleaner reduces bale weight an additional 1.69% (Anthony, 1996; Baker, 1972; Mangialardi, 1972, 1981, 1993).

[y] Row with the number of lint cleaners producing maximum value for each scenario italicized.

There are systems that provide real-time bypass of lint cleaners based on estimates of lint foreign-matter content. One example, commercially available as Intelligin (Uster Technologies, Inc.), constantly estimates loan value of the cotton from real-time measurements of color and leaf grade to determine the optimum number of lint cleaners (Anthony and Byler, 1998; Byler and Anthony, 1998). Another system has been developed that can bypass individual grid bars on a lint cleaner, marketed as the LouverMax Lint Cleaning System (Bajaj ConEagle, Millbrook, AL), allowing for greater control of the tradeoff between increased cleaning and higher turnout with improved fiber quality (Anthony, 2000). These control systems can help ginners minimize fiber damage and maximize turnout to realize the best return for the grower.

The only other cleaner that can typically be bypassed in a gin is the stick machine, and the Intelligin system can do this automatically. Because the stick machine does little fiber damage and fiber and seed losses are usually low, there is little to gain from bypassing the stick machine and this generally should be done only with relatively clean, spindle-picked cotton, especially if the gin has only a single stage of extracting prior to the extractor-feeder. Both lint cleaners and aggressive drying are more damaging to the fiber than stick machines.

Cultivar Effects. Be aware of the cultivar being ginned. Seed cotton from some cultivars will contain greater amounts of leaf because of the presence of additional leaf hairs that adhere to the fiber. These hairy-leaf cultivars might require additional lint cleaning, compared to cultivars described as smooth-leaf, although one lint cleaner will often be optimum for both (Mangialardi, 1993). Although leaf hairiness affects the amount of foreign matter in the seed cotton, some cultivars are easier to clean at the gin, including some hairy-leaf ones (Hardin and Byler, 2013). Keeping records of how different cultivars perform in the gin will allow for appropriate levels of cleaning to be used as the ginning season progresses. If the growing season is limited, full-season cultivars will be more likely to produce immature cotton than early-maturing cultivars. Immature fiber (indicated by lower micronaire than typical for that cultivar) is more sensitive to mechanical handling, being more prone to fiber breakage (Krifa, 2006) and nep formation (Mangialardi et al., 1987). As with immature fibers, longer and finer fibers are also more flexible and likely to form neps (Hebert et al., 1986). Therefore, when trying to balance the need for cleaning with fiber damage, it is better to err towards less processing—lower heat and less lint cleaning—with immature cotton or cultivars with longer or finer fibers. For example, if it is believed an extra stage of lint cleaning could improve leaf grade, such a decision would be more appropriate for a more mature cotton (higher micronaire), and must be weighed against the decrease in turnout. A conservative ginning rate is appropriate for cultivars known to have a high seed-coat fragment potential, especially in a year where seed-coat fragment problems are being reported.

Contamination. Contamination of fiber is costly for textile mills, due to the expense of removal equipment, downtime, and material waste from contaminated finished goods. U.S. produced cotton is among the least contaminated in the world, according to surveys of textile mills conducted by the National Cotton Council (NCC) (2009) and the International Textile Manufacturers Federation (ITMF) (2014a). Although contamination levels remain low compared to the rest of the world, the ITMF survey indicated that contamination of U.S. cotton from plastic film has increased since 2009. Technology for contaminant detection systems at spinning mills has greatly improved and is used at more mills. Improved detection of contamination has increased awareness of this problem and the potential economic consequences for cotton producers and gins. Additionally, the introduction of the John Deere (Moline, IL) cotton harvester with on-board module builder that wraps modules in plastic film has increased concerns about contamination.

It is critical that gins preserve the U.S. reputation for contamination-free cotton by being certain that no plastic or other non-plant matter (e.g., cover tie downs, rags, trash) enters the process stream. Conventional ginning equipment does not effectively remove plastic; therefore, a significant amount of plastic entering the gin will be found in the bale (Byler et al., 2013). Although some plastic is removed by carding and combing in the textile mill, the yarn produced from contaminated bales will likely contain some plastic, if a contamination detection system is not used at the mill (van der Sluijs and Freijah, 2016). Examples of a contaminated bale and fabric are shown in Figs. 6 and 7.

Figure 6. Bale with plastic contamination (large black object) at textile mill. Photo courtesy of Dale Thompson, NCC.

Figure 7. Polyethylene film contamination in a knit fabric.

Research is underway to develop sensing technology to detect and remove plastics during ginning. For now, the best method of preventing plastic contamination is to keep the plastic out of the cotton in the first place by removing plastic from fields, turn rows, and gin yards. Field and gin workers must be educated on the problems that plastic can cause throughout the industry and on ways to reduce the incidence of plastics in cotton. Both the NCC and Cotton Incorporated have developed educational programs to instruct growers and ginners of the problem and provide best management practices to help alleviate the incidence of plastic contamination. Also, be sure to prevent hydraulic oils or grease from coming into contact with the lint by fixing any leaks immediately and properly maintaining machinery. Finally, care must be taken to preserve the bale packaging material when transporting bales to the warehouse or holding area.

SUMMARY

Cotton quality is best the day the boll opens on the plant, and the ginner must try to preserve that quality throughout the ginning process. With the increased importance of global markets and competition from synthetic fibers, it is more critical than ever that the ginner takes every step possible to preserve fiber quality. This process begins by encouraging producers to select high-quality cultivars, harvest during the right environmental conditions, and store seed cotton appropriately. Ginners need to pay careful attention to the compromise between cleaning and fiber damage when drying seed cotton and deciding what cleaning machinery to use. Only use the amount of drying and lint cleaning needed to get the leaf grade that maximizes producer revenue, because additional processing reduces both turnout and fiber quality. Control systems can select appropriate levels of drying and cleaning to help modern gins optimize the delicate balance between foreign matter removal and fiber damage. Finally, gins must ensure that no contaminants are introduced during the ginning process.

DISCLAIMER

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U. S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available. USDA is an equal opportunity employer.

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