

# 13. Post Harvest Management

*The main concerns for this phase are to maintain quality, optimise lint yield and contain the costs of ginning. Appropriate ginning and handling practices post-harvest are important to maximise returns for growers and maintain the industry's reputation for high quality. Good communication between growers and ginners is a key factor in assisting this process (Table 13.1)*

**Table 13.1:** Summary of key post harvest decisions for optimising quality.

Objectives	At the Gin
Maintaining fibre length	In the gin, fibre length can be preserved and short fibre contents reduced, by reducing the number of lint cleaner passages (depending on quality of seed cotton) and ensuring fibre moisture is between 5 and 7 % over the gin and between 5.5 and 6.5 % through the lint cleaners. Lower combing ratios (ratios between 19 and 23) between feed rollers and the saw of lint cleaners also reduces the amount of fibre breakage.
Reducing the incidence of neps	Lint cleaners are responsible for most of the neps found in baled cotton. Reducing the number of lint cleaners reduces neps. Maintenance of prescribed setting distances, e.g. feed and grid bar distances to the lint cleaner saw reduces fibre loss and nep creation, as does close and proper setting of the doffing brush to the saw. Preservation of fibre moisture as prescribed for length preservation also helps reduce nep creation.
Preventing contamination	Clean gravelled module storage yards. Frequent inspection of tarps on modules. Appropriate bale covering/wrap. Storage and handling to avoid country damage.

The ginning industry in Australia is relatively modern, with higher throughput gins compared with other countries. The principal function of the cotton gin is to separate lint from seed and produce the highest total monetary return for the resulting lint and seed, under prevailing marketing conditions. Current marketing quality standards most often reward cleaner cotton and a certain traditional appearance of the lint.

A ginner has two objectives: (1) To produce lint of satisfactory quality for the grower's classing and market system, and (2) to gin the cotton with minimum reduction in fibre spinning quality so the cotton will meet the demands of its ultimate users, the spinner and the consumer. The spinner would prefer fibre without trash, neps and short fibres. Unfortunately, the highly mechanised (and productive) harvesting and ginning processes used today, mean that removing trash is difficult without introducing some neps and increasing short fibre.

---

The challenge for the ginner is therefore to balance the amount of cotton produced (turn-out), the speed at which it is ginned and the effects that the various cleaning and ginning components have on the fibre quality. Particular settings in a gin for speed or heat can exacerbate nep and short fibre content. The use of lint cleaners, while removing trash, also increases the number of neps and short fibres. Whilst not included in existing classification systems for cotton, the presence of neps and short fibre seriously affect the marketing ability. The ginner must also consider the weight loss that occurs in the various cleaning machines. Often the weight loss to achieve higher grade results in greater removal of lint as well, which results in a lower total monetary return to growers and ginners as they are both paid on a per bale basis.

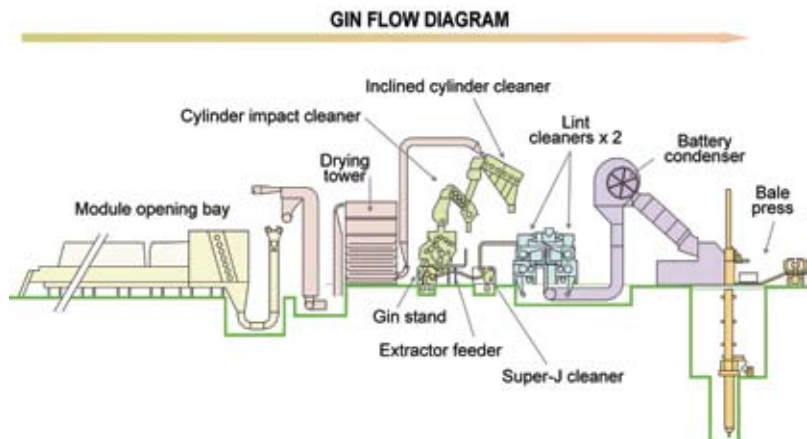
Cotton quality after ginning is a function of the initial quality of the cotton, and the degree of cleaning and drying it receives during ginning; the exact balance between turnout and grade will depend upon the particular premium-and-discount (P&D) sheet applied to the cotton in question. For every P&D sheet there will be a point in the balance between turn-out and grade that maximises the return to the grower. Given this need to balance competing considerations, it is essential that growers seek to; ensure defoliation and harvest practices limit trash; contamination is limited; and the size and moisture of the module are appropriate. Ultimately it is important that growers communicate with ginners these aspects of their harvest prior to the start of the ginning season. An understanding of the issues that were faced in the field may give the ginner insights on how the cotton can be handled to optimise turn-out and quality together.

## Ginning Process

Modern gins are highly automated and productive systems that incorporate many processing stages. Gins must be equipped to remove large percentages of plant matter from the cotton that would significantly reduce the value of the ginned lint, according to the classing grade standards. Figure 13.1 shows the cross-section of a gin with machines that are typical of those found in a modern gin. It is noted that most Australian gins typically have more pre-cleaning stages. This gives them the flexibility to process both spindle harvested cotton and stripper harvested, which requires more pre-cleaning.

At ginning the lint is separated from the seed. Moisture can be added to dry cotton prior to the gin stand at either the pre-cleaning stage or after the conveyor distributor above the gin stand. However, In Australia the moisture addition at these points is not common. After ginning, fibre travels by air to one or two lint cleaners for further cleaning and preparation. At the lint cleaners moisture content is critical to prevent cotton from significant damage (neps and short fibres). Cotton that is too dry (< 5.0% moisture content) will be damaged to a greater degree during the lint cleaning process.

The following sections give more detail on the processes in; the module bay, pre-cleaning, drying and moisture restoration, ginning, lint cleaning and bale moisture restoration.



**Figure 13.1:** Gin flow diagram showing cross-sections of machines used in a modern gin to process spindle harvested cotton



**Figure 13.2:** The module bay is an important intervention point for removing non-cotton contamination from modules. (Photo: CSIRO).

### Module Bay

Ginning begins with seed-cotton delivered in modules to the gin (Figure 13.2). Modules of seed-cotton are opened by a series of beaters and transported by air through ducts to one or a series of pre-cleaners, which remove large trash e.g. sticks, stones, unopened bolls, before the gin. If the seed-cotton is too wet pre-cleaning may be preceded by passage through a drying tower or chamber where the seed-cotton is dried with large volumes of dry heated air. Drying wet cotton improves the cleaning ability of the seed-cotton, which in turn improves the classing grade.

The module bay also acts as one of the only intervention points for removing non-cotton contamination from modules. Contaminants or contaminated seed-cotton (from oil spills and stains etc) should be removed clear of the module and module bay floor. The number of incidences and types of contaminant must be reported to the grower.

### Pre-cleaning

The use of stick machines and extended incline and impact cylinder machines should be considered in the light of whether; the cotton harvested has been well presented and defoliated for harvest; the harvest period has been wet and/or the crop has been spindle or stripper picked. Some gins have more extensive pre-cleaning equipment, e.g. combinations of stick machines, drying equipment and inclined and impact cleaners, than others. Very clean Australian cotton requires only minimal pre-cleaning to achieve satisfactory classing grade results. The use of these machines does not ordinarily damage the fibre in the same way that the ginning and lint cleaning processes do.

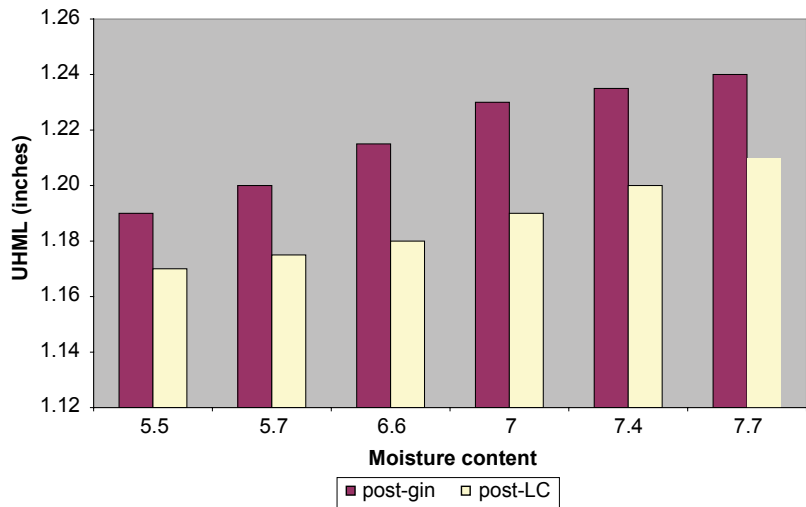
---

### **Drying and moisture maintenance**

To ameliorate the harsh effect of heat and/or dry cotton in the gin, moisture restoration systems are available. These systems typically add moisture to seed-cotton immediately before ginning and in doing so help maintain fibre length and reduce the number of fibres broken at the gin stand and lint cleaners, which translates into improved yarn quality. Newer work is looking at moisture restoration of lint before lint cleaning. Other benefits resulting from moisture restoration include reducing the static electricity level of the cotton, reducing the volume of the cotton required to achieve a given bale size and reducing the force required to press the bale. The resilient forces exerted on the restraining bale ties are also lower for the higher moisture cotton.

Many approaches have been used to restore moisture in cotton fibre. Moisture restoration may occur at several locations such as module feeder, feed control, pre- and post-gin dryer, above extractor feeders, into moving-bed conditioners, at battery condensers and other apparatus in the lint slide. There is a physical limit to the quantity of moisture that may be added to seed-cotton. Wetting of the cotton by condensation within machinery and pipes must be prevented or choking will result. If liquid water is present on the seed-cotton mass, gin stand operation will become irregular and may cease altogether. Cotton with fibre moisture in excess of 9% may be rough in appearance and will not smooth out properly when processed through the lint cleaners. Thus, the recommended fibre moisture level of 6% to 7% is based on production aspects as well as quality aspects. Lint moisture in the bale must be uniform and must not exceed a maximum value of 7.5% in order to avoid fibre discoloration and significant weight loss during storage.

One approach is to use humid air to moisten cotton. The air must be heated to carry sufficient moisture to the cotton fibre. This humid air is then blown through the cotton causing fine water droplets to form on the cotton fibres throughout the cotton batt. The amount of moisture restoration with this system is limited, especially at higher ginning rates, adding typically no more than 1% moisture to seed-cotton depending on ambient conditions. Whilst in absolute terms this amount seems insignificant, significant improvements are seen in fibre quality, gin productivity and bale weight as a result. Figure 13.3 shows improvements in fibre length through the same gin stands and lint cleaners with increasing amounts of moisture applied. The improvements in fibre length give rise to concomitant improvements in length uniformity, short fibre content and fibre strength. Note the damaging effect of the lint cleaner on fibre length.



**Figure 13.3:** The effects of humidified air moisture restoration on fibre length measured as UHML (Upper half mean length). Fibre samples taken post gin and post lint cleaner (fibre test results courtesy of Auscott Ltd.).

Another approach is to atomise water and spray it directly on the cotton. Sometimes a wetting agent is added to the water to hasten its distribution through the cotton. Applying water as an atomized spray directly on cotton or seed-cotton during ginning or cleaning is fraught with difficulty, although if applied successfully can result in fibre quality improvements. In general studies have shown atomizing sprays applied, for example prior to the distributor conveyor, result in fibre with longer staple length and reduced short fibre content. Most Australian gins use this spray system on the cotton at the lint slide in order to restore moisture and weight to the bale, although sprays can also be applied in other parts of the gin, e.g. in the post-dryer, pre-cleaning area. Extreme care must be exercised to avoid wet spots in the bale, which promote bacterial and fungal growth and cause degradation of the fibre.

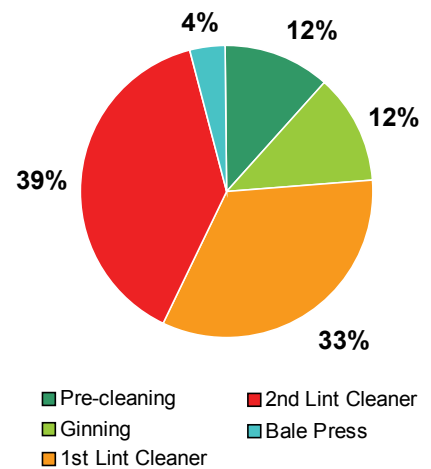
### Ginning

The ginning process works when seed-cotton is fed into a cylindrical chamber to form a seed roll, against which up to 200, 12 to 18 inch gin saws perform a raking process that detaches lint from the seed and draws it through ribs separating each saw. A doffing brush removes the lint attached to the saws and propels it through ducting to the lint cleaners, usually via a Super-J cleaner (see Figure 13.1).

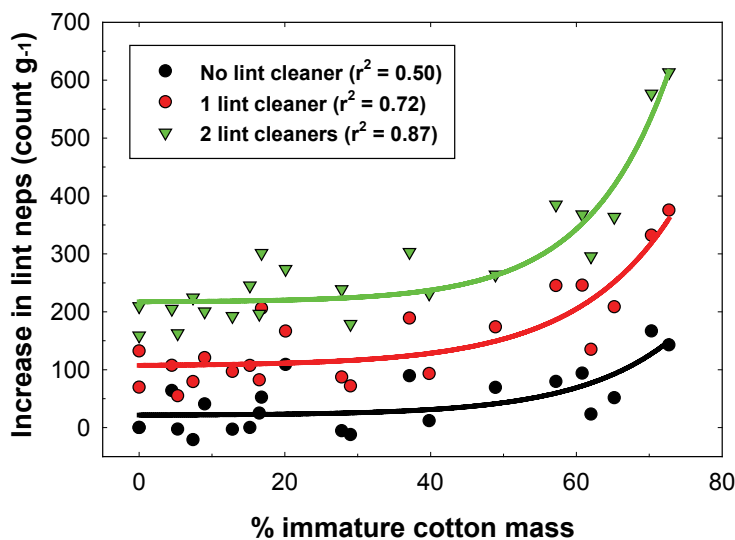
There are many machine settings around the seed box that influence the quality of ginning. Quality at this point is largely defined in terms of turn-out (percent lint extracted) and efficiency (bales per hour). There are also some consequences for fibre quality, although the regard for these is not high at this point. The main factors affecting ginning quality are gin saw sharpness, saw speed, gin point wear and seed roll compaction. Indicators of poor ginning quality are higher levels of residual lint on ginned seed, which leads to lower turn-out, and seed coat damage found as seed coat neps in ginned lint.

## Lint cleaning

It is widely known the saw lint cleaner damages fibre during cleaning and preparing cotton for market. Many studies have been conducted that show levels of nep and short fibre increase, while staple length and residual trash decrease with the number of passages through the saw lint cleaner. Figure 13.4 shows the results of an Australian study on the effect of each ginning stage on nep creation. In the study over 70% of neps found in baled lint were created when lint was cleaned through two saw lint cleaner passages. The impact of lint cleaning is greater on immature fibre and also on longer, finer fibre types. Figure 13.5 shows the effects of the number of lint cleaner passages and percent immature cotton at harvest on the number of neps.



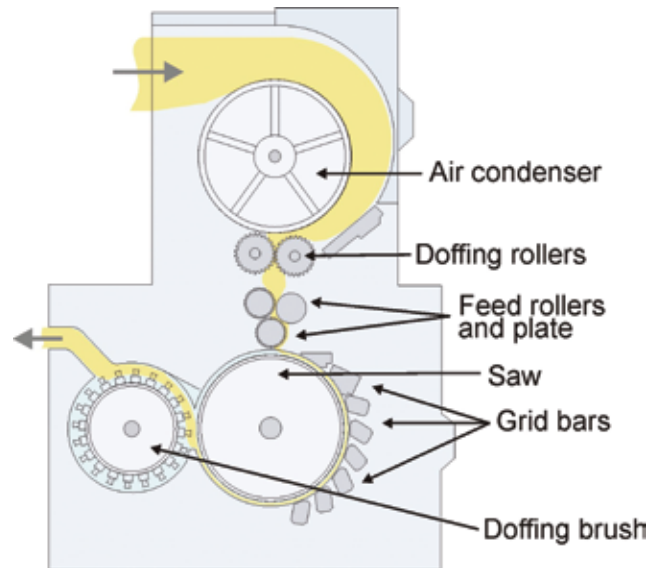
**Figure 13.4:** Nep creation in Australian base grade cotton at different stages through the gin. Data courtesy of D. Draheim, Auscott Ltd.



**Figure 13.5:** The effects of immature cotton and the number of lint cleaners on neps (Bange et al. 2009). Understanding whether cotton is more or less mature may help with decisions on the number of lint cleaning passages.

Modern lint cleaning, in most cases, refers to the fixed or controlled-batt saw type lint cleaner, which was introduced to gin operations after World War II following the advent of mechanized harvesting, which also increased the amount of trash found in cotton. Figure 13.6 shows the main elements of a fixed-batt saw lint cleaner. In these systems ginned lint is formed into a thick batt of around 250 g/m<sup>2</sup> on a slow moving condenser drum. The formed batt is then doffed from the condenser and fed with minimal draft through a series of close set rollers to a nip point between a final resiliently mounted feed roller and fixed feed bar. The batt is then combed onto a saw moving in excess of 1500 m/min. The draft i.e., the ratio of the surface speeds between the final feed roller and the saw, is fixed and is usually set between 20 and 35. The fibre transferred onto the saw is cleaned by grid bars, which deflect the contiguous fibre web back into the saw teeth at the same time as expelling heavier discrete trash particles that are subject to greater centrifugal force than the fibre. Most modern lint cleaners use between five and eight grid bars. Fibre is removed from the saw by a brush cylinder

revolving at 1.35 times the speed of the saw, i.e. a speed in excess of 2000 m/min. Lint doffed by the brush can be subject to further identical lint cleaning passages or can be collected and compressed into a bale.



**Figure 13.6:** Cross-section of a fixed-batt saw lint cleaner.

The feed zone, and in particular the transfer point between the final feed roller and the saw, is where fibre is damaged most during the lint cleaning process. Damage is reflected in increased neps and short fibre content and reduced staple length. The other elements used to clean and move cotton through this system, i.e. the grid bars and brush, create little damage by comparison. The longer and finer a cotton is, the greater the damage at this point. Lower combing ratios, extra draft in the feed work, more consistent batt density and lint conditioned between 5.5% and 6.5% are the best methods of reducing damage at the lint cleaner.

#### **Maintenance of bale moisture**

Excessive moisture in bales stored for extended periods creates quality problems for merchants and mills. Moisture augmentation of cotton bales resulting in excessive amounts of water, mainly via spray systems, leads to a reduction in fibre quality. Cotton colour grade can be adversely affected (increased yellowing and greyness) with moisture levels as low as 7.5% impact greyness and yellowness.

Achieving a moisture content less than 7.5% is a difficult task when applying moisture via sprays to cotton at the battery condenser and/or lint slide. Two important problems are associated with spray systems: (1) applying just the right amount of water to reach the most desirable moisture content and; (2) applying the water in an even and consistent manner. Direct spraying of liquid water on the top of a fast moving thick batt of cotton, achieves only uniform application to the top surface of the batt. It is generally believed that transfer of the liquid water to the remaining 10 to 30 centimetres of cotton

---

is difficult because raw cotton fibre does not readily absorb liquid water because of its hydrophobic wax layer, and that the cotton bale is immediately packaged at high densities, which greatly retards any further movement of water vapour or liquid. In this respect humidified air, which contains water in a vapour phase is more readily absorbed by fibre, and that it is pulled or blown through the cotton by means of a condensing unit, means that moisture is absorbed in a relatively more uniform manner.

Australian gins have a good reputation in achieving appropriate moisture content of bales. This is largely a result of most Australian gins (> 80%) testing the moisture of each ginned bale using the Australian Vomax microwave technology.

## Bale wraps

Cotton lint is baled at the gin after removal and separation from the seed. The wrapping material that covers the bale is designed to protect the baled lint during transport, storage and delivery to Australian and overseas spinning mills. From this perspective the wrapping should have sufficient strength to protect the lint from damage and contamination en-route to the final destination.

Around the world cotton bales are covered in a range of wrapping materials; from fabric constructed from natural fibres such as cotton and jute, to synthetic fibres such as polypropylene (PP) and plastic films such as polyethylene (PE). Each material has its own distinct advantages and disadvantages. The majority of bales produced world-wide are covered by a cotton material.

Whilst jute hessian is relatively cheaper and durable these attributes are not significantly different from alternate packaging including cotton.

Of all bale wrapping materials only cotton presents as contamination-free packaging. As well as being zero-risk in terms of contamination cotton wrap material is also favoured by spinning mills in terms of ease of disposal. Polyethylene film (plastic) is reasonably low-risk in that it does not separate out into fibres and is more easily removed in mill cleaning processes. Polypropylene and jute are however difficult to remove and easily incorporated into yarn and fabric because of their fibrous nature.

Despite cotton being the least durable of the bale wrap materials, the majority of the world's cotton producing nations use cotton as bale wrapping. For Australia, which sends the bulk of its cotton overseas, the issue of cotton's low inherent strength compared with alternate wrapping materials can be addressed by specifying heavier woven cotton fabrics. This adds some cost to the wrapping material but ensures that bales delivered overseas are able to maintain their appearance during delivery.

Cotton, jute and woven PP also allow the cotton to equilibrate (breathe) to ambient conditions. A sealed PE bag is the only packaging that will retain, for better or worse, the moisture that is in the cotton when the bale is pressed. Very careful moisture management through the gin must prevail to preserve the quality of cotton in PE bags.

## Bale Warehousing

The best warehouses are those that are fully enclosed and both clean and conditioned. Conditioned warehouses ensure the best returns for merchants (the warehouse owner or user) and spinners alike. The type of warehouse conditioning that can be used is dependent upon the local climate. In dry, hot areas evaporative cooling (and conditioning) represents one of the best options as the water transition to vapour is dependent upon the existing ambient conditions. Water sprays must be used very carefully, similar to their application in baling. Serious quality issues can arise in the baled cotton if excess amounts of water are allowed to be sprayed. Where warehouses are located in sub-tropical or tropical areas no conditioning is required, only protection from water. Figure 13.7 shows cotton and jute hessian wrapped bales in a typical Australian bale storage area.



**Figure 13.7:** Correct warehousing of cotton bales is important to maintain quality. (Photo: CSIRO).

## Classing

Most cotton today is still 'classified' for quality using a classer's subjective assessment against a physical grade sample, e.g. like the United States Department of Agriculture (USDA) physical grade boxes. Unfortunately, the value attached to cotton from this type of classing does not enable spinners to properly assess the value of the cotton they buy. Thus demand from modern spinners and retailers, largely affected by cost pressures, has generated the need for all cotton to be rapidly and objectively measured. A resolution to extend this message to the cotton world was recently made by the international cotton industry through the International Cotton Advisory Committee (ICAC). The resolution also has a significant role in maintaining cotton's position in the textile world against man made fibres (MMF). Well specified cotton will be in a better position to compete with new MMF. Whilst exporting countries such as Australia, USA and Brazil have long classified their fibre using high volume automatic testing systems, other countries are now being encouraged to apply objective testing. The instrument systems, termed high volume instruments (HVI), give the cotton spinner valuable and transparent information about the fibre characteristics of every bale of cotton they purchase or intend to purchase. Figure 13.8 is a photo of HVI classing lines in Australia. This ensures growers are paid on the performance qualities of their fibre. For spinners, HVI results are used to maintain product consistency in cotton blended from bale laydowns in the mill ensuring in processing and yarn quality.

---

If Australia is to maintain its reputation as a consistent supplier of high quality cotton it needs to ensure that the Australian classing facilities consistently specify their cotton. To this end the Best Management Practice (BMP) for classing has been implemented to ensure that all classing facilities comply with the industry standards.

### Further Reading

Anthony WS, Mayfield WD (1994) 'Cotton Ginners Handbook', USDA ARS Publication No. 503.

Anthony WS (2004) Moisture management practices at gins. In Proceedings Cotton Incorporated Engineered Fiber Selection Conference (Greenville SC).

Anthony WS (1999) Post-harvest management of fiber quality. In 'Cotton fibers: Development biology, quality improvement and textile processing', Basra AS (ed.) (Food Products Press, Binghampton NY) pp.293-333

Anthony WS (2006) The harvesting and ginning of cotton. In 'Cotton: Science and technology' Gordon SG and Hsieh YL (eds.) (Woodhead Publishing, Cambridge) pp.176-201

Commercial Standardisation of Instrument Testing of Cotton (CSITC) transactions <http://www.icac.org/>.

USDA AMS (2001) 'The Classification of Cotton', Agricultural Handbook 566.

CCAA (2007) 'Best Management Practice Classing Handbook', version 6.0.



**Figure 13.8:** Modern classing rooms use both traditional classing methods and HVI to grade cotton and establish fibre quality traits essentially for marketing and for spinning mill requirements. (Photo: CSIRO).