

COTTON HARVEST-AID SUGGESTIONS

Henry Wilson, Extension Weed Scientist, Eastern Shore AREC

Although the cliché has been overused, defoliation is truly “an art and a science.” Selecting harvest aids can be one of the toughest but most critical decisions a producer will make all year. At this point in the season, the producers’ investments in the crop have peaked, and timing is also critical. Unfortunately, there is no one encompassing prescription. Producers have to assess their current situations and environmental conditions and make adjustments.

Boll maturity should be an important part of the decision. Once the leaves are removed, the bolls will come close to, or altogether cease maturation. The goal of defoliation is to eliminate leaves from the plant. To do this, the harvest aid must not kill the leaf immediately, but keep it alive long enough to form an abscission zone that allows leaf and petiole separation from the plant. If the leaf desiccates too rapidly, the leaves will stick to the plant, possibly resulting in grade reductions.

Advantages associated with harvest-aid applications prior to harvest include: increased harvester efficiency, reduced leaf and trash content in harvested lint, and quicker drying of dew from the lint surface. This can increase picking hours, retard boll rot, straighten lodged plants, maintain or improve certain fiber quality characteristics (trash content, micronaire, color, etc.), and stimulate boll opening (increased earliness). Weed control afforded by defoliant with desiccating activity can also increase harvest efficiency.

Factors that influence defoliation include environmental and crop conditions, crop maturity, and harvest scheduling. Harvest scheduling is especially important in Virginia where most cotton producers also have a valuable peanut crop to harvest. Due to changes in the weather and the crop, the appropriate harvest-aid materials and rates are subject to rapid change.

Defoliant should be applied in the morning or late afternoon when the wind is calm and humidity is high. In general, defoliant work best when nighttime temperatures are above 60° to 65°F. Most defoliant are not mobile in the plant and therefore complete coverage is essential.

Defoliation Timing

Properly timing defoliation involves balancing the value of potential increases in yield with the value of changes in fiber quality. Early defoliation can be critical in maximizing yield. Delaying defoliation increases the risks of yield loss due to damaging early frosts and late season inclement weather, both of which are possible in the Virginia cotton-growing region. However, delaying defoliation allows immature bolls to develop, thus enhancing yields. Defoliating too late or too early may negatively impact fiber quality, including micronaire and staple. Several methods for timing defoliation can be used.

Using the percentage of open bolls is one method for timing defoliation. The traditional recommendation for harvest-aid application has been 60 percent open boll in most areas. Research has demonstrated that most varieties can be defoliated between 40 percent to 60 percent open boll without adversely affecting yield or micronaire. This method, focusing on the opened portion of the crop, has two disadvantages, one being that it does not account for fruiting gaps and the second being the time it takes to perform this measurement. Percent open boll can be measured by marking a section of row (e.g., 10 feet) and counting the number of total bolls within that row distance. Then, the open bolls are counted. The number of open bolls divided by the total bolls times 100 is the percent open boll for that area. Keep in mind, that number only represents the area measured and may not be representative of the entire field. Also, the bolls counted should only include harvestable bolls. Bolls where anthesis (flowering) took place prior to August 15 should be considered harvestable in a typical year. As defoliation nears, questionable bolls can be tested with the sharp knife technique to determine harvest potential. If the boll is very difficult to cut in cross sections, seed coats are brown to black, and no jelly is present within the seed walls, the boll is at a point where harvest-aid application will not negatively impact its yield potential.

Nodes above cracked boll (NACB) is a method of timing defoliation whereby only plants containing a first-position cracked boll are observed. Beginning with the node (branch) above the sympodial (fruiting) branch containing the highest first position cracked boll, nodes are counted upward **to the node containing the highest harvestable boll** (see above). The number of nodes traversed equals the NACB. Research has demonstrated that an optimal time to apply harvest aids relative to changes in yield and micronaire is when the crop reaches NACB < 3. This method, in contrast to the percent open boll method, focuses on the unopened portion of the crop. One advantage of this method is that it takes less time than percent open boll. Like all methods of defoliation timing, measurements need to be taken in numerous areas of the field to accurately represent the overall condition.

Harvest Timing

Harvest timing is also an important part of managing for yield and fiber quality. As cotton harvest is delayed, open bolls can be exposed to adverse weather conditions. Research has demonstrated that rainfall during the harvest period can cause significant yield losses and fiber-quality discounts.

In years when the reproductive cycle is completed but plants continue to grow vegetatively at the end of the season, regrowth may become an issue and it will be important to carefully coordinate defoliation with the time you anticipate harvesting. Unless you intend to come back with a second application to control regrowth, apply a chemical that controls regrowth, defoliating only what you can pick in 10 to 14 days.

In some cases, picking without defoliating may be an option. If cotton is completely cutout and has dropped leaves naturally (possibly older, tough leaves remaining), cotton harvested with care may not require defoliation to eliminate leaf trash and prevent excess staining. If the decision is made to not defoliate,

avoid picking too early or late in the day as this may result in excessive moisture. Producers are strongly urged to harvest an adequate sample to evaluate effects on ginning efficiency prior to performing this on a large scale.

Product Selection - General

As mentioned, the objectives of harvest-aid applications include defoliation, inhibition of regrowth, boll opening, and weed desiccation. There are few stand-alone products that can accomplish all objectives and tank-mix combinations typically are required. Harvest-aid compounds have either herbicidal or hormonal activity. Herbicidal compounds (Aim, Def, Folex, Harvade, ET) injure the plant, reduce auxin levels, and stimulate ethylene production. Ethylene is a hormone that causes the leaf petiole to form an abscission layer and ultimately, drop from the plant. If herbicidal defoliants kill the leaf before the abscission zone is formed, leaves are likely to “stick.” Dropp, FreeFall, Finish, FirstPick, and Prep are examples of hormonal defoliants. Through several methods, they promote synthesis of ethylene in the plant.

Defoliation Materials

DEF 6, Folex

These phosphate-based compounds have been a standard defoliant for many years and provide good defoliation of older more mature leaves in well cutout (mature) cotton. These products provide minimal regrowth inhibition and are typically mixed with other products (e.g. ethephon, Prep, Super Boll, etc.). They are similar in efficacy and will perform well over a wide range of environmental conditions. However, the high end of the labeled rate performs best in cool conditions. Leaf drop is fast and they only require a rain-free period of two hours. The activity of these compounds improves with increased cutout of the crop. The addition of surfactants or crop oils can increase activity under adverse conditions. The pungent odor of these products may be a consideration in populated areas.

Dropp 50 WP and SC, Freefall 50 WP, etc. (thidiazuron)

Dropp and FreeFall defoliate mature leaves, have excellent activity on juvenile leaves, and suppress or delay regrowth. A minimum of 0.1 lb/A WP or 1.6 SC fl oz/A is needed for ten to 14 days of regrowth inhibition. Higher rates will result in longer periods of regrowth inhibition. Thidiazuron alone is usually equal to or better than other defoliants in drought-stressed situations where leaves have thicker cuticles. Dropp and FreeFall are somewhat slower acting than other defoliants and their activity is temperature dependent. Temperatures less than 65°F will reduce activity; however, the addition of crop-oil concentrate, or a phosphate-type defoliant will help the activity of thidiazuron under cooler conditions. The addition of 2 to 4 oz/A of DEF or Folex will shorten the required 24-hour rain-free period. The label provides specific tank clean-out procedures when using thidiazuron. This strategy avoids the premature defoliation associated with sprayer use the following year. When thidiazuron is tank mixed with a phosphate-type defoliant or insecticide, the label recommends a surfactant to aid in tank clean out. When using the WP formulation, thorough rinsing is critical.

Ginstar

Ginstar is a premix emulsifiable concentrate of thidiazuron (active ingredient in Dropp and Freefall) and diuron. Ginstar has been found to be more active under cool conditions than most thidiazuron containing materials. Ginstar is a strong inhibitor of terminal regrowth. It is more likely to cause unwanted desiccation and sticking of cotton leaves than thidiazuron alone. Tank mixing and higher rates increase the potential for leaf sticking. Labeled rates are 6.4 to 16 oz/A and growers are cautioned not to exceed 8 oz with this product until more information is available from Virginia. Growers are cautioned that rates in excess of 10 oz have shown a tendency to desiccate leaves. The label does not allow mixing of phosphate type defoliant (DEF, Folex). However, ethephon-containing materials (Prep, SuperBoll, Finish, FirstPick, etc.) can be tank mixed at low rates for enhanced defoliation. The use of adjuvants with Ginstar is not recommended. Research in Virginia with this product is limited. *Pay attention to the label for Virginia, some other state labels differ greatly. Pay close attention to rotational restrictions on the label.*

Harvade (dimethipin)

Harvade is an herbicidal-type defoliant that provides effective defoliation of mature leaves but minimal inhibition of terminal regrowth. It has little activity on emerged juvenile growth. Harvade is less temperature-sensitive than phosphate defoliant and is reported to have better activity at lower temperatures. In combinations with ethephon, it has demonstrated the ability to desiccate morning glory and prickly sida. The addition of 1 pt/A of crop oil is required by the federal label and is needed for acceptable defoliation. Harvade needs a 6-hour rain-free period following application. **Pay attention to precaution statements on label.**

Leafless

Leafless is a combination of the active ingredients in Dropp/Freefall (thidiazuron) and Harvade (dimethipin). It combines effective defoliation of mature leaves (dimethipin) with regrowth inhibition and removal of juvenile growth (thidiazuron). Limited research is available for this product in Virginia. The recommended rate of 10 to 12 oz/A delivers the equivalent of 0.125 to 0.15 lb. Dropp/FreeFall and 6.4 to 7.7 oz/A Harvade. If morning glory desiccation is desired, additional Harvade can be added. Crop-oil concentrate at 0.5 to 1.0 pt/A should be added to Leafless for acceptable activity.

Aim, ET, Blizzard, and Resource

These products have different active ingredients (carfentrazone, pyraflufen, fluthiacet, and flumiclorac, respectively) but similar modes of actions. They are all contact herbicidal defoliant that do not appear to be extremely temperature sensitive. Research indicates they can cause excessive desiccation at high rates under warm conditions where rank, juvenile growth is not present. They perform best in well-cutout cotton and can be beneficial when used as a second application. They provide regrowth control but have no residual activity and are good morning glory desiccants. These products can be mixed with most other defoliant/boll openers. See labels for adjuvant requirements and use restrictions.

Finish

Finish contains the active ingredient in Prep (ethephon) and a synergist (cyclanilide) that aids in defoliation. Finish tends to open bolls more rapidly than Prep alone and thus shortens time to harvest. It is less temperature sensitive than most products. In situations where regrowth or added defoliation is needed, thidiazuron (Dropp, FreeFall, etc.) and/or DEF/Folex should be added to the tank.

FirstPick

FirstPick weighs 12.45 lb/gal and contains 2.28 lb of ethephon (Prep) and 7.30 lb of a synergist (AMADS). Like Finish, it is an excellent boll opener. Acceptable defoliation with FirstPick typically occurs within seven days in well-cutout cotton containing mature leaves. FirstPick also provides limited control of terminal regrowth. Where thick regrowth is a concern, add thidiazuron (Dropp, Prepp, etc.). DEF/Folex may be added to enhance defoliation of juvenile or rank growth. Thorough rinsing of the tank is recommended following application.

Roundup (glyphosate, many formulations)

Glyphosate can be applied as a harvest-aid material. Tank mixed with defoliant or ethephon, it provides regrowth inhibition in conventional (non-Roundup Ready) cotton. It also provides excellent control of perennial grasses. Check specific product labels for registrations as a harvest aid.

Sodium chlorate

Sodium chlorate is most effective in defoliating mature leaves although it is not good at removing juvenile growth and provides no regrowth inhibition. However, sodium chlorate may be the best defoliant choice when temperatures are below 55°F. Application should not be made before cotton has 85 percent or greater open bolls. *At higher rates, sodium chlorate tends to stick cotton leaves. It is not safe to tank mix sodium chlorate with other defoliant, oils, surfactants, or insecticides due to the potential for formation of toxic fumes. Limited research exists on this product in Virginia.*

Boll-opening Materials

Although some boll openers are used to enhance the activity of defoliant, they typically are used to hasten the maturity of boll opening. Boll openers are meant to open mature bolls and can alter micronaire and fiber length if applied too early. They are not systemic, making thorough coverage essential. Boll openers are most beneficial for cotton that needs to be picked between 7 to 14 days following application. The active ingredient in Prep (ethephon) is also found as a premix in several products but is below the boll-opening rate. Check labels to make sure the boll-opening rate is applied, if this is the objective.

Ethephon 6, Prep, Super Boll, Cottonquik, Finish (ethephon)

With adequate spray coverage, ethephon products expedite natural boll

opening. While ethephon can enhance defoliation, tank mixing with products such as DEF, Folex, Dropp, FreeFall, Ginstar, ET, Blizzard and/or Aim is necessary for acceptable defoliation and/or regrowth control. Allow at least seven days following application before harvest for optimum boll-opening effect. If cotton is not picked within 14 days following application, there is likely no advantage to ethephon use. FirstPick and Finish are combinations of ethephon and a synergist to increase defoliation and speed boll opening over ethephon alone. Bolls that are not mature at the time of application have little chance of opening in 14 days regardless of ethephon use. *Do not mix with sodium chlorate due to the potential for toxic fume formation.*

Gramoxone Max, Gramoxone Extra, and Starfire (paraquat)

Paraquat can enhance defoliation of juvenile growth when applied in combination with other defoliantes although it will not inhibit regrowth. It can stimulate boll opening. High rates may result in excessive desiccation and “freezing” of closed bolls. It also can be used as a spot treatment for weed desiccation. It should not be applied at weed desiccation rates before cotton is at least 90 percent open and the remaining 10 percent is mature. It is necessary to pick within seven days following paraquat application to avoid bark contamination. *Consult the label for use rates and pay close attention to precautions.*

Defoliating Cotton under Adverse Conditions

Drought-stress

Dryland cotton producers are often faced with the task of defoliating drought-stressed cotton. When soil moisture conditions become low and daytime temperatures are above 90°F, cotton can quickly become stressed. Because the leaves of drought-stressed cotton often have thick cuticles that inhibit uptake of many defoliantes, the response of cotton to defoliantes can be less than desirable. Additionally, the potential for regrowth often is high due to residual nitrogen and early cutout. The uptake of thidiazuron-containing products (i.e. Leafless and Ginstar) can be reduced in drought-stressed cotton, thus higher rates may be required. Research suggests uptake of certain thidiazuron containing products can be higher in drought-stressed cotton than thidiazuron alone (Dropp or FreeFall). The addition of a surfactant, ammonium sulfate, or DEF/Folex can increase uptake of Dropp or FreeFall on drought-stressed cotton. However, the use of adjuvants such as crop-oil concentrate or ammonium sulfate in high temperatures will increase the probability of leaf sticking. If regrowth is not a concern, DEF/Folex is often an adequate defoliant choice in drought-stressed cotton. If only Leafless or Ginstar is utilized, high rates of these defoliantes should be avoided.

Cool temperatures

Because of geographic location, defoliating cotton when temperatures are cool (high temperature less than 80°F and low temperature less than 60°F) is often a concern for Virginia producers. Most harvest aids are temperature sensitive and do not perform as well when temperatures are cool. Harvade has traditionally

been recommended in most states as a good cool-weather defoliant. Though Harvade is the least sensitive to low temperatures, high rates of DEF/FoLex also can be used to effectively defoliate mature cotton in cool weather. With the labeling of Aim and ET for cotton defoliation, these two products now can be used to defoliate cotton when temperatures are low. Because of the leaf-sticking potential with high temperatures, Aim and ET are probably better suited for use when high temperatures are below 80°F. Adjuvants are essential for achieving successful defoliation with many of these products, thus crop-oil concentrate must be added to Harvade and a nonionic surfactant to Aim or ET. For boll opening, higher rates of ethephon (Prep) are needed as temperatures decrease. Because regrowth potential is often less when temperatures are cool, Dropp/FreeFall can sometimes be omitted if temperatures are likely to remain below 70°F.

Rank growth

The most important aspect to defoliating rank cotton is coverage. This is challenging and the tendency is to increase the rate. Rate increases are not advised; however, as they increase the possibility of desiccation and leaf sticking. Excessively rank cotton in most situations will require a two-application defoliation program. Deliver the first application as normal with the goal of knocking all the leaves off except a skirt around the base of the plant. A product such as Aim or ET works well as an affordable second application. A boll opener used in conjunction with this program will be more effective with the second application when good coverage can be achieved. Rank cotton is also more prone to damage from boll-rot pathogens. A close examination of the crop prior to defoliation can be beneficial in determining boll-rot levels. If the bottom crop is severely damaged due to boll rot, it may be desirable to allow more time for the top crop to mature, given that most of the yield will come from the top of the plant. However, historical weather patterns in Virginia suggest little potential for making a late-season crop. The best solution for avoiding late-season difficulties with rank cotton is proper in-season mepiquat chloride (Pix) and nitrogen management.

Table 39. Harvest aid effectiveness and temperature.

Defoliation Only, Field Cutout	Defoliation with Regrowth Anticipated	Defoliation & Boll Opening	Defoliation & Boll Opening with Regrowth Anticipated	TEMPERATURES		
				Low $\geq 70^{\circ}\text{F}^1$ High $\geq 85^{\circ}\text{F}$	Low $60^{\circ}\text{-}70^{\circ}\text{F}^2$ High $75^{\circ}\text{-}85^{\circ}\text{F}$	Low $<60^{\circ}\text{F}^3$ High $<75^{\circ}\text{F}$
				Rate Per Acre		
DEF 6/Folex 6EC				1.5 pt	1.5 - 2.0 pt	2.0 - 3.0 pt
Harvade 5F +COC*				0.5 pt + 1.0 pt	0.5 pt + 1.0 pt	0.5 pt + 1.0 pt
Finish 6SC				1.33 pt	2.0 pt	2.67 pt
CottonQuik/ FirstPick				2.0 qt	2.0 qt	3.0 qt
	thidiazuron SC **			2.0 -3.2 oz	2.0 -3.2 oz	-----
	DEF 6/Folex 6EC + thidiazuron SC **			1.0 - 1.5 pt + 1.6 - 2.4 oz	1.0 - 1.5 pt + 1.6 - 2.4 oz	2.0 pt + 1.6 - 2.4 oz
	Harvade 5F + COC* + thidiazuron SC **			0.5 pt + 1.0 pt +1.6 oz	0.5 pt + 1.0 pt + 1.6 - 2.4 oz	0.5 pt + 1.0 pt + 1.6 - 2.4 oz
	Finish 6SC + thidiazuron SC **			1.33 pt + 1.6 oz	2.0 pt + 1.6 oz	2.67 pt + 1.6 - 2.4 oz
	CottonQuik/ FirstPick + thidiazuron SC **			2.0 qt + 1.6 oz	2.0 qt + 1.6 oz	3.0 qt +1.6 - 2.4 oz
	DEF 6/Folex 6EC + ethephon 6EC***			1.33 - 1.5 pt + 1.33 pt	1.5 - 2.0 pt + 1.5 pt	1.5 - 2.0 pt + 1.5 - 2.0 pt
	Harvade 5F +COC* + DEF 6/Folex 6EC + ethephon 6EC***			0.5 pt + 1.0 pt + 4.0 oz + 1.33 pt	0.5 pt + 1.0 pt + 6.0 oz + 1.5 pt	0.5 pt + 1.0 pt + 8.0 oz + 2.0 pt
	Harvade 5F +COC* + ethephon 6EC***			0.5 pt + 1.0 pt + 1.33 pt	0.5 pt + 1.0 pt + 1.5 pt	0.5 pt + 1.0 pt + 1.5 - 2.0 pt
	CottonQuik/ FirstPick			2.0 qt	2.0 qt	3.0 qt
	CottonQuik/ FirstPick + DEF 6/Folex 6EC			2.0 qt + 8.0 oz (rank growth)	2.0 qt + 8.0 oz (rank growth)	3.0 qt + 8.0 oz (rank growth)
	thidiazuron SC** + ethephon 6EC***			1.6 - 2.4 oz + 1.33 pt	2.0 qt - 3.2 oz + 1.5 pt	-----
	Finish 6SC			1.33 pt	2.0 pt	2.67 pt
	Finish 6SC + DEF 6/Folex 6EC			1.33 pt + 8.0 oz (rank growth)	2.0 pt + 8.0 oz (rank growth)	2.67 pt + 8.0 oz (rank growth)

Table 39. Harvest aid effectiveness and temperature. (cont.)

Defoliation Only, Field Cutout	Defoliation with Regrowth Anticipated	Defoliation & Boll Opening	Defoliation & Boll Opening with Regrowth Anticipated	TEMPERATURES		
				Low $\geq 70^{\circ}\text{F}^1$ High $\geq 85^{\circ}\text{F}$	Low $60^{\circ}\text{-}70^{\circ}\text{F}^2$ High $75^{\circ}\text{-}85^{\circ}\text{F}$	Low $<60^{\circ}\text{F}^3$ High $<75^{\circ}\text{F}$
				Rate Per Acre		
			DEF 6/Folex	4.0 - 8.0 oz	4.0 - 8.0 oz	4.0 - 8.0 oz
			6EC	+ 1.6 - 2.0 oz	+ 2.0 - 2.4 oz	+ 1.6 - 2.4 oz
			+ thidiazuron	+ 1.33 pt	+ 1.5 pt	+ 1.5 - 2.0 pt
			SC **			
			+ ethephon			
			6EC***			
			thidiazuron	1.6 - 2.4 oz pt	2.0 - 2.4 oz	-----
			SC **	+ 1.33 pt	+ 1.5 pt	
			+ ethephon			
			6EC***			
			CottonQuik/	2.0 qt	2.0 qt	3.0 qt
			FirstPick	+ 1.6 oz	+ 1.6 oz	+ 1.6 - 2.4 oz
			+ thidiazuron			
			SC **			
			Finish 6SC ⁴	1.33 pt	2.0 pt	2.67 pt
			+ thidiazuron	+ 1.6 oz	+ 1.6 oz	+ 1.6 - 2.4 oz
			SC **			
			Harvade 5F +	0.5 pt + 1.0 pt	0.5 pt + 1.0 pt	0.5 pt + 1.0 pt
			COC*	+ 1.6 oz	+ 1.6 - 2.4 oz	+ 1.6 - 2.4 oz
			+ thidiazuron	+ 1.33 pt	+ 1.5 pt	+ 2.0 pt
			SC **			
			+ ethephon			
			6EC***			

NOTES:

* COC = crop-oil concentrate

** The active ingredient thidiazuron is available as the trade name products Dropp SC, Dropp 50WP, and FreeFall 50WP. SC and WP equivalents are 1.6 oz = 0.1 lb, 2.4 oz = 2.4 lb.

*** The active ingredient ethephon is available as 6EC formulations in a number of trade name products such as Prep, Ethephon, Super Boll, etc.

¹Low $\geq 70^{\circ}\text{F}$, High $\geq 85^{\circ}\text{F}$

- With drought stressed cotton, regrowth is likely where boll load is low to moderate and late season rainfall occurs.
- Regrowth suppression with Dropp 50WP/FreeFall 50WP increases with increasing rates. The activity of Dropp 50WP/FreeFall 50WP is temperature sensitive and declines as temperatures decline.
- With drought stress and high temperatures (85°F) three-way mixes and high rates of DEF/Folex 6EC and Harvade have a tendency to rapidly desiccate and "stick" cotton leaves.
- Ethephon rates may be increased to 2.0 pt/A to accelerate boll opening.

²Low $60^{\circ}\text{-}70^{\circ}\text{F}$, High $75^{\circ}\text{-}85^{\circ}\text{F}$

- With drought-stressed cotton, regrowth is likely where boll load is low to moderate and late-season rainfall occurs.
- Regrowth suppression with Dropp 50WP/FreeFall 50WP increases with increasing rates. The activity of Dropp 50WP/FreeFall 50WP is temperature sensitive and declines as temperatures decline.
- Ethephon rates may be increased to 2.0 pt/A to accelerate boll opening.

³Low $<60^{\circ}\text{F}$, High $<75^{\circ}\text{F}$

- With cool conditions (highs $<75^{\circ}\text{F}$, lows $<60^{\circ}\text{F}$) it is advisable to delay defoliation treatments until warmer conditions return. Harvest-aid treatments are much less effective at cool temperatures.
- Use of Dropp 50WP/FreeFall 50WP alone (without a tank-mix partner) when nighttime temperatures are expected to fall below 60°F can result in less than desirable defoliation and/or regrowth inhibition. The use of adjuvants such as petroleum-based crop oil or penetrating oils approved for use on growing crops has been shown to improve performance during low nighttime temperatures (60° to 65°F).

⁴Some growers using ground application equipment experienced varying amounts of compatibility issues when Finish 6SC was mixed with phosphate defoliant such as Folex® and DEF®. Check with your supplier for a list of compatibility agents.