

Cotton defoliation is a complex production decision with many chemical options to choose from. Harvest-aids are utilized to prepare the crop for machine harvest, and timely defoliation and harvest of cotton can reduce weathering losses (yield and quality), and decrease trash in the lint. A basic knowledge of crop development and maturity as well as an understanding of the physiology of harvest aids is necessary in making decisions concerning defoliation.

Harvest Aid Functions: Harvest aids have four functions. Based on the time of year defoliation is occurring, all processes may not be necessary for cotton harvest. An understanding of these processes is necessary to determine appropriate products and rates. These functions are: 1) Removal of mature foliage; 2) Removal of juvenile foliage; 3) Boll opening; and 4) Regrowth suppression. The first two processes are considered defoliation. Defoliation is a natural plant process; however, in a cotton crop, leaf drop does not occur simultaneously throughout the canopy. Thus, to facilitate timely harvest, producers must manipulate the plant to drop its leaves in a short period of time. Auxin and ethylene are the two plant hormones involved in defoliation. Auxin promotes growth and prevents abscission, whereas ethylene is a ripening hormone that promotes abscission. Leaves fall from the plant once ethylene moves from the leaf to the base of the petiole to activate cell wall-degrading enzymes that form the abscission layer. Auxin and ethylene concentrations in the leaf are based on leaf age. Younger leaves have higher concentrations of auxin while older leaves have higher concentrations of ethylene. This makes older leaves more conditioned for defoliation, while young leaves might be more difficult to remove. Although higher rates of defoliant might be necessary to remove juvenile growth, it could also lead to desiccation and leaf sticking. An increase in ethylene from defoliant can also hasten boll opening, and regrowth suppression is necessary to prevent follow-up applications to control regrowth. Manipulating these hormones with harvest-aids will facilitate the leaf abscission process and also allow for boll opening and regrowth suppression.

Types of Defoliant: There are two main types of defoliant for cotton: herbicidal and hormonal. Herbicidal defoliant injure the leaf, stimulating production of ethylene. Hormonal defoliant increase the ethylene concentration in the leaves without causing injury. Specific examples of each type can be found below.

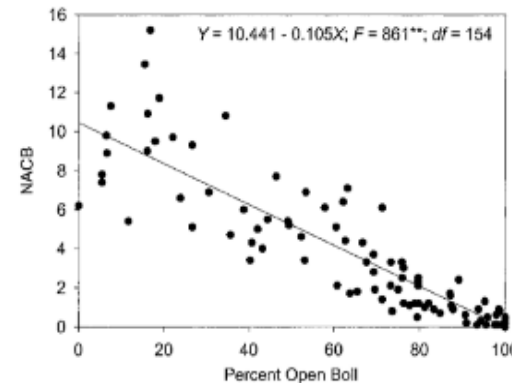
Herbicidal defoliant
Tribufos (Folex) – Injures leaf below the cuticle, causing stress and stimulating ethylene production.
PPO Inhibiting Herbicides (Aim (carfentrazone-ethyl), ET (pyraflufen ethyl), Resource (flumiclorac), Blizzard (fluthiacet methyl), Sharpen (saflufenacil), others) – Destroys cell membranes, causing ethylene production.

Hormonal defoliant
Ethephon (Prep, others) – Increases production of ethylene, leading to leaf drop and accelerated boll opening. Other ethephon containing products include Finish 6 Pro (ethephon plus cyclanilide) and FirstPick (ethephon plus urea sulfate).
Thidiazuron (Dropp, Freefall, others) – Enhances production of ethylene and inhibits auxin transport. Primarily used for juvenile growth removal and regrowth suppression. Ginstar is a premix of thidiazuron plus diuron.

Defoliation Timing: Determining when to defoliate your cotton crop is of the utmost importance, because defoliation timing can impact both yield and fiber quality. Poor defoliation reduces fiber quality, early defoliation reduces yield and micronaire, and late defoliation increases the likelihood of boll rot as well as reductions in yield and quality from weathering. Additionally, late defoliation can increase the likelihood of suboptimal defoliant performance due to lower temperatures. There are three primary ways to determine crop maturity and defoliation timing:

1. 60 to 75% open boll
 - 60% in a uniform crop ONLY
2. Sharp Knife
 - Using a sharp knife, cut into the uppermost boll that has a chance of contributing to yield. The cotton should string out when the boll is cut and the seeds should be fully developed with a brown seed coat and cotyledons inside the seed.
3. Nodes above cracked boll (NACB)
 - 4 NACB or less. There is a relationship between percent open boll and the number of nodes between the uppermost first position cracked boll and the uppermost first position harvestable boll. That relationship is illustrated in the chart to the right.

Relationship between NACB & % Open Bolls (Bednarz et al. 2002)



% Open Bolls	NACB
30	7.3
40	6.2
50	5.2
60	4.1
70	3.1
80	2.0
90	1.0
100	0

Fig. 1. Nodes from the uppermost first sympodial position cracked boll to the uppermost harvestable boll (NACB) vs. percent open boll in harvest timing studies conducted at the University of Georgia Coastal Plain Experiment Station in 1998, 1999, and 2000. **Denotes significance at the $P = 0.01$ level.

Defoliant Applications: Most defoliants do not translocate through the plant, making spray coverage extremely important. To ensure adequate spray coverage, the proper spray pressure, ground speed, and nozzle size must be used in order for the proper application volume to be applied, in accordance to label instructions. Much attention has been given to defoliation using auxin nozzles (i.e. nozzles labeled for 2,4-D and dicamba applications), and there have been concerns with adequate spray coverage. A study conducted across the cotton belt found that sprayer output (GPA) was far more important in defoliation than nozzle type. Higher GPA results in greater defoliation, with a good output target being 15 GPA. Also, many growers across the state of Georgia have participated in the Using Pesticides Wisely training over the past few years. Although this training primarily has to do with the use of 2,4-D and dicamba, these lessons should not be dismissed when applying other pesticides. Care should be taken to prevent off-target movement of defoliants, particularly around sensitive crops and homeowners, as defoliants can be extremely visible. When defoliating, only treat enough acres to anticipate harvesting in the next 10 to 14 days. Rain occurring after application can affect defoliant activity, so weather forecasts should be consulted prior to application. In Table 1, some of the more common defoliants are listed with rates, rain-free periods, PHIs, and expected activity. This table can also be found in the 2020 Mid-South Cotton Defoliation Guide written by Tyson Raper, Brian Perialisi, Donnie Miller, Tyler Sandlin, Steve Brown, and Bill Robertson, and is at this link: <https://www.uaex.edu/farm-ranch/crops-commercial-horticulture/cotton/2020%20Mid-South%20Cotton%20Defoliation%20Guide.pdf>.

Table 1. Use pattern and expected activity for defoliants and desiccants (from the Mid-South Cotton Defoliation Guide).

Harvest Aid ¹	Labeled Broadcast Rate/Acre	Max. Use per Season	Rainfree Period (hours) ²	Pre-Harvest Interval (Days)	Small Grain Re-Crop Interval	Estimated min. temp.	Mature leaves	Juvenile growth	Regrowth prevention	Boll opening
Thidiazuron SC	1.6 - 6.4 oz	9.6 oz	24	5	14 days	65 F	Excellent	Excellent	Excellent	None
Ginstar	6.4 - 16 oz	16 oz	12	5	1 month	60 F	Excellent	Excellent	Excellent	None
Folex 6	16 - 24 oz	24 oz	1	7	None	60 F	Excellent	Fair	Poor	None
Aim	0.5 - 1.6 oz	3.2 oz	8	7	None	55 F	Excellent	Excellent	Poor	None
Display	1.0 oz	2.0 oz	8	7	None	55 F	Excellent	Excellent	Poor	None
ET	1.5 - 2.75 oz	5.5 oz	1	7	None	55 F	Excellent	Excellent	Poor	None
Sharpen	2.0 oz	2.0 oz	1	5	None	55 F	Excellent	Excellent	Poor	None
Ethephon	21 - 42 oz	42 oz	6	7	1 month	60 F	Fair	Poor	Poor	Excellent
Finish 6 Pro	21 - 42 oz	42 oz	6	7	1 month	60 F	Excellent	Poor	Fair	Excellent
Glyphosate ³	11 - 44 oz	44 oz	4	7	None	55 F	Fair	Fair	Excellent	None
Desiccants										
Paraquat	3.1 - 32 oz	32 oz	0.5	3	None	55 F	Fair	Excellent	Poor	Fair
Sodium Chlorate	4.5 lbs ai	N/A	24	7	None	55 F	Fair	Fair	Poor	None

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

²Expected rainfree 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.

³Non-glyphosate tolerant varieties only.

Table 2. UGA "Three-way" Defoliation Mixtures.

Season (Temperatures)	Ethephon (Prep 6S C)	Thidiazuron (Dropp 4S C)	Tribufos (Folex 6EC)
	—BROADCAST RATE/ACRE—		
Early Season (highs >90 F, lows >70 F)	21 – 24 fl oz	1.6 – 3.2 fl oz	6 – 12 fl oz
Mid-Season (highs 80<89 F, lows 60<70 F)	24 – 32 fl oz	2 – 2.3 fl oz	8 – 12 fl oz
Late-Season (highs <80 F, lows <60 F)	32 – 42 fl oz	X	16 – 20 fl oz
Ethephon – Higher rates necessary with cooler temperatures to increase boll opening			
Thidiazuron – Increase rates for greater regrowth potential, less activity when lows are less than 65 F for 3 days			
Tribufos – Higher rates necessary for cooler temperatures, however too high can desiccate			
X = denotes product not suggested during these environmental conditions			

Specific Recommendations: For particular defoliant tank-mixture recommendations, refer to the UGA Pest Management Handbook at the following link: <https://extension.uga.edu/content/dam/extension/programs-and-services/integrated-pest-management/documents/handbooks/2021-pmh-comm-chapters/Cotton.pdf>. In the defoliant section of the pest management handbook, recommendations are broken up by “season”, or relative range of temperatures at and around application, along with expected defoliant activity. Although there are many options when choosing defoliants, one of the most common tank-mixtures is a three-way mix of ethephon (Prep, others), thidiazuron (Dropp, others), and tribufos (Folex/Def). Rate recommendations based on temperatures at and in the time surrounding defoliation can be found in Table 2. For more information on these and any recommendations and how to incorporate them into your operation, please contact your local UGA County Extension Agent.

Weed Management at Defoliation: In cases where weeds are present at harvest, some defoliants have herbicidal activity on certain weeds. Table 3 lists some of those options. These treatments should be followed by desiccants to further prepare the cotton crop for harvest, including products containing paraquat or sodium chlorate.

Table 3. Harvest aid weed management options.

HERBICIDE	BROADCAST RATE/ ACRE	REMARKS AND PRECAUTIONS
<i>carfentrazone-ethyl</i>		<i>The rates below are given in the broadcast amount per acre unless otherwise noted.</i>
Aim 2.0EC	1 fl oz	Add 1% v/v crop oil. Effective on morningglory, coffee senna, and tropical spiderwort.
<i>carfentrazone-ethyl + fluthiacet-methyl</i>		
Display 2.05EC	up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
<i>glyphosate</i>		
Roundup Powermax 3 5.88S, others	up to 2.5 pts	Use in combination with defoliants.
<i>paraquat</i>		
Gramoxone 3S, others	1-4 fl oz	Use in combinations with standard defoliation applications.
Gramoxone Inteon 2S	3-5 fl oz	May cause crop desiccation and damage to unopened bolls.
<i>pyraflufen ethyl</i>		
ET 0.208EC	1.5 oz	Add 0.5% v/v crop oil when temperatures are above 90°F. Add 1% v/v crop oil when temperatures are 89°F or below. Effective on morningglory. Label allows rate to be increased to 2.75 fl oz/A.