Application of Cotton Defoliation Aids in Alabama

► **The use of defoliation products can improve the harvest efficiency, yield, and fiber quality of cotton. Learn the applications that are best for your crop.**

Cotton defoliation is a process that naturally occurs when cotton plants shed leaves at maturity. Various environmental factors, insect pests, pathogens, nematodes, etc., also can induce leaf shedding, often prematurely. Similarly, boll opening is a natural process that occurs as the crop matures.

Cotton producers typically expedite the processes of defoliation and boll opening through applications of harvest aids. Harvest aids serve multiple important functions, including leaf removal, regrowth inhibition, and boll opening, thereby minimizing boll rot and increasing air movement and lint drying. The ultimate goal is to improve harvest efficiency, yield, and fiber quality.

Chemical defoliation is often a mix of art and science. The objective of defoliation is not to kill leaves on the plant (which results in desiccation) but rather to get the plant to accelerate the formation of leaf abscission layers throughout the plant canopy.

An abscission layer is created where the leaf petiole (stalk that supports the leaf blade) meets the main stem or branch. Specialized cells at this junction of petiole and stem produce enzymes, which dry up the cells in this layer and sever the connection to the plant, causing leaves to shed. Desiccation or “stuck” leaves can occur when application rates are too high given current environmental conditions. Successful defoliation requires the consideration of several factors.

Factors that Influence the Defoliation Process

Condition of the Crop

Plants that are mature, uniformly fruited, and have expended resources typically are much easier to defoliate than those that are stressed or, conversely, rampant and aggressively growing. Drought-stressed plants can be difficult to defoliate due to thick leaf cuticles. They often are inactive, and leaf uptake of defoliants is

inhibited. Regrowth potential is usually high in drought-stressed cotton due to remaining nitrogen reserves. Regrowth and juvenile growth can be especially difficult to remove.

Plants with aggressive growth due to excess nitrogen, rainfall, or irrigation may have lush canopies and be more prone to stuck leaves. These plants require careful application rate and product selection.

Weather Impacts

Pay close attention to current and future weather forecasts when preparing to apply harvest aids. Efficacy can be critically influenced by weather conditions at application and at 3 to 5 days following application.

Warm, sunny days at application and several days following typically produce greater success in leaf removal and boll opening. Cotton plants tend to be more active during these conditions than during extremes. Defoliation during excessively high temperatures (greater than 90 degrees F) may cause desiccation, and caution should be exercised when determining application rates. Rainfall incurred within 3 to 12 hours following an application can minimize the effectiveness of certain harvest aids (table 1). Prolonged cloudiness along with cool temperatures typically reduces the effectiveness of defoliants. Most defoliants and boll openers do not work well below 60 degrees F, and application rates should be increased during cooler temperatures. See "Defoliation Scenarios" for common product and rate combinations for varying temperatures.

Timing

Determining when to apply harvest aids is critical. Applications that are made before a crop is ready can result in lower yields and reduced fiber quality. Defoliating too late can have negative impacts as well. Lint loss due to weathering, increased lint stain, and increases in boll rot can occur when delaying defoliation beyond the optimal timing. Several methods are commonly used when determining proper defoliation timing:

- percent open boll
- node above cracked boll (NACB)
- sharp knife technique (slicing bolls)

Percent open boll is the most common method used when determining defoliation timing. As a general rule, when a crop is 60 percent open, it typically is safe to defoliate. Exceptions can occur due to crop conditions and variety.

The percent strategy works best in crops that have uniform fruit distribution. Cotton plants that have fruiting gaps due to insect pressure or stress can result in a high proportion of immature bolls. Defoliating at 60 percent open in this case would likely disrupt fiber development prematurely and reduce yield and micronaire (mic).

Some varieties have the tendency to produce high mic, some low mic. Defoliating at 60 percent may be too early for some varieties that have the potential for low mic. Conversely, waiting until 80 percent open may be too long for varieties that have the potential for high mic. For more insight on micronaire and other fiber characteristics, see *How to Think About Cotton: Fiber Quality* (Extension publication ANR-2637).

Determining percent open needs to be validated by actually counting open and closed bolls at several locations in the field. Trying to determine percentage of open bolls from the truck cab is often inaccurate. Select ten different locations within the field and measure 3 feet of rows. Count the number of open and closed bolls within the 3 feet at each location to accurately determine percentage of open bolls.

Nodes above cracked boll (NACB) is another method that can be used to properly time defoliation applications. Using this method requires finding the uppermost first position of a cracked boll. When there are harvestable bolls no more than four nodes above this uppermost first position cracked boll, then it is generally safe to defoliate. There may be times when more than four nodes above the cracked boll are fully mature and ready to defoliate. This can be determined best by slicing bolls with a sharp knife. This is known as the sharp knife technique.

The sharp knife technique should be used to validate both percent open and NACB to truly gauge defoliation timing. Using this method entails locating the uppermost harvestable boll that significantly contributes to yield. This boll typically is located a few nodes down from the top of the plant. It is important to be realistic when locating the uppermost harvestable boll. Do not select small, knotty bolls that will require a long time period to mature and will contribute little to overall yield.

Once the uppermost harvestable boll is located, cut across the boll with a sharp knife. When bolls are difficult to cut, have folded cotyledons that have progressed beyond the "jelly" stage, and have darkened seed coats, then it is safe to defoliate. Like other methods, it is important to check several places in the field, since maturity within a field may vary.

Bolls arranged left to right from least mature to most mature. The last two bolls on the right are safe for defoliation. Photo by Darrin Dodds

Application Considerations

Spray coverage is key when applying defoliants and harvest aids; therefore, nozzle selection and water volume are of vast importance. Application of harvest aids should be made at no less than 15 gallons per acre by ground and 5 gallons per acre by air. Hollow cone nozzles generally are preferred for ground applications and typically provide better coverage than other nozzle types. Flat fan nozzles also can provide acceptable results but tend to provide slightly less coverage than hollow cones. Nozzles that produce large, coarse droplets (such as air induction nozzles) should be avoided for harvest aid applications.

Most cotton is ready to harvest approximately 10 to 14 days after harvest aid application. Leaf drop generally commences at 4 days and is complete at 10 days. Bolls may be fully open as early as 7 days after treatment, though additional time is normally required. To avoid weathering and fallout, base the number of acres to be defoliated on harvest capacity. As soon as the crop is ready, proceed with harvest.

Types of Defoliants

Defoliants generally are grouped into two categories: herbicidal or hormonal. Defoliants with herbicidal activity include Folex, ET, Aim, Sharpen, and related generic products.

Herbicidal defoliants injure leaf tissue, resulting in the production of ethylene. Ethylene is known as the ripening hormone. It aids in forming an abscission layer, resulting in leaf drop. Lower rates of these defoliants should be used in warm to hot temperatures. If application rates are too high for a given temperature, desiccation “leaf stick” (resulting from leaf injury and death) often occurs before ethylene induces the formation of an abscission layer. Some products contain both herbicidal and hormonal activity, namely Ginstar (and similar generic products).

Hormonal defoliants include thidiazuron, Ginstar, Finish, and ethephon. Ethephon promotes ethylene production within the plant, which causes the formation of an abscission layer on leaf petioles and in boll walls. Thidiazuron contains the plant hormone cytokinin. Cytokinins typically produce leaf health in plants, but high concentrations in cotton produce ethylene. Since these products are hormonal, desiccation typically is less likely to occur as compared to herbicidal defoliants.

You will find a list of products, rates, and use patterns in table 1 and replanting restrictions in table 2.

Common Defoliation Materials

Folex 6 EC (phosphate-type materials containing tribufos). These products have been used for years, are regarded as standards, and have a strong organophosphate odor. They work well over a broad range of environmental conditions and temperatures. These materials are excellent at removing mature leaves but do not inhibit regrowth or open bolls. Activity on immature or juvenile leaves is only mediocre. These products work rapidly. Rates should be selected carefully in hot temperatures to avoid leaf stick. Use of surfactants should be considered only if extreme cold conditions exist.

Ginstar, Cutout, Adios (thidiazuron + diuron). These are combination products that provide good defoliation and excellent regrowth inhibition. They work well in warm and cool temperatures and effectively remove both mature and immature leaves. They have been regarded as go-to defoliants for the Tennessee Valley region of Alabama and typically are tank-mixed with ethaphon or Finish 6 Pro to enhance boll opening. Leaf stick can occur if rates are too high or when mixed with other herbicidal defoliants under hot conditions.

Thidiazuron-TDZ (Dropp, Daze, Freefall, others). These products provide good defoliation of mature leaves and juvenile growth and inhibition of regrowth. Activity is slower with these products as compared to Folex, and they are more sensitive to cool weather. Temperatures below 65 degrees F at night can result in less than optimal defoliation. These products also require a 24-hour rain-free period after application for maximum performance, but uptake can be enhanced (and rain resistance improved) with the addition of tribufos (Folex). Folex often is tank-mixed with TDZ products to expedite leaf removal and to reduce the rain-free period needed for TDZ alone.

Aim EC (carfentrazone), ET (pyraflufen ethyl), and Sharpen (saflufenacil). These are low-use-rate PPO herbicide products that provide activity over a wide range of environmental conditions. They typically are used as cool/cold weather treatments or second-pass defoliants.

These products provide good to excellent removal of juvenile growth but do not inhibit regrowth. They contain no boll-opening activity. Use of these products in a first-pass scenario or during hot temperatures often can result in desiccation. Adjuvants are needed with these products. Aim needs the addition of 1 percent v/v crop oil, while the ET label states that 0.5 to 1.0 percent crop oil is required. Sharpen requires the addition of 1 percent v/v methylated seed oil (MSO).

Common Boll Opening Materials

Finish 6 Pro. This is a combination product containing ethephon plus the synergist cyclanilide. It promotes boll opening and aids in leaf removal through the formation of abscission layers on leaf petioles and boll walls. This product typically is tank-mixed with other defoliants such as Folex, Ginstar, or TDZ. Finish also can be tank-mixed with other ethephon products.

Ethephon 6 (many products). This is the standard product for opening bolls. Boll opening usually occurs 10 to 14 days after application but is dependent upon rate and environmental conditions (temperature and sunlight). Best results are achieved when ethephon is applied during periods in which night temperatures are above 60 degrees F. Day temperatures between 65 and 75 degrees F will require twice the rate of ethephon to produce the same speed and degree of boll opening as an application made at temperatures between 85 and 95 degrees F.

Ethephon can be and is typically applied in combination with defoliants to achieve leaf removal and boll opening with the same application. Good coverage on bolls is necessary for optimal results. Dense canopies may impede coverage to bolls, requiring a second application or an application after leaves have been removed.

Table 1. Use Pattern and Expected Activity for Defoliants

Harvest Aid[1]	Labeled Broadcast Rate/Acre	Max Use per Season	Rain-free Period (Hours)[2]	Preharvest Interval (Days)	Estimated Min Temp	Mature Leaves	Juvenile Growth	Regrowth Prevention	Boll Opening
Thidiazuron SC	1.6–6.4 oz	9.6 oz	24	5	65° F	Excellent	Excellent	Excellent	None
Ginstar	6.4–16 oz	16 oz	12	5	60° F	Excellent	Excellent	Excellent	None
Folex 6	16–24 oz	24 oz	1	7	60° F	Excellent	Fair	Poor	None
Aim	0.5–1.6 oz	3.2 oz	8	7	55° F	Excellent	Excellent	Poor	None
Display	1.0 oz	2 oz	8	7	55° F	Excellent	Excellent	Poor	None
ET	1.5–2.75 oz	5.5 oz	1	7	55° F	Excellent	Excellent	Poor	None
Sharpen	2.0 oz	2.0 oz	1	5	55° F	Excellent	Excellent	Poor	None
Ethephon	21–42 oz	42 oz	6	7	60° F	Fair	Poor	Poor	Excellent
Finish 6 Pro	21–42 oz	42 oz	6	7	60° F	Excellent	Poor	Fair	Excellent

Source: 2019 Mid-South Cotton Defoliation Guide

[1] Addition of spray adjuvants may enhance defoliation during cold temperatures or when leaves are tough from drought-stressed conditions. However, adjuvants may increase leaf desiccation during the early season when temperatures are warm.

[2] Expected rain-free periods are estimates only and may or may not be exact. Other conditions, including temperature, moisture, and crop status, will play a role in product performance.

Table 2. Label Restrictions for Planting Small Grains Following Harvest Aid Application in Cotton	
Harvest Aid	**Small Grain Re-crop Interval**
Thidiazuron	14 days
Ginstar	1 month
Folex 6	None
Aim	None
Display	None
ET	None
Sharpen	None
Finish 6 Pro	1 month
Ethephon	1 month

Source: 2019 Mid-South Cotton Defoliation Guide

Defoliation Scenarios

Since cotton is grown from the Tennessee Valley to the Gulf Coast region within Alabama, vast weather differences may be seen on any particular day throughout the state. The scenarios that follow describe weather conditions at particular times. These events may occur simultaneously within the state depending on the growing region. The recommendations and situations are not exhaustive and are meant only to be a guide. Past experience and local conditions should always dominate when determining what harvest aids should be utilized.

Early Season, Warm to Hot Temperatures, Potential for Regrowth, One Application

- Thidiazuron 3oz/A + Folex 6 EC 4–6 oz/A + Ethephon 24–32 oz/A
- Ginstar or Cutout 4–5 oz/A + Finish 6 Pro 21–24 oz/A
- Ginstar or Cutout 4–5 oz/A + Folex 6 EC 4oz/A + Finish 6 Pro 21–24 oz/A
- Ginstar or Cutout 4–5 oz/A + Finish 6 Pro 12–16 oz/A + Ethephon 12–16 oz/A
- Ginstar or Cutout 4–5 oz/A + Folex 6 EC 4oz/A + Finish 6 Pro 12–16 oz/A + Ethephon 12–16 oz/A

Early Season, Warm to Hot Temperatures, Potential for Regrowth, Second Application Needed

Most growers within the state routinely plan to accomplish full harvest readiness with a single application. A second application is needed sometimes to remove remaining leaves, deal with late or lingering regrowth, and open additional bolls. The following recommendations reflect that type of scenario; that is, a follow-up treatment after any of the above combinations have been applied. If regrowth is an issue, products containing thidiazuron are preferable. If no bolls need to be opened, then ethephon-containing products can be left out.

- Folex 6 EC 8–12 oz/A
- Folex 6 EC 8–12 oz/A + Ethephon 16–24 oz/A
- Ginstar or Cutout 4–5 oz/A
- Ginstar or Cutout 4–5 oz/A + Ethephon 16–24 oz/A
- Thidiazuron 2–3 oz/A
- Thidiazuron 2–3 oz/A + Ethephon 16–24 oz/A
- ET or Aim: see labels for rate ranges

Mid- to Late Season, Cool to Cold Temperatures, Low Regrowth Potential

Depending on the crop condition at application, there may be a need for defoliants plus boll openers, defoliants only, or boll openers only during this time frame.

- Folex 6 EC 16 oz/A
- Folex 6 EC 16 oz/A + Ethephon 32–42 oz/A
- Ginstar or Cutout 5–6 oz/A + Folex 6 EC 6–12 oz/A
- Ginstar or Cutout 5–6 oz/A + Folex 6 EC 6–12 oz/A + Finish 6 Pro 32 oz/A
- Ginstar or Cutout 5–6 oz/A + Folex 6 EC 6–12 oz/A + Finish 6 Pro 16–21 oz/A + Ethephon 16–21 oz/A
- ET, Aim, or Sharpen (see labels for rate ranges) + 32–42 oz Ethephon

Since products do not work as well in cooler temperatures, a follow-up application may be needed. Folex, ET, Aim, and Sharpen typically are used in these follow-up scenarios. Additional boll opener may be needed but should be used in accordance with labeled rates.

Summary

- Harvest aid applications are a mixture of art and science, often more art than science.
- Harvest aid decisions should be made on a field-by-field basis.
- Previous and current experiences, crop conditions, and local weather conditions should guide decision-making.
- Adjustments should be made as the season progresses, as the prevailing crop response (i.e., the difficulty or ease of defoliation and boll opening) becomes apparent, and as the weather changes.
- Trying to save a dollar on defoliation oftentimes results in a mess and requires more money and time to fix.
- Defoliation results should be good but don't have to be perfect.

Tyler Sandlin, *Assistant Extension Professor*, and **Steve M. Brown,** *Extension Specialist* and Assistant Professor, Agronomic Crops, Auburn University.

For more information, contact your county Extension office. Visit www.aces.edu/directory.

New September 2020, ANR-2688

www.aces.edu