Specific Recommendations: For particular defoliant tank-mixture recommendations visit the UGA Pest Management Handbook (pages 226 – 235) at http://www.ent.uga.edu/pest-management/Commercial-Cotton.pdf In the UGA cotton defoliant section of the handbook, recommendations are broken up two different ways. First, a separate section is available for each "season" or relative range of temperatures. This is done to account for effectiveness of products related to temperature. Another way the recommendations are organized relates to harvest aid functions needed to get the crop ready. For more information on these recommendations and how to incorporate them into your operation, please contact your local UGA Cooperative Extension office. Although there a lot of tank mixture options for cotton defoliation, one mixture utilizes three products and has become one of the most common and effective treatments in Georgia. This "three-way" mix contains ethephon to open bolls, tribufos to remove mature foliage, and thidiazuron to remove juvenile tissue and prevent regrowth. The table below contains rates for each product based on seasonal temperature.

Comments on Additives: Refer to manufacturer's recommendations. Consider potential negative effects with increased leaf desiccation. Hot temperatures can increase potential for leaf desiccation and possible fiber quality deductions. Unless a label requirement, USE AT OWN RISK.

"Three-way" Defoliation Mixtures

Season (Temperatures)	Ethephon (Prep)	Thidiazuron (Dropp)	Tribufos (Folex)
Early Season (Highs > 90, lows > 70)	21 - 24 oz (1.33 to 1.5 pt)	1.6 - 3.2 oz	6 - 12 oz
Mid-Season (Highs 80-89, lows 60-70)	24 - 32 oz (1.5 to 2.0 pt)	2 - 3.2 oz	8 - 12 oz
Late-Season (Highs < 80, Lows < 60)	32 – 42 oz (2.0 to 2.67 pt)	---	16 – 20 oz

Ethephon = rates increase with cooler temps

Thidiazuron = rates increase with cooler temps, increase rate with more regrowth potential. Activity is lessened when low temperatures are less than 65F for 3 days.

Tribufos = Increase rate with cooler temps. When rates are too high for conditions leaf desiccation may occur.

In cases where weeds are present at harvest, some cotton defoliants are products that have herbicidal activity on particular pests. See the table below from the UGA Pest Management Handbook for specific recommendations.

HARVEST AID WEED MANAGEMENT

PRODUCT COMMON NAME	BROADCAST RATE/ ACRE	REMARKS AND PRECAUTIONS *The rates below are given in the broadcast amount per acre unless otherwise noted.*
carfentrazone Aim EC	1 oz.	Add 1% v/v crop oil. Effective on morningglory, coffee senna, and tropical spiderwort.
carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
glyphosate (numerous brands)	1.2-2 pt.	Use in combination with Def/Folex, dimethipen (Harvade) and/or ethephon. Glyphosate provides fair regrowth suppression of cotton. However, glyphosate WILL NOT provide regrowth suppression when applied to RF cotton. See specific labels for product rates.
paraquat Gramoxone Max, Firestorm, or Parazone	1-4 oz.	Use in combinations with standard defoliation applications. May cause crop desiccation and damage to unopened bolls.
Gramoxone Inteon	3-5 oz.	
pyraflufen ethyl ET	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.
Follow-up Treatments Desiccants paraquat or sodium chlorate	See "Desiccants for Cotton Harvest Preparation" next page.	

GEORGIA COTTON COMMISSION

UGA extension

COTTON DEFOLIATION IN GEORGIA (2016) UGA EXTENSION

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Cotton harvest-aids are used primarily to facilitate machine harvest. Timely defoliation and harvest of cotton also reduces weathering-induced yield and fiber quality losses and decrease leaf trash and stain, which further reduce lint quality. Thus, a basic knowledge of crop development and maturity along with an understanding of the physiology of harvest-aids is necessary in making decisions concerning the effective application of these materials. Successful preparation of a cotton crop for harvest factors in the complexities of crop leaf senescence, boll maturation and the diversity of harvest-aid functions

Defoliation Timing: Cotton defoliation is a sensitive process. For a successful harvest, defoliation must be carefully timed and carried out. Poor defoliation can lower fiber quality, while defoliating too early lowers yield and micronaire. Late defoliation increases the likelihood of boll rot and lint damage or loss due to weathering. Late defoliating also increases the possibility that defoliant activity will be inhibited by lower temperatures Three ways to determine crop maturity and defoliation timing: • 60 to 75% open bolls (only 60 for uniform crop) • Sharp Knife – cotton strings when boll is cut – Seed are fully developed (brown coat & cotyledons) • Nodes above crack boll (NACB) – 4 or less (around 3 days per node) There is often a relationship between percent open bolls in the canopy and the number of nodes between the uppermost first position cracked boll and uppermost first position harvestable boll (NACB). The chart below to the right shows predicted percent open bolls to NACB (60% = 4.1 NACB)

Relationship between NACB & % Open Bolls

(Bednarz et al. 2002)

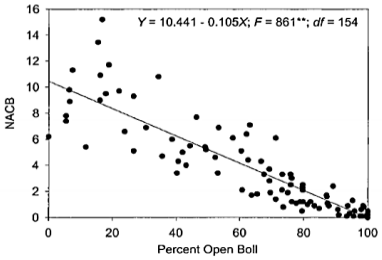

Fig. 1. Nodes from the uppermost first sympodial position cracked boll to the uppermost harvestable boll (NACB) vs. percent open boll in harvest timing studies conducted at the University of Georgia Coastal Plain Experiment Station in 1998, 1999, and 2000. **Denotes significance at the $P = 0.01$ level.

% 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

Types of Defoliants:

Herbicidal defoliants

Tribufos (Folex) – Injures leaf below cuticle, causing stress which stimulates ethylene production P.P.O. INHIBITBITING HERBICIDES – Destructs cell membranes, causing ethylene production **Aim - Carfentrazone • ET - Pyrafluefen ethyl • Resource - Flumiclorac • Blizzard - Flutiacet-methyl**

Hormonal defoliants

Ethephon (Prep, etc.) – Increases production of ethylene, leading to leaf drop – Accelerated boll opening • **Finish 6 Pro** – ethephon + cyclanilide • **FirstPick** – ethephon + urea sulfate

Thidiazuron (Dropp, Freefall, etc.) – Enhances production of ethylene and inhibits auxin transport – Inhibits regrowth • **Ginstar** – thidiazuron + diuron

Applications: Most harvest aid materials do not translocate or move very far within the plant. Therefore, application coverage is important. To ensure adequate foliar coverage use the proper spray pressure, ground speed and nozzle size in order to apply the desired spray volume in accordance of label instructions. **WATER VOLUME CAN SIGNIFICANTLY IMPACT OVERALL PERFORMANCE, THE MORE WATER THE BETTER (SHOOT FOR 15 GPA).** Be sure to consider harvest when making defoliant applications and treat enough acres to anticipate harvesting the crop 10 to 14 days after application. Leaf drop should start in about four days and be complete in about 10 days. Rainfall occurring after applications can affect defoliant activity. Be sure to consider weather forecasts when making applications and pay attention to rain-free periods of particular products. Thidiazuron is of particular concern, since it requires a 24 hour rain-free period. See the two tables below from the "2014 Mid-South Cotton Defoliant Guide" written by Darrin M. Dodds, Daniel B. Reynolds, L. Thomas Barber, and Tyson. B. Raper for use details and activity of selected defoliants and desiccants. http://www.mississippi-crops.com/wp-content/uploads/2014/09/2014-CottonDefoliation-Guide_Final.pdf

Harvest Aid Functions: There are four basic functions of harvest aids when applied to cotton. Each process may or may not be required to prepare cotton harvest. An understanding is needed of these processes in order to properly determine products and rates to be chosen. **1. Removal of Mature Foliage 2. Removal of Juvenile Foliage 3. Boll Opening 4. Regrowth Suppression.** The first two functions are considered to be involved with defoliation. Defoliation or leaf abscission is a natural plant process. The problem is this natural leaf drop does not occur simultaneously throughout the plant canopy, or in time to effectively facilitate mechanical harvest. Therefore, producers must manipulate the plant to drop its leaves in a relatively short period of time. While the leaf abscission process is quite complex, it can be simplified as being governed by two major hormones within the plant, auxin and ethylene. Auxin is a growth-promoting hormone that stimulates leaf growth and development. Ethylene can be classified as a senescence or ripening hormone that causes leaf drop. Leaves fall from the plant once ethylene moves from the leaf blade to the base of the petiole and stimulates the formation of an abscission layer. The amount of auxin or ethylene present in the leaves of the cotton plant is related to leaf age. Younger leaves have a more elevated level of auxin, while older leaves have lower levels of auxin and higher levels of ethylene. This is why older leaves are more conditioned for defoliation than younger leaves. Furthermore, because of the hormone balance of younger leaves, low rates of harvest aids often have no effect, and higher rates may actually kill the leaf, leading to desiccation and leaf sticking. Eventually, almost all the leaves on a cotton plant age so they will abscise naturally. However, producers can manipulate these hormone levels so all the leaves abscise at the same time. When harvest-aids are applied ethylene levels artificially increase so the abscission process begins. All cotton harvest-aids can be classified into two modes of action, herbicidal and hormonal. Herbicidal harvest-aids injure the leaf, stimulating the production of ethylene. Hormonal harvest-aids increase the ethylene concentration in the leaves without causing any injury. Product selection and application rates should be adjusted to match environmental conditions as they change during the harvest season in order to reduce occurrence of leaf desiccation.

Table 1. 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
Glyphosate	None
Finish® 6 Pro	1 month
Ethephon	1 month
Paraquat	None
Sodium Chlorate	None

Table 2. Use pattern and expected activity for defoliants and desiccants.

Harvest Aid[1]	Labeled Broadcast Rate/Acre	Max. Use per Season	Rainfree Period (hours)[2]	Pre-Harvest Interval (Days)	Estimated min. temp.	Mature leaves	Juvenile growth	Re-growth 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
Glyphosate[3]	11-44 oz	44 oz	4	7	55 F	Fair	Fair	Excellent	None
Desiccants									
Paraquat	3.1-32	32	30 min.	3	55 F	Fair	Excellent	Poor	Fair
Sodium Chlorate	4.5 # ai	N/A	24	7	55 F	Fair	Fair	Poor	None

[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 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.

[3] Non-glyphosate tolerant (Roundup Ready Flex®; Glytol®/Liberty Link™) varieties only.

Tables credit: Mid-South Cotton Defoliation Guide: Darrin Dodds, Daniel Reynols, Thomas Barber, Tyson Raper; 2014