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COTTON DEFOLIATION

Before mechanical cotton pickers were invented, the requirement for hand harvesting was only the opening of bolls. This allowed the greatest preservation of natural cotton fibre properties and yield. On Australian cotton fields where mechanical harvesters gather up the seed cotton, the leaves must be removed from the plant to prevent contaminating the lint. This preparation is known as defoliation.

An October sown crop will show first open bolls around mid-February. The rate bolls open is temperature dependent, ranging from 2% to 3% per day and up to 5% as boll opening progresses. Cooler, short season areas such as the Central Downs and Breeza Plain will be slower than other areas.

Conditioning (or defoliation) usually should occur when the top harvestable boll is mature. The two common methods used to determine boll maturity include first examining seed maturity inside the developing boll, and, second, the nodes above cracked boll (NACB) method.

In some years with ideal growing conditions, some degree of vegetative growth control may be necessary mid-season to ensure the plant remains manageable for later pesticide and defoliant applications, and picking. The use of a growth regulator, applied once or as a lower rate split application, may be warranted under these conditions.

Terminology

The basic terminology is worth defining before discussing the tools and strategies of this facet of cotton production.

Conditioning and/or defoliation (by artificial means) describes a management practice which aids the formation of abscission layers in the leaf petioles and results in the desiccation or shedding of foliage earlier than would have occurred naturally. It artificially prepares a crop for harvest. Chemicals used to condition and defoliate include dimethipin (Harvade®), and thidiazuron + Diuron (Dropp Ultra®) for cool conditions, thidiazuron (Dropp WP®) for hot conditions, ethephon (Prep®), ethephon and AMADS (CottonQuick®) and ethephon + Cyclanilide (Finish®).

KEY POINTS:

Defoliation

- **Hot temperatures are best for more effective defoliation results.**
- **Optimum timing of defoliant spray is important for efficient defoliation and to maximise lint quality.**

Contamination

- **Careful management, good agricultural practices, harvest crew induction and attention to harvest hygiene are essential to contaminant-free cotton.**
- **Failure to follow basic guidelines could prove costly.**

Picking

- **Secure contractor early.**
- **Coordination and planning equipment and staff is essential .**

Desiccation or the rapid drying and death of foliage is often used to describe conditioning and defoliation. Desiccants include diquat (Reglone®) and paraquat plus diquat (Sprayseed®), and sodium chlorate (Atlacide®, Leafex®).

Plant growth regulators are compounds applied directly to a target plant to alter its phenology or its structure to improve quality, reduce disease risk, increase yield or facilitate harvesting. Mequat chloride (PIX®) and ethephon (Prep 720®) are the only growth regulants used in cotton.

A synergist is a chemical which increases the action of another e.g. Endothal (Accelerate®).

A wetting agent is a substance that by reducing the surface tension of a liquid allows it to spread on the leaf surface or penetrate the leaf cuticle e.g. D-C-TRON.

Objectives

From March through to May each year, cotton growers in the various growing areas, covering both short and long season districts, begin the defoliation process to:

- Remove the leaf canopy or foliage to allow more efficient operation of mechanical pickers
- Promote earlier picking
- Eliminate material that could stain cotton fibres
- Reduce the trash content of seed cotton.

When to defoliate

The aim in timing a defoliant application is to apply the material when the crop is physiologically mature. Physiological maturity is defined as that time when the crop has put all available nutrients into its reproductive tissues and has started to slow its transpiration rate prior to natural senescence.

Physiological maturity is determined by several well accepted methods. The first is by examining seed maturity inside the developing cotton boll. Bolls that are difficult to cut using a sharp knife and show no "jelly" within the developing seed will be harvestable after a defoliant is applied. The seed coat (on a cross section) should be turning brown (seen as a distinct brown ring within the immature seed coat). The second well accepted method is the "nodes above cracked boll" method. This method shows that the last harvestable bolls occurs 4 nodes above the most recently cracked (opening) boll.

Defoliating when the crop is physiologically mature is a more reliable method than the previous reliance on a percent open boll threshold. The relevance of this method is greatly influenced by the length of the fruiting period. A crop set over a six week period might incur a yield penalty if defoliated at 65% open, while one set in three weeks might be safely defoliated at 40 to 50% open because all bolls are maturing at approximately the same time. Percent open bolls may be used as a guide but should not be used as the sole criteria in determining when to commence defoliation.

When determining crop and plant maturity, all of the above methods should be used in conjunction with each other to select the correct time for defoliant application. Ideally defoliation should commence when the last desired harvestable boll is physiologically mature.

Boll opening

Modern cotton production has worked towards a single picking. The economics of second picking cotton have to be carefully assessed. Boll openers like ethephon (Prep720®) and defoliation enhancement products like CottonQuick® and Finish®, help speed up the time required for all the bolls to open. These products will open immature bolls as well so they should not be applied too early.

HOW

The grower, keeping these objectives in mind, can assess the particular techniques required to successfully pick the crop confronting him. The questions most commonly asked involve - whether one or two defoliant sprays are needed; is a pre-conditioning spray going to benefit? When should the first application be applied? What chemicals should be used? and how long after the first spray should the second one be applied?

The major problem situations are:

1. Lush rank crops where sufficient mature bolls exist and the grower feels the need to defoliate.
2. Crops with extremely heavy boll loads that have lodged creating thick impenetrable canopies.
3. Late crops where the grower has anticipated a better top crop and faces cold temperatures.
4. Frosted crops also present special problems.

These situations are special events and may require specialist treatment, however for the industry generally, several classes of crops can be briefly discussed here in relation to defoliation techniques.

Perhaps the easiest crop to defoliate is the one which has "cut-out". Vegetative growth has ceased, natural senescence has started to occurr and abscission layers are clearly defined. The whole canopy being reasonably uniform can usually be successfully defoliated using a single application of Dropp Ultra®, or sodium chlorate (known here as Chlorates). The grower has merely to check that the top bolls are mature. The crop that completely cuts out may be one where soil nitrogen was depleted early or successfully managed so as to run out in March. Alternatively drought or mite damage can produce partially defoliated crops.

A second, and common, crop situation is where lower bolls are opening while the top bolls are firm and surrounded by an active canopy. Some growers use two applications of chlorate in this type of crop. The prerequisite for the first application is that the top bolls are mature. The second spray may follow in 7 to 14 days depending on the quality of the first spray. An alternative technique is to use Dropp Ultra® or Dropp WP® depending on temperatures. These chemicals can be used at varying rates or mixes to create numerous degrees of defoliation.

Never mix a defoliant with a desicant and never follow a desicant with a defoliant.

A common practice is to apply a moderate rate once the top bolls are mature followed some 7 to 10 days later with a chlorate spray, or Prep 720®, CottonQuick® or Finish®. The initial spray is known as a conditioning application and aids in the formation of abscission layers in the leaf petioles. By moving through a field and assessing the ease with which leaves can be made to fall from the bush, the timing of the second spray can be easily determined. Once the lower leaves have been exposed the second application can easily reach these lower leaves.

The need for two applications of a defoliant may exist where ever a big crop is grown, though not necessarily rank and active, and where there is a necessity to obtain better defoliant penetrations to lower leaves.

A third crop situation encountered, particularly on new fields and high nitrate soils, is the rank crop. The use of PIX® should be considered in season in the management of these crops. In these situations the grower needs to identify the top harvestable boll and ignore those bolls that won't mature by harvest. Once the top harvestable boll is mature defoliation can proceed. A crop of this sort may have 45% of the bolls open while still producing luxuriant top growth. One technique for managing this predicament would be the initial application of a low rate of defoliant to slow down the crop and encourage the plants towards maturity. Around 7 to 10 days later a higher rate of defoliant can be used which will further induce hardening of bolls and formation of abscission layers. The final defoliant spray can usually follow some 10 days later and may be a chlorate application.

Partially irrigated crops and dryland crops that have suffered moisture stress are sometimes very difficult to defoliate. High rates and a change to desiccants are sometimes necessary to prepare the crop for harvest. Crops that are to be harvested by stripper pickers must be defoliated completely to prevent lint staining and dockages.

The adherence to a set defoliant 'recipe' no matter what the conditions are like should be avoided. Each crop, because of its different cultural and agronomic history, will need to be judged on a field by field basis. Temperatures at time of defoliation will also influence rates and product selection.

Various mixes and chemicals can be used, including Dropp Ultra® Dropp WP® Prep 720®, chlorates, CottonQuick® and Finish®.

Dimethoate is sometimes mixed with the defoliant to control aphids whose "honey-dew" can adversely affect the fibre quality. Past experiences have indicated that mixes with chlorate should be avoided. Care should be taken when tank mixing products. For example, mixing organophosphates and sodium chlorate can cause an explosion.

Mixtures of Dropp®/Prep® with Glyphosate have been used to successfully defoliate cotton. This mix can be used as a single spray system or as a second hit mix. The Glyphosate is effective in reducing regrowth and green staining while providing a degree of weed control if required.

Chemicals which enhance the activity of conventional defoliants are now widely used. The most common additive is a derivative of ethephon (Prep720®) and is most often used in a mix with the first or second application. These additives have negated the use of a following chlorate spray. The use of surfactants can also improve the defoliation job.

Desiccants are sometimes used in cotton defoliation, the most common chemicals being diquat or Sprayseed® (ground rig application only). Frost frozen crops can be made to "pop" open using desiccants. The major danger with this form of chemical is that leaves tend to be "frozen" onto plants because of the very rapid death which can lead to increased trash problems.

Numerous other substances have been used for defoliation in the past. Cacodylic acid, calcium cyanamide, dithiin tetraoxide, ammonium nitrate and anhydrous ammonia have all been used. These compounds need to be assessed in the light of the objectives of defoliation.

ISSUES

Successful defoliation is not a foregone conclusion. The problems and factors which need consideration include:

(a) Defoliation enforces a cessation of further fibre and seed development

(b) Excessively early defoliation can inhibit the opening of immature bolls

(c) Desiccated leaves can create increased trash problems

(d) Frosts can cause leaf and boll "freezing"

(e) Rain following a defoliation spray may create variable results

(f) Cool weather or active plant growth will retard the rate of the defoliant activity

(g) Spraying is most effective when wind turbulence will allow greatest movement of chemical around the lower plant parts. Large droplet size will favour the shock effect of the chlorates, swarth widths are usually reduced when applying defoliant.

(h) Both the over or under use of defoliants can represent an adverse economic cost.

(i) Drift of defoliants onto trees and other vegetation must be avoided to prevent damage.

(j) In dryland situations especially skip-row configurations there is an excellent opportunity to use a ground rig for defoliation. Final coverage is very important and a minimum of 100 litres per sprayed hectare should be used.

SUMMARY

Many factors control the success of a defoliation application. They involve plant growth, weather, spray coverage, chemical degradation, chemical absorption and translocation which contain both controllable and uncontrollable inputs for the grower. There is a need to produce manageable crops where nitrogen run-out can be controlled. This task becomes easier after several seasons of cropping.

Finally, when the cotton producer confronts the crop at defoliation time, an assessment of the objectives, the grower's needs and the tools and techniques available has to be made to successfully pick Australia's high quality cotton crop.

CONTAMINATION OF COTTON

Contamination of cotton with foreign substances lowers the value of the product and often causes problems and increased costs for those processing the cotton at both the ginning and spinning mill stages.

Contamination occurs in many ways. There are natural agents such as leaf, bracts and bark which occur at the harvesting stage, excessive green leaf causing discolouration and sometimes spotting, weed contamination – especially burrs and grass which are harvested with cotton, and honey dew produced by aphids which causes a sticky sugary substance to foul the cotton.

Many of these natural contaminants can be avoided with careful management and good agricultural practices both prior to and during harvest. Rain on a crop which is ready for harvest can often exacerbate the cleaning of these natural contaminants especially leaf and bract trash.

Picking cotton which is too moist, particularly when that cotton may be stored in a module for some time, can lead to sweating and subsequent discolouration or spotting. Thus, moisture can also be regarded as a contaminant. Picking too early when the dew is on the cotton or picking too late into the night when the moisture level rises can lead to deterioration in quality.

There are also man made contaminants. Synthetics such as plastic and twine, oils used in module builder hydraulics, grease from spindle and bar lubrication in picker heads, and food wrappers and drink bottles from equipment operators, can also find their way into a grower's module. Mostly these man made contaminants can be eliminated. Failure to clean the grids on the tops of picker baskets often means that dirty, immature fibre is dumped into a module of high quality cotton thereby threatening to reduce the value of some bales from that module.

From time to time gins find pieces of metal and equipment in modules which can damage ginning equipment and cause fires within the gin.

Contamination also occurs from the failure to properly protect modules from the elements. A range of tarping materials is used and generally the ginners find that the well designed, fitted tarps provide the best protection. Many growers only see their modules on-farm following construction. During transport to the gins modules are often stretched and covers and ropes dislodged. In the yard ginners often have to cover modules that arrive in poor condition or whose ropes and plastic sheeting have become dislodged. Rain and windy weather can lead to damage to the cotton if it is able to penetrate through torn or loose covers. Cotton contamination caused by moisture is a serious problem at the gin. As the cotton module is fed into the feeder head with spike rollers and drop down into the J where it is mixed with hot air in preparation for ginning, localised pockets of contaminated cotton are mixed and distributed contaminating the entire module.

All contaminants lower the value of the final product and can potentially damage Australia's reputation as a supplier of quality cotton. Problems caused by contaminants include:

1. Increased trash leading to a higher chance of pin trash and lower grades which reduces the value of the fibre.
2. Increased need for more lint cleaning which can affect fibre quality.
3. Reduced out-turn at the gins due to the sheer weight of trash and sometimes the loss of fibre caught up in burrs and sticks.
4. An increased risk of gin fires due to rubbish causing sparks, or increased rubbish leading to tags at the gin stands and often gin stand rib fires.
5. Grass and bark in cotton is difficult to completely remove since it becomes shredded during ginning and behaves just like fibre. Spinning mills too, find it hard to remove and often the fibres go right through to the final product. The cost of bark and grass can be high. For example: Middling light grass can be discounted by $20 per bale while light bark bales can be reduced in value by $30. Heavy bark sees the discount rise much higher.
6. Plastics, especially ones that shred and form into fibres, such as bailing twine, can lead to synthetic pieces appearing in fabric. This often renders the product useless or of considerably less value. A claim on the processor or merchant, often many times higher than the value of the bale, can often result.
7. Excessive green moist leaf in the module can lead to spotting which lowers the value of the module. For example, a light spotted bale can be discounted up to $24 per bale. At 7.5 bales per hectare this equates to $180 per hectare lost! In cases where the spotting becomes severe a spotted middling cotton can be discounted by around $70 per bale. On a 7.5 bale per hectare crop this amounts to $525 per 100 hectares.
8. Honey dew causes problems for the spinning mills. Instead of being able to draw thin strands of fibre, the honey dew causes the cotton to stick to spinning equipment causing breakages and uneven yarn. It will also affect dye uptake. Discounts for honey dew can be extremely high.
9. Oil, grease and other contaminants which discolour the cotton lead to uneven dyeing and can leave off-coloured threads in the finished fabric. Oil gums up spinning equipment and contaminates fibre being drawn into fine yarn.

Australia is recognised as having the highest standards in the world in the cleanliness and freedom from contamination of its cotton. This standard must be maintained and the responsibility for keeping Australian cotton clean and contamination free rests with everyone involved in growing the crop, preparing it for harvest, harvesting and module construction, transport to the gin, ginning and shipping to the mill. Contamination can occur at any one of these steps.

By far the largest contribution to contamination occurs at harvesting and module building time. A site inspection prior to putting down a module is a must. Rocks, a common form of contamination, can be avoided if an inspection is carried out. Often contamination occurs because of ignorance. The actions of people involved at harvest time can often inadvertently lead to substantial down grading of a grower's cotton. The lunch bag that blows into the module builder, the bailing twine that is used instead of proper rope on tarps can often badly contaminate a module, the leaking module tramper ram that is left unattended can result in severe oil contamination.

Plastic and other synthetics which become shredded and mix in with the lint can render garments unsaleable or heavily discounted and the cost to processors and growers can be many times the value of the bale. Often these substances are on the ground before a module is built – a piece of rag, remnants of a fertiliser bag, a piece of wire – and the module built on top of them is contaminated. A site inspection before putting down a module can prove very useful. Providing crews with a garbage bin in which all waste is thrown can also be beneficial.

All module building crews should be trained to watch out for contaminants. Make them aware of the potential problems and provide them with the facility to clean up and isolate rubbish. When ground crews sweep up cotton that has spilled around a module make sure they don't sweep up contaminants or excessive dirt and place it in your module.

Failure to clean the top grids on a regular basis leads to unwanted waste and very dirty cotton getting in with the more valuable lint from the basket.

Keeping Australia's high quality cotton contaminant free is essential – it is the responsibility of all involved from growing through harvest to shipping to watch out for contamination.

HARVEST

Picking

Cotton picking is a specialised operation requiring two machines, a spindle picker or stripper harvester, and a module builder. Many current growers are fully equipped for owner operation whilst new growers need to decide on buying machinery or using a contractor.

For new growers, the use of contract harvesters is recommended. It is difficult to justify the purchase of harvesting equipment, particularly if the enterprise could be abandoned after one season. For those with longer term intentions, fully reconditioned pickers are available but used module builders may be scarce for those wanting to purchase their own equipment. Another option is to form a pool arrangement and share with other new growers.

Moisture content in the cotton determines the start of picking, the length of picking day (early starts and late finishes) and (failing breakdowns) the uninterrupted continuation of picking until harvest is completed.

Harvest should commence when the moisture content drops below 12%. A moisture meter can be used or the seed can be bitten: it will crack if ready for harvest.

Excessive moisture in cotton causes spindle wrap (difficult for the gin to handle) which leads to lower out-turns, lower quality cotton and lower returns to the grower. Spindle wrap will also lead to a very poor picking job, it could also cause head chokes which are a major cause of fires.

Wet cotton in the module also results in increased temperatures with a subsequent deterioration in both the quality and quantity of cotton ginned. Quality loss depends on how wet and for how long the wet cotton remains in the module before ginning. Wet cotton is also more likely to result in cavitoma caused by microbial degradation of fibre.

Wet harvests have shown that the decision to start, and/or continue picking is not that simple. There will always be trade-offs between the chance of further rain versus getting the crop off, and the damage this can cause if cotton is too wet. Growers need to be aware that picking well into the night may be good in terms of completing harvest, but disastrous in relation to potential quality damage.

The spindle picker

Spindle picking is generally the slowest and most expensive way of harvesting cotton.

Spindle pickers have the advantage of being able to operate under a wide range of crop conditions and in both high and low yielding crops, generally producing higher out-turns (less trash). In high yielding crops, spindle pickers are superior to stripper harvesters.

A great deal of care and attention should be paid to setting up a picker and maintaining these settings during harvest. At all times follow the manufacturer's instructions. Correct height adjustment of the picker heads, and proper adjustment of pressure doors, doffers and moisture pads will guarantee efficient picking and result in better quality and greater quantity of cotton harvested.

Cleanliness of the picker basket is very important. The top of the basket and grid bars should be cleaned regularly to avoid contamination of clean cotton as it is emptied into the module builder. Chute doors should be cleaned regularly to prevent build up of mud and rubbish which can cause blockages in the chutes and possibly lead to a fire in the heads or in the basket. Failure to clean leads to dirty cotton, more pin trash, lower uniformity ratios, lower micronaire, lower quality and thus lower returns to the grower.

Stripper harvesters should not be used to second pick a spindle field, as the quantity of trash makes it impossible to gin.

Extreme care is necessary when setting up pickers whilst heads are engaged or when operating any machinery near power lines.

The stripper harvester

Stripper harvesting is generally the cheapest way of harvesting dryland cotton.

Stripper harvesters must be fitted with pre-cleaners.

Stripper harvesters can harvest both high and low yielding crops. On crops of less than around 3.5 b/ha, they are cheaper to operate than spindle pickers. In lower yielding crops a higher proportion of the bolls, those more

difficult for spindles, will be harvested resulting in a higher yield.

Stripper harvesters have a lower out-turn than spindle pickers (29% to 32% compared to 36% to 38%), and cotton may be a half grade lower ($14 discount per bale) compared to spindle pickers. In some instances there has been a full grade difference. There is a higher risk of lower micronaire as more immature bolls may be harvested while excessive bark can also result in a discount of $20 per bale.

MODULES AND IN-FIELD HANDLING

Modules are an aspect that some growers pay a lot of attention to and others very little. Even, well compacted, consistent modules, dome shaped on top to shed water, should be the objective.

Properly built modules are easier to move, shed water, don't break apart, contain more bales and are thus cheaper to transport per unit.

Modules should always be built in flood free areas, free of rocks, with easy truck access and never built under or adjacent to powerlines. Ideally they should be on mounded compacted pads with all weather access a further advantage.

At no time should an operator work on or in a module builder when the harvester is unloading.

Avoid contamination of any kind. Regularly check hydraulic fittings. Blown hoses can spray oil over the module, contaminating the cotton causing severe downgrading. Other contaminants, particularly plastic in the module will also cause severe downgrading.

Module tarp covers are an item commonly overlooked by growers. In some cases, this can be an expensive oversight conservatively costing the grower between $50 and $60 per bale due to downgrading of cotton during a wet harvest.

Tarps are designed to protect modules in the field. Modules can be valued at anything from $8,000 - $10,000 and up to $15,000 depending on the price of cotton. Skimping on module covers can easily cost far more than the value of the tarps in downgrading during a wet harvest.

Tarps should be checked annually for holes and either repaired or replaced. Old tarps should also be inspected to ensure that they are not worn out and that the weave is still in good condition and not starting to let go.

Poorly built modules tend to be flat on top encouraging water to pool during a wet harvest. If tarps are holed, or old or worn out, water seeps into the cotton resulting in losses through rotting, heavy spotting and contamination resulting in severe downgrading.

Care should also be taken with the way tarps are tied down. Ropes tend to channel water into the module. It is best if ropes are covered by flaps to prevent this problem. Modules should be sited away from floodways and areas of poor access after rain.

Module handling is a relatively expensive operation which is organised by contractors. Costs are made up of the module lift plus one way distance of travel to the gin. Chain beds are used for short hauls. Flat beds and in-field loaders are more economic for longer hauls.

Left: Harvesting dryland cotton.

Right: Module makers in the field

Left: Cotton classing using the latest High Volume Instrument (HVI) system.

Right: The traditional method of classing cotton.