Ginning and Classing

The function of the gin is to separate lint from gin to create two marketable products, fiber and seed. The gin must also be equipped to remove foreign matter, control moisture and remove other contaminants that significantly reduce the value of the bale. The gin's customer is the grower, the one who pays in one way or another to have the cotton ginned. It is the ginner's responsibility to maximize the revenue from every module of cotton. This does not simply mean maximizing the value of a bale, or the price per pound for the fiber, or even the grade. Instead, it means maximizing the return to the grower. As ginners, you need to know how to operate the gin so as to optimize its performance for the growers and for their customers, the textile mills. Good communication and cooperation between the grower and the ginner is essential to help optimize bale value.

Ginning Basics

Cotton Fibers must be separated from the seed before they can be spun to yarn and used to manufacture textile goods. It is believed that the first mechanical gin (Churka) was a roller gin consisting of two rollers turning together by means of a hand crank. The Churka gin was most efficient when handling naked seeded varieties with loosely attached fibers. Early American settlers found that the fuzzy seeded varieties (upland cotton) that yielded best in this country were difficult to gin on this machine. Consequently, the fiber was generally pulled from the seed by hand until Eli Whitney patented his cotton gin in 1794.

Whitney's gin used spikes on a hand-driven cylinder to remove fibers from the seed. The spikes pulled lint through slots that were too narrow for the seeds to pass. Whitney's gin could process as much cotton as 100 people could gin by hand. Henry Ogden Holmes received a patent in 1796 for an improved gin that used saws rather than spikes to remove the fibers from the seed. The saws were spaced on a shaft to provide openings that allowed the clean seed to drop out the bottom. Holmes, invention made ginning a continuous rather than a batch process, and greatly increased capacity. The basic principles developed by Whitney and Holmes are used in modern gin stands, but there have been many improvements. This invention enabled cotton growers to rapidly expand production, and marked the beginning of the modern cotton industry.

When cotton was hand picked and carefully handled, the only machines needed in a ginning system were a gin stand and a baling press. Rougher hand harvesting methods and mechanical harvesters caused more moisture and foreign material (trash) to be mixed with the seed cotton. Thus, seed cotton cleaning, drying equipment and lint cleaners were developed to compensate for the faster harvesting methods. On average, gins must process about 1,400 and 1700 pounds of seed cotton to produce a 480- pound bale of lint for spindle picked and field-cleaned stripper harvesting methods, respectively.

Storing and Transporting Seed Cotton

When harvested, seed cotton is generally stored in modules in the field and transported to the gin on module trucks. Modules should be carefully formed so water will run off the top and sides, placed on a well-drained site, and covered with a good quality tarp. Large amounts of cotton can be safely stored in modules if its moisture content is kept at 12 percent or less. High moisture cotton or cotton containing green plant material can heat during storage and quickly deteriorate. Hot modules must be ginned immediately or both lint and seed quality could be lost. Wet seed cotton coming into the gin requires extensive drying energy and costs. The turnout is significantly reduced, which hurts the producers yield, and processing volume is greatly reduced.

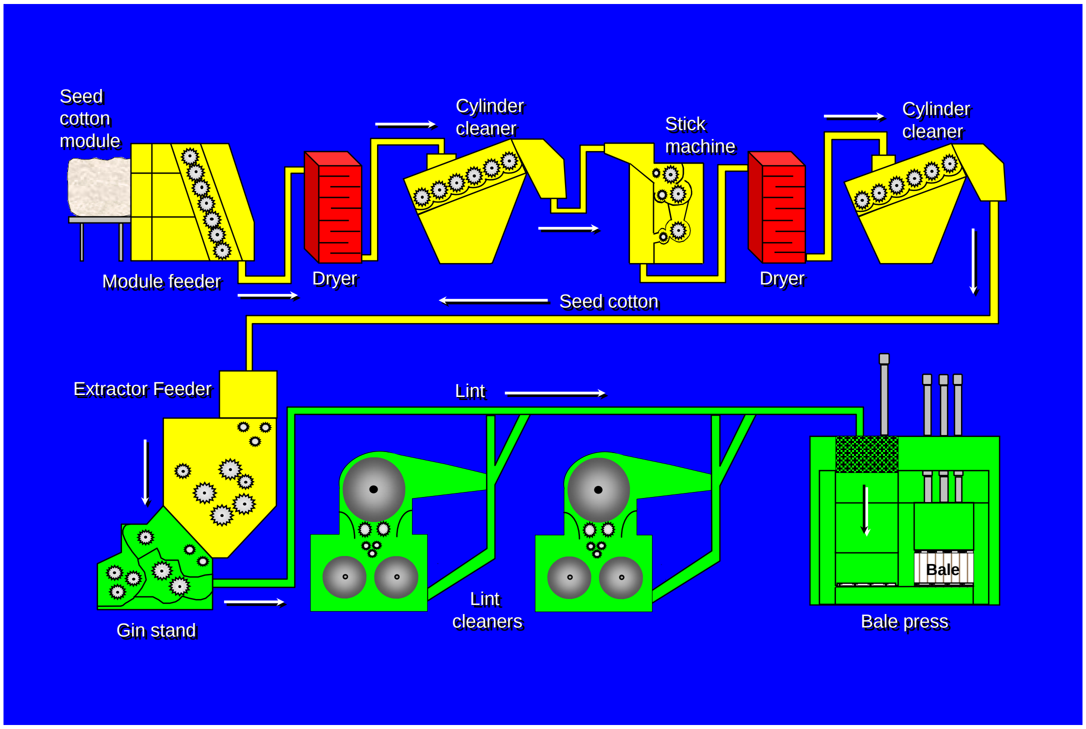
Machinery in the Saw Ginning System

Quality preservation during ginning requires the proper selection and operation of each machine in a ginning system. These decisions are based on the quality of cotton coming into the gin, the amount of trash and moisture content. The more uniform these parameters, the more consistence the ginning process. The generally utilized machinery sequence for spindle-picked cotton is as follows:

Ginning Machinery Sequences

1. Module Feeder

2. Feed control
3. Tower drier
4. Cylinder cleaner
5. Stick machine
6. Tower drier
7. Cylinder cleaner
8. Impact cleaner (optional)
9. Extractor feeder
10. Gin stand
11. Lint cleaner(s)
12. Bale Press



Typical gin equipment processes for picker harvested cotton.

Feed Control and Pre-Cleaners

Gin machinery operates more efficiently when the cotton flow rate is constant. In early gins the flow rate was often erratic because of the variable work rate of the person unloading the wagon. The automatic feed control was developed to solve this problem by providing an even flow of cotton to the gin's cleaning and drying system. The module feeder also performs a similar function and may be used to feed seed cotton directly from a module into the gin. The green boll trap is important for removing green bolls, rocks, and other heavy foreign matter from rough cotton. These large, heavy materials should be removed early in the ginning system to prevent damage to machinery and to preserve fiber quality. Green boll traps use sudden changes in flow direction and/or reduce air velocities to separate heavy foreign materials from seed cotton

Driers

The most important factor in preserving quality during ginning is the fiber moisture content. At higher moistures, cotton fibers are stronger, but trash is harder to remove and cleaning machinery is less efficient. At low moisture, fibers are easily broken. Consequently, controlling fiber moisture content is a compromise between good trash removal and quality preservation. For most conditions, cotton should be ginned at 6 to 7 percent lint moisture. Practically all of the gins are equipped with at least one stage of seed cotton drying and most ginning systems have two stages. The temperature of the conveying air is regulated to control the amount of drying. To prevent fiber damage, the maximum temperature in the drying system should be kept below 350 °F.

Cylinder Cleaners

Cylinder cleaners consist of six or seven revolving spiked cylinders that turn about 400 rpm. These cylinders convey the cotton over a series of grid rods or screens, agitate the cotton, and allow fine foreign materials such as leaf trash and dirt to fall through openings for disposal. In many gins, two cleaners are installed in parallel (split stream), with each one cleaning half the seed cotton. Cylinder cleaners break up large wads and generally get the cotton open and in good condition for additional cleaning and drying. Cylinder cleaners may also be used to remove seed cotton from the hot air line as it comes from the drier. They may be used in either a horizontal position or inclined at an angle of about 30 degrees (inclined cleaners).

Stick Machines

The stick machine was developed to remove the extra foreign matter taken from the plant by mechanical harvesters. Stick machines use the centrifugal force created by high-speed saw cylinders to sling off foreign material while the fiber is held by the saw. Inside a stick machine, seed cotton is wiped onto the saw teeth by stationary wire brushes. Grid bars or stationary wire brushes are located around the saw cylinder to reduce the amount of seed cotton that is thrown off the cylinder. The seed cotton which is thrown off with the foreign matter is picked up by reclaimer saws and put back into the seed cotton stream. Reclaimer saw cylinders are similar to main sling-off cylinders, but usually run slower and have more grid bars. The foreign matter that is slung off the reclaimer feeds into the trash handling system.

Extractor-Feeders

The primary function of an extractor-feeder is to feed seed cotton uniformly to the gin stand at controllable rates. Seed cotton cleaning is a secondary function. Feed rollers, located at the top of the extractor-feeder and directly under the distributor hopper, control the feed rate of seed cotton to the gin stand. These feed rollers are powered by variable-speed motors controlled manually or automatically by various interlocking systems with the gin stand.

Gin Stand

The gin stand consists of a set of saws rotating between ginning ribs. The saw teeth pass between the ribs at the ginning point. Here the leading edge of the teeth is approximately parallel to the rib to pull the fibers from the seed rather than cutting them. The actual ginning process (separation of lint and seed) takes place in the roll box of the gin stand. When all the long fibers are removed, the seeds slide down the face of the ginning rib between the saws and fall onto a conveyor under the stand. Lint is removed from the saw by a rotating brush. It is then conveyed to the next machine in the ginning system, usually a lint cleaner.

Lint Cleaners

Gins typically use two types of lint cleaners, air jet and saw. The air-jet lint cleaners are directly behind the gin stand and use centrifugal force to remove trash from the lint as it makes a sharp turn in the duct work. In a saw-type lint cleaner, a condenser removes the fiber from the conveying air stream and forms it into a batt. The batt is fed to a saw cylinder which normally rotates at approximately 1,000 revolutions per minute. The saws carry cotton over grid bars, which, aided by centrifugal force, remove immature seeds (motes) and foreign matter. The cleaned lint is removed from the saw by a rotating brush which also provides air to convey it to the next machine. Lint cleaners can improve the grade of cotton by removing foreign matter if the cotton has the necessary color and preparation characteristics. Lint cleaners may also blend light spotted cotton so that it becomes a white grade. But fiber length and several other important quality factors can be damaged by excessive lint cleaning, especially when the cotton is too dry (<5% moisture content).

For average machine-picked cotton, the first stage of saw-lint cleaning can remove 20-30 pounds of lint and foreign matter from each bale. The second lint cleaner would be expected to remove an additional 10-12 pounds and the third stage about 6 pounds. Determining the number of lint cleaners that gives maximum bale value is a compromise between increased grade and reduced length, turnout, and other fiber quality factors important to textile manufacturers. The price differentials for grade and staple length have a great influence on this decision. Under most circumstances, one or two saw-type lint cleaners will give the best economic returns. Consequently, ginning systems should be designed so that all saw-type lint cleaners after the first stage can be by-passed.

Bale Press
Cotton must be baled and packaged to protect it from contamination during transportation and storage. The U.S. textile industry has required that bales be packaged a standard dimension and density of 28 pounds per cubic foot. This standard bale supports storage, handling and process uniformity though out the marketing and processing system. Bale coverings and ties should meet the specifications developed by the Joint Cotton Industry Bale Packaging Committee.

Process Control
Computer control of the ginning process is one way to ensure that the appropriate drying and cleaning are done to the fiber. Process control uses instruments the determine trash, color and moisture contents of the seed cotton and fiber through out the ginning process. From this information, machine adjustments are continually made to the feed rate, the drying temperature and number of drying stages, the number of lint cleaners, and finally the moisture content of the fiber as it is packaged in the bale. Using market economics and standard machine operational parameters, seed cotton is processed to optimize it value to both the grower and the textile processor.

Cotton Classification

The classification system for upland cotton consists of instrument measurements and classer determinations. All instrument measurements currently utilized in USDA upland cotton classification are from Uster High Volume Instrument (HVI) systems and include color grade, fiber length, micronaire, strength, length uniformity index, color Rd, color +b, and trash percent area. Classer determinations are leaf grade, extraneous matter and preparation.

Classification of all cotton samples are based on official standards as determined by the United States Department of Agriculture (USDA). Quality Control is a vital part of the USDA classification system and HVI instruments are routinely tested for accuracy based on maximum allowable tolerances. Both temperature and humidity conditions influence the measurement of cotton fiber properties, and are therefore tightly controlled in the classing laboratory.

Fiber Measurements
A description of each measurement included in USDA's official cotton grade follows:

> Color - Color measurements are made by a colorimeter. The instrument measures grayness (Rd), which indicates how light or dark the sample is, and also yellowness (+b), which indicates how much yellow color is in the sample. The color grade is determined by location the point at which the Rd and +b values intersect on the Nickerson-Hunter diagram for upland cotton. The majority of the crop is classed as white 21, 31, or 41 color grade. A 32 or 42 would be a light spotted grade. There are 25 official color grades plus 5 categories of below-grade color. Color gives an indication of the fibers' ability to accept dyes in the manufacturing process.
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> Fiber Length - Fiber length is measured on a beard of cotton fibers on HVI systems and is reported in hundredths of an inch and equivalent staple length in thirty-seconds of an inch. Length is a good indicator of yarn strength and spinning efficiency.

Micronaire - The airflow instrument in the HVI system measures resistance to air flow which is related to fiber fineness. Fineness and maturity are highly correlated within the same cotton variety. Fiber fineness affects yarn appearance, yarn uniformity, and yarn strength.

Strength - The fiber strength measurement is made by clamping and breaking the beard of fibers with 1/8-inch gage spacing between the clamp jaws. The strength reported is the force in grams required to break a bundle of fibers one tex unit in size. A tex unit is equal to the weight in grams of 1,000 meters of fiber. Fiber strength is closely related to yarn and fabric strength and to spinning efficiency.

Length Uniformity - Length uniformity measures the degree of fiber length uniformity in a sample. Fiber length uniformity is related to spinning efficiency, yarn uniformity, and yarn strength.

Trash percent area- The trash measurement is made by a video trashmeter, which measures the percentage area of trash on the sample surface. This measurement provides an estimate of the total amount of trash in the bale.

Leaf Grade - Highly trained human classers determine the leaf grade by comparison with the practical forms of the Universal standards for the grades.

Extraneous Matter – Extraneous matter is any substance in the cotton other than fiber of leaf. Examples of extraneous matter are bark, grass, preparation, seedcoat fragments, dust and oil. The kin of extraneous matter, and an indication of the amount, light or heavy, are noted by the classer on the classification document.

Preparation - Classers determine the degree of smoothness or roughness of the ginned cotton lint termed preparation or prep or sometimes referred to as spindle twist. Various methods of harvesting, handling, and ginning cotton produce differences in roughness or smoothness of preparation that sometimes are very apparent. If cotton has abnormal preparation, that notation is shown under Extraneous Matter on the classification record.

Classing Offices

USDA operates 12 cotton classing facilities across the cotton belt. The facilities are designed specifically for cotton classification and are staffed exclusively with USDA personnel. Cottons grown in Arkansas are classed in three different classing offices depending on the county, which include Rayville, LA, Dumas, AR and Memphis, TN. Additional information of cotton classification can be obtained from the web at: http://www.ams.usda.gov/Cotton/

Additional cotton quality measurements

The HVI measurements provide an important identification of cotton fiber quality attributes for textile processing. Other important quality measurements are short fiber content, neps, immature fiber, and stickiness. These quality attributes are not part of the classing system but can have major influence on textile processing.

Short fibers in cotton reduce textile processing efficiency and product quality. Short fiber content (SFC) is defined as the percentage of fibers shorter than half-inches. SFC is typically measured by the Uster Advanced Fiber Information System (AFIS). SFC can also be determined from HVI measurements of fiber length and uniformity. Each method provides different numbers but can identify variability in SFC between treatment samples.

Neps are small entanglements of cotton fibers created as cotton is manipulated mechanically or pneumatically. Neps are typically measured by AFIS however there are other manual methods sometimes used. Neps are formed at every stage of the ginning processing. Clumps of immature fibers, which are sometimes called shinny neps, pose particular problems when they dyed deep colors in certain cotton fabrics. Shinny neps or white specks because they do not dye uniformly and are clearly visible in the fabric. Variety, environment, and crop management are more important in eliminating these fibers from the bale.

Stickiness in cotton is often caused in the field by whiteflies or aphid deposits often referred to as honeydew. Stickiness in extreme cases can cause problems with material flow in the gin, wrapping on feeders and saws. Stickiness can also shut down a textile mill by clogging up cards and spinning frames. Problems with sticky cotton are most often seen in arid cotton production regions where rainfall does not wash the deposits from the fiber. Mechanical and chemical methods are used to measure or rank the amount of stickiness in the fiber.

Fiber quality aspects of cotton ginning

Several fiber properties are important to the cotton value and to the textile mill and many are affected by how the gin is operated. These fiber properties are:

Cleanness (leaf grade, % area, seed-coat fragments, grass and bark)
Length (staple, uniformity index, short fiber content)
Maturity (mic, dye uptake, yarn strength)
Strength (fiber strength (g/tex), yarn and fabric strength)
Color (Rd and +b)
Smoothness (Prep)
Contamination (stickiness, foreign fibers, grass and bark)

Cleanness

It is no surprise that clean cotton is worth more per pound than trashy cotton. Cleaning involves the removal of trash, but it also can mean the loss of some marketable fiber. In most of the mid-south, leaf grade 4 with a 41 color grade is normal for domestic markets, and there are only small premiums for better, but heavy discounts for worse. With increasing international market demands, leaf grade 3 with a 31 color is in demand. The general rule is that cleaning to a better leaf grade than is normal for your production region, i.e. 41color and 4 leaf, can result in a loss of value to the grower because the premiums for the extra cleaning do not compensate for the loss of marketable weight (gin turnout) in the form of lint-cleaner waste or motes. When normal leaf grades are being exceeded, one or more of the second-stage lint cleaners should be bypassed — but not necessarily all of them — until you are getting the right leaf grade, with as few bales as possible above that level and almost no bales below it. Remember, the discounts for bales that are trashier than normal are heavy, and when the normal grades are not being attained, all available cleaning, and aggressive drying must be used in your attempt to meet your customer's goal.

Unneeded cleaning has other disadvantages — it reduces staple length and it causes the creation of short fiber and neps, which are especially detrimental in the spinning process. A gin’s reputation among mill buyers is often related to the amount of short fiber and neps that are believed to be in that gin’s cotton, causing buyers to speak of over-ginned cotton. The over drying that often goes along with excessive cleaning also causes loss of marketable weight, water. Even the best lint-slide humidifiers seldom bring over-dried cotton back up to about 7 percent moisture, which is generally desirable and expected by the mills.

Seed-coat fragments (SCF) result from broken seed, which can be caused by harvesters, by high-impact gin machinery or by worn gin saws and ribs. The cotton variety is a contributing factor in SCF, based on the thickness of the seed coat and strength of the fiber attachment. Tight seed rolls can aggravate the problem. Lint cleaners reduce the volume of SCF present but their number tends to remain unchanged because the lint cleaners make what is not removed smaller.

In summary, do only the drying and cleaning that are in the grower's best interest and discuss this with growers; above all, know your job and how to operate your gin to accomplish the goal. Be sure that growers know the importance of harvesting the crop in the best possible condition so that cleaning stages can be bypassed.

Length

Three length properties are important: (1) staple length or the average length of the longer half of the fiber; (2) the percentage by weight of the fibers shorter than half an inch, referred to as short fiber content (SFC); and (3) length uniformity index (UI) or the average fiber length as a percentage of staple length. Longer staple cottons sell at a premium price in part because of superior length properties that make it suitable for the manufacture of fine, strong yarns. Staple and UI, but not SFC, are measured in the USDA Classing Office. The loan charts specify premiums and discounts for differing staple lengths but cotton buyers know when to suspect that short fiber problems when the UI is lower than it should be. Ginners must therefore know how gin operation affects length.

The staple length of modern cotton varieties is the result of years of breeding, and is not something that the ginner can produce. But the ginner must know how to protect length and avoid creating short fiber. As a general rule, do only the cleaning and drying necessary to achieve the desired leaf grade. Each lint cleaner can reduce staple by up to 1/32 of an inch and this is worsened if excessive drying has weakened the fiber.

Changes in SFC during ginning are a function of fiber moisture content and machinery processing. Ginning rate and additional use of saw-type lint cleaners contribute to increases in SFC. The SFC increases as one and two stages of lint cleaning is added with greater increases found for weaker cotton than for strong ones.

Strength

Strength is another quality resulting from breeding, and gin operation has little effect on it. Cotton can be made weak by over drying, thus worsening both the loss of staple and the creation of short fibers during ginning and cleaning. Humidification can improve strength but not staple loss. In the HVI strength-measuring system, the classing offices condition lint samples so that each has the same moisture. Fiber strength is measured in g/Tex. The loan charts provide premiums and discounts for strength. In summary, strength cannot be improved by how a gin is operated but temporary loss of strength during the ginning and cleaning processes (because of over-drying) leads to loss of other qualities.

Color

The color is important to mills in the dyeing of fabric. Color of cotton as harvested depends on weather, and on the presence of stains from green or other material such as soil or deteriorating seed. Seed cotton or bale storage with high moisture contents will reduce the brightness of the cotton. The least serious level of undesirable color ("light spot") can sometime be obscured by the way lint cleaners disperse small tufts of stained fiber, in which case the value is not discounted because of poor color. But lint cleaners cannot obscure full-spotted, tinged or yellow-stained color grades. Using no lint cleaning can cause an increase in light-spotted color grades even if the leaf grades were satisfactory without any cleaning – this could cause loss of revenue to growers. Always use at least one lint cleaner unless your customer instructs you otherwise. Be sure that growers know about the color problems caused by storing cotton damp.

Maturity

Fiber maturity is related to the amount of cellulose deposited during boll development. It is primarily a function of variety, culture, and weather. Cellulose is the element of the fiber that is dyed in the textile process and the more cellulose present, the better dye uptake. Maturity is not affected by gin operation but there is some evidence that dye uptake is reduced in fiber that has been heated above 350°F. Most gins are equipped with limiting devices that prevent such high temperatures.

Micronaire or mic is measured on the HVI line by blowing air through a standard volume of cotton and measuring the volume of air. When fiber is fine or thin-walled, less air passes and low micronaire is indicated.

When fiber is thick, air passes through the plug easily and high micronaire is indicated. Low micronaire is usually a predictor of low dye uptake and high micronaire is a sign of good dye uptake but very high micronaire causes reduced yarn strength. Cotton buyers provide premiums for the most desirable micronaire (3.8 – 4.2), with varying discounts for departures above or below the premium range. In summary, maturity (the ability to take up dye) is important to mills but is not affected by gin operation. If fiber is very trashy, it appears more mature because the micronaire reading is high.

Smoothness and Neps
Rough preparation refers to the appearance of cotton and causes increased waste to be produced during textile processing. Only about 0.5 percent of the crop is currently penalized because of preparation. Processing cotton while it is wet, transporting cotton in pipes with excessive air speeds, and feeding too much air into air-fed cylinder cleaners can cause the twisting, knotting and roping that are recognized as poor preparation.

Incomplete doffing of gin or lint-cleaner saws causes recirculation and produces neps in vast quantities. Be certain that doffing brushes or air-blast doffing systems are correctly maintained. Cotton can enter the gin with preparation problems because of spindle twist from harvesting. Lint cleaning helps to remove twisted bundles of cotton but the best solution is to never create them. The less mechanical processing that the fiber receives, the lower will be its nep content. Be sure that gin maintenance is on schedule.

Contamination
Fiber contamination is a serous and expensive problem for the mills. This includes stickiness from insect sugars, grass and bark and synthetic fibers. Stickiness is caused by insect sugars on the fiber forming sticky deposits on the surfaces of mill machinery with which cotton comes into contact. The same deposits are often seen in gins (especially roller gins) and they can make ginning very difficult, the same way they make carding, drawing and spinning difficult for mills. Ginners can use a textile over-spray (containing a textile lubricant) to make the gin run smoother but the effect of the lubricant does not carry over into the mill. Increasing dryer temperatures to drive out any moisture is the easiest method to process sticky cotton. Control of late season insects is the only way to prevent the deposits of various tacky sugar compounds on the fiber.

Grass and bark enters the system during the harvesting and field storage process. Once this material gets ground up, it can resemble fibers and is difficult to separate from the cotton. The keys are to keep it from getting in to the seed-cotton or remove it before ginning. Classers look for grass and bark while grading the cotton and it is discounted based on the level of material in the sample. When grass and bark are problems, ginners must provide good pre-cleaning of seed cotton before ginning.

Foreign fibers or other contaminates can enter into the cotton during harvesting, field storage and ginning. Module covers and tie downs have been major source of fiber contamination. Once this material gets into the gin or the mill, it is distributed through out the fibers and is difficult to remove. It is very difficult to detect until the fabric has been dyed. Ginners must be aware of the problems with contamination of cotton and instruct workers of the same.