

2009 Cotton Defoliation and Harvest Aid Guide¹

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Cotton requires about 155 days of growth from planting to harvest in Florida. Important management decisions have to be made throughout the growing season. Decisions about defoliation and boll opening and regrowth suppression can affect quality and storage time if the crop is put into modules. Stain from poorly defoliated plants or regrowth and moisture from the green tissue cause the greatest loss in quality.

There are several ways to determine when to defoliate cotton. An old rule of thumb is to defoliate when 60-75% of the bolls are open. Another method is “nodes above cracked bolls” (NACB). Research has shown that cotton with four nodes above the highest cracked boll can be defoliated without significant loss in weight or quality. If NACB counts average five or more, defoliant applications should be delayed. Harvest aids work best when there is a good boll load and most of the nitrogen applied for the cotton crop has been utilized.

Experience with harvest aids (boll openers, regrowth retardants, desiccants, and mature and juvenile foliage removal) has shown that timing of



Figure 1. A cotton plant that has been defoliated for two weeks is shown in this September 2008 photo, taken at the University of Florida's North Florida Research and Education Center in Quincy, FL. Credits: David Wright, UF/IFAS

the defoliant should be based on yield potential and quality of the mature, unopened bolls while also considering the potential loss in yield and fiber from the bolls that are already open. The largest bolls are generally those set early and low, nearest to the main stem on the plant. If fruiting was hindered by early insect damage, wait as long as possible before

1. This document is SS-AGR-181, one of a series of the Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. First published, September 2002. Revised July 2006 and October 2009. Visit the EDIS Web Site at <http://edis.ifas.ufl.edu>.
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defoliating to allow the top crop to develop; the 60-75% rule may not apply.

A crop that has set and retained most of the early fruit may be ready for defoliation at 50% open bolls. Also, where large acreage has to be harvested, growers may sacrifice some of the more immature bolls that contribute little to the final yield, so that harvest can begin before adverse weather conditions reduce overall yield and quality of the crop. Bolls set in mid-summer are usually larger and mature in 40-50 days while bolls set in August can take 60 days or longer to mature and often contribute little to the final yield if the crop had a normal fruiting season. Those late flowers look attractive and may give the appearance of adding to the final yield of the crop, but should not be given preference over the fruit that was set during the first three-to-four weeks of bloom. The fruit set during the first four weeks of bloom normally contributes 90-95% of the total yield of the cotton crop.

Estimating the number of mature, open bolls in the field is helpful in scheduling the defoliant and boll opener. Ten mature bolls per foot of row will produce a bale of cotton under good growing conditions. More bolls will be needed if they are higher on the plant; fewer bolls are needed if they are lower on the plant. Counts should include (1) open bolls, including cracked bolls; (2) green bolls that are mature and string out when cut with a knife; and (3) immature bolls that are harvestable or will mature while conditions are favorable.

The crop should be defoliated in stages where large acreages are to be harvested. Harvest aids should be applied approximately 12-14 days ahead of picking. A four-row picker can pick about 40 acres a day in the early part of the season, but will pick less later in the season due to shorter days.

There are different ways to defoliate cotton, and several harvest-aid chemicals are available that work well in Florida. The choice depends on whether the cotton has normal growth, is rank or has weed overgrowth and also depends, on the time of year. With rank cotton and cotton that has weed overgrowth, use a normal rate of defoliant and then come back with a second application to defoliate the bottom of the crop. Higher rates of defoliant may

kill the plant and cause the leaves to stay attached, instead of allowing the crop to mature and form the abscission layer, resulting in leaf drop.

Drought stress and cool weather can make plants more difficult to defoliate, especially where high levels of nitrogen remain in the plant. High residual nitrogen in the soil and in the plant can result in regrowth as soon as moisture is available. The young, green leaves that appear in the terminal can stain the lint during the picking process. As the weather cools later in the season, harvest aids are less active. Harvest aids should be applied three or four days after a cool snap.

Defoliant work in one of two ways, by herbicidal action or by hormonal activity. Some examples of herbicidal defoliant that injure plant leaves are the following: Folex/Def, Dropp/Free Fall, Ginstar, Aim or ET. Plants respond by producing ethylene, which causes the formation of the abscission layer at the base of the leaf petiole. High rates of these materials kill the plants, slowing or preventing leaf drop, thus causing more trash in the lint during the picking operation. Prep, Pluck and Ethephon 6 are ethephon materials and are hormonal defoliant. The ethephon products release ethylene, which stimulates further ethylene production in the bolls and leaves. Dropp is an example of a growth hormone called cytokinin, which promotes ethylene production in cotton. These materials are compatible in tank mixes that aid the defoliation process. Under cool conditions, use of petroleum-based crop oils has been shown to improve performance. Use of crop oils under high temperatures may result in leaf sticking because plants are killed before the abscission layer has formed.

There is no best harvest-aid material that will defoliate, stimulate boll opening, prevent regrowth, and perform equally well under hot-or-cool and dry-or-moist conditions. Combinations of products can result in good performance under a broad range of conditions that normally occur in Florida. All of the harvest-aid chemicals have a significant reduction in activity at 60-65°F. Of all the defoliant, Dropp is the most temperature-dependent. The least temperature-dependent chemicals are Def 6 or Folex, which provide adequate activity at temperatures of

55° F. Ethephon (Prep, Pluck, Ethephon) is intermediate in activity at cool temperatures.

Finish 6 Pro and FirstPick are combination materials that defoliate and are used primarily for acceleration of boll opening. Both of these materials are widely used and provide faster boll opening than equivalent rates of ethephon. However, after two weeks Finish 6 Pro and FirstPick show little difference in opening over ethephon. DEF/Folex, Dropp/Free Fall, Ginstar, Aim and ET can be added to these materials for better performance, as determined based on the needs of defoliation or regrowth suppression.

A cotton crop that has a good boll load, low amounts of available soil moisture and nitrogen, that is mature and has little new growth at defoliation can be easily defoliated with any material. By contrast, fields that have green, actively growing leaves and are still blooming due to excess fertility and moisture can be more difficult to defoliate, and regrowth may occur.

Regrowth suppression is usually accomplished with Dropp as long as temperatures are above 60-65°F. If temperatures drop below this range, glyphosate products may be the best choice for regrowth suppression on non-Roundup Ready cotton. Glyphosate in combinations with Def has been shown to do a satisfactory job of defoliating cotton -- as have Dropp and Def combinations -- with no more and, in some cases, less desiccation.

Gramoxone Max/Firestorm/Parazine (paraquat) will desiccate regrowth to prevent staining of the lint and heat problems in the modules. However, paraquat can freeze unopened bolls, so all mature bolls should be open before use of paraquat. Generally, trash from desiccation can be removed in the ginning process, but stains cannot.

Perhaps the most important factor to consider in timing of defoliant is whether unopened bolls are harvestable. Mature bolls will be too hard to dent when squeezed with your hand. These bolls cannot be easily cut with a knife, lint will string out when the boll is sliced, and seed coats will be yellow-to-tan in color. Bolls that set late in the season -- where moisture and nitrogen are adequate or excessive --

should not overly influence timing of application of harvest aids due to concern over potential loss of large, mature bolls at the bottom of the plant. Late, top bolls are often small and may be damaged by frost and contribute little to yield.

2009 Cotton Defoliation/Harvest Aid Suggestions

The following recommendations are general guidelines for harvest-aid application. Specific rates should be adjusted according to temperature, humidity, day-length, plant leaf condition and maturity, expected weather and desired effects, such as defoliation, regrowth control, boll opening and/or weed control. Defoliant should be applied in a minimum spray volume of 5 gal/A by air and 10 gal/A by ground. Fields should fit into one of the following categories based on temperature and crop conditions. (Pesticide rates are in amounts product per acre or as a percentage of the total spray solution.)

I – Early Season (high 90°F plus, lows 70°F plus)

Defoliation Only

1. DEF/Folex @ 1.5-1.75 pt (reduce to 1.25 pt if above 94°F)
2. Aim @ 0.67 oz + crop oil @ 1 % v/v (trial basis)
3. Resource @ 4-8oz + 1 pt crop oil- limited data
4. Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data
5. ET @ 1.5 oz + crop oil @ 0.5% v/v
6. Sodium Chlorate @ 3 lb (mature foliage only; do not mix with DEF/Folex or ethephon)

Defoliation and Regrowth Control

7. Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.2 lb (for maximum regrowth control)

8. Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1 lb (for minimum regrowth control) + DEF/Folex @ 1 pt

9. Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.125 lb (for good regrowth control) DEF/Folex @ 8-12 oz

10. Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.15 lb (for superior regrowth control) DEF/Folex @ 4-6 oz

11. Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1-0.15 lb + 1 pt crop oil + one of the following:

- Aim EC @ 0.75 oz. + NIS @ 0.25% v/v
- ET @ 1.5oz + crop oil @ 0.5% v/v
- Resource @ 4-8oz + 1 pt crop oil- limited data
- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data

12. Leafless @ 10 oz + 1 pt crop oil

13. Ginstar @ 6.4-8 oz.

14. glyphosate @ 1.2-2 pt + DEF/Folex @ 1 pt

Defoliation and Boll Opening

15. ethephon @ 2.0-2.67 pt

16. ethephon @ 1.33-1.5 pt + one of the following:

- DEF/Folex @ 1-1.25 pt or
- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1 lb or
- Ginstar @ 4-6 oz or
- Aim EC @ 1 oz + crop oil @ 1% v/v

- Resource @ 4-8oz + 1 pt crop oil- limited data

- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data

- ET @ 1.5 oz + crop oil @ 0.5% v/v

17. FirstPick @ 1.75-2 qt + one of the following:

- DEF/Folex @ 4-6 oz or

- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1 lb or

- Ginstar @ 4-6 oz or

- Aim EC @ 0.75-1 oz + NIS @ 0.25 v/v or

- ET @ 1.5 oz + crop oil @ 0.5% v/v

- Resource @ 4-8oz + 1 pt crop oil- limited data

- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data

18. Finish 6 Pro @ 1.33 pt + one of the following:

- DEF/Folex @ 4-6 oz or

- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1 lb or

- Ginstar @ 4-6 oz or

- Aim EC @ 1 oz + crop oil @ 1% v/v or

- Resource @ 4-8oz + 1 pt crop oil- limited data

- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data

- ET @ 1.5 oz + crop oil @ 0.5% v/v

Defoliation, Boll Opening and Regrowth Control

19. ethephon @ 1.33-1.5 pt + one of the following:

- Dropp/Free Fall/Thidiazuron/Klean-Pik SC/50W @ 0.1-0.125 lb + DEF/Folex @ 4-6 oz or
- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.125 lb or
- Ginstar @ 6.4 oz

20. FirstPick @ 1.75-2 qt + one of the following:

- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1-0.125 lb or
- Ginstar @ 6.4 oz

21. Finish 6 Pro @ 1.33 pt + one of the following:

- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1-0.125 lb or
- Leafless @ 10 oz or
- Ginstar @ 6.4 oz

II – Mid Season (highs 80-89°F plus, lows 60-70°F)

Defoliation Only

1. DEF/Folex @ 1.5-1.75 pt
2. Aim EC @ 0.75-1 oz + crop oil @ 1% v/v
3. Finish 6 Pro @ 11 oz + DEF/Folex @ 6-8 oz
4. Sodium Chlorate @ 4 lb (mature foliage only; do not mix with DEF/Folex or ethephon)
5. ET @ 1.5 oz + crop oil @ 0.5% v/v

Defoliation and Regrowth Control

7. Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.2 lb

8. Dropp/Free Fall/Thidiazuron/Klean-Pik 50 W SC/50W @ 0.125-0.14 lb + one of the following:

- DEF/Folex @ 1 pt or
- ET @ 1.5 oz + crop oil @ 0.5% v/v or
- Aim EC @ 0.75-1 oz + crop @ 1% v/v
- Resource @ 4-8oz + 1 pt crop oil- limited data
- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data

9. Ginstar @ 6.4-8 oz

10. glyphosate @ 1.2-2 pt + one of the following:

- DEF/Folex @ 1 pt or
- Aim EC @ 0.75-1 oz + crop @ 1% v/v or
- Resource @ 4-8oz + 1 pt crop oil- limited data
- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data
- ET @ 1.5 oz + crop oil @ 0.5% v/v

Defoliation and Boll Openning

11. ethephon @ 2-2.67 pt

12. ethephon @ 1.5-2 pt + one of the following:

- DEF/Folex @ 1-1.25 pt or
- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1 lb or
- Ginstar @ 6.4 oz or
- Aim EC @ 0.75-1 oz + crop oil @ 1% v/v or

- ET @ 1.5 oz + crop oil @ 0.5% v/v
- Resource @ 4-8oz + 1 pt crop oil- limited data
- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data

13. FirstPick @ 2 qt + one of the following:

- DEF/Folex @ 8-12 oz or
- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1 lb or
- Ginstar @ 6.4 oz or
- Aim EC @ 0.75-1 oz + crop @ 1% v/v or
- ET @ 1.5 oz + crop oil @ 0.5% v/v
- Resource @ 4-8oz + 1 pt crop oil-limited data
- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil-limited data

14. Finish 6 Pro @ 1.33-1.5 pt + one of the following:

- DEF/Folex @ 8-12 oz or
- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.1 lb or
- Ginstar @ 6.4 oz or
- Aim EC @ 0.75-1 oz + crop oil @ 1% v/v or
- ET @ 1.5 oz + crop oil @ 0.5% v/v

Defoliation, Boll Opening, and Regrowth Control

16. ethephon @ 1.5-2 pt + one of the following:

- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.125-0.14 lb + DEF/Folex @ 8-10 oz or
- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.125-0.16 lb

17. FirstPick @ 2.0 qt + one of the following:

- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.125-0.14 lb or
- Aim EC @ 0.75-1 oz + crop @ 1% v/v or
- ET @ 1.5 oz + crop oil @ 0.5% v/v
- Resource @ 4-8oz + 1 pt crop oil- limited data
- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data
- Ginstar @ 6.4-8 oz

18. Finish 6 @ 1.33-1.5 pt + one of the following:

- Dropp/Free Fall/Thidiazuron/Klean-Pik 50W SC/50W @ 0.125 to 0.14 lb or
- Aim EC @ 0.75-1 oz + crop @ 1% v/v or
- ET @ 1.5 oz + crop oil @ 0.5% v/v
- Resource @ 4-8oz + 1 pt crop oil- limited data
- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data
- Ginstar @ 6.4-8 oz

III - Late Season (highs below 80°F, lows below 60°F)

NOTE: Under these conditions, cotton should often be preconditioned and then defoliated (see Section IV) or routinely defoliated with combinations, which include ethephon.

Defoliation Only

1. DEF/Folex @ 1.5-2 pt + Gramoxone Max/Firestorm/Parazone @ 4-6 oz
2. Ginstar @ 8-10 oz
3. Finish 6 @ 11 oz to 16 oz + DEF/Folex @ 6-12 oz

4. Aim EC @ 1 oz + crop oil @ 1% v/v
5. Sodium Chlorate @ 4 lb
6. ET 1.5 oz + crop oil @ 0.5% v/v
7. Resource @ 4-8oz + 1 pt crop oil- limited data
8. Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data

Defoliation and Boll Opening

7. ethephon @ 2-2.67 pt
8. ethephon @ 1.5-2.67 pt + one of the following:
 - DEF/Folex @ 1.25-2 pt or
 - Ginstar @ 8-10 oz or
 - Aim EC @ 1 oz + crop oil @ 1% v/v or
 - ET @ 1.5 oz + crop oil @ 0.5% v/v
 - Resource @ 4-8oz + 1 pt crop oil- limited data
 - Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data
9. FirstPick @ 2 qt + one of the following:
 - DEF/Folex @ 1-1.5 pt or
 - Ginstar @ 8-10 oz or
 - Aim EC @ 1 oz or
 - ET @ 1.5 oz + crop oil @ 0.5% v/v
 - Resource @ 4-8oz + 1 pt crop oil- limited data
 - Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data
10. Finish 6 Pro @ 1.5 pt + one of the following:
 - DEF/Folex @ 1-1.5 pt or

- Ginstar @ 8-10 oz or
- Aim EC @ 1 oz + crop @ 1% v/v or
- Resource @ 4-8oz + 1 pt crop oil- limited data
- Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data
- ET @ 1.5 oz + crop oil @ 0.5% v/v

IV – Preconditioning

Fields with dense canopy of foliage and significant numbers of green bolls may require two applications. The goal is to remove much of the foliage with an initial application, exposing unopened bolls. The follow-up application should be made seven-to-10 days later, when sufficient leaf drop has occurred to allow spray coverage of bolls with ethephon, FirstPick, or Finish 6 Pro.

Initial Preconditioning Treatment

1. DEF/Folex @ 0.5-1.25 pt
2. ethephon @ 0.67-1.33 pt
3. glyphosate @ 1.2-2 pt
4. ET @ 1.5 oz + crop oil @ 0.5% v/v
5. Aim EC @ 1 oz + crop @ 1% v/v
6. Resource @ 4-8oz + 1 pt crop oil- limited data
7. Blizzard @ 0.5-0.6 oz. + 1 pt crop oil- limited data

Follow-up Treatments Should Include Boll Openers with Harvest-Aid Mixtures Listed in Sections I, II, and III.

General Notes

Beware of off-target movement of harvest-aid products, especially with aerial applications. Significant problems have been observed with mixtures that include glyphosate, paraquat, or Aim.

Dropp 50W is sensitive to wash-off if rain occurs within six hours of application; addition of DEF/Folex improves rain-fastness. Ammonium sulfate @ 2 lb/A often improves activity of Drop/Thidiazuron/Klean-Pik 50W SC/50W. DEF/Folex plus Dropp 50W combinations have a tendency to cause “leaf sticking” when temperatures exceed 94°F, in combinations with spray adjuvants, or when rates are too high. Consider reducing rates by 10-20% when temperatures exceed 94°F. Regrowth control is minimal with Dropp /Thidiazuron/Klean-Pik 50W SC/50W rates below 0.1 lb/A or Ginstar rates below 6.4 oz. Ginstar includes the same active ingredients as in Dropp and diuron.

Roundup or generic glyphosate products will NOT provide regrowth suppression on RR cotton. Adding spray adjuvant may enhance activity of treatments when temperatures are low. However, adjuvants may sometimes cause “leaf sticking,” and, thus, these products should be used with caution early in the season.

Addition of Gramoxone Max/Firestorm/Parazone @ 1-4 oz may aid defoliation and weed desiccation with standard harvest-aid mixtures. Off-target movement may cause injury to sensitive plants, such as pine trees.

Accelerate may be used as a tank-mix with either DEF/Folex or sodium chlorate to hasten leaf drop by approximately two-to-three days.

V – Harvest Aid Weed Management

1. Gramoxone Max/Firestorm/Parazone @ 1-4 oz in combination with standard defoliant mixtures.

Use lowest rate during warm temperatures. Avoid off-target drift, especially to pines.

2. Roundup @ 1.5-2 pt in combination with DEF/Folex and/or ethephon. Roundup provides fair suppression of cotton regrowth. Avoid off-target drift.

3. Aim @ 0.67 oz + crop oil @ 1% v/v. Effective on morningglory and coffee senna.

4. a) Defoliate, then b) Dessiccate with Gramoxone Max/Firestorm/Parazone as listed below.

Table 1. Dessicants for Cotton Harvest Preparation

Dessicate	lb A/gal	Formulation Rate/Acre	Spray Volume, gal/A	
			Ground	Air
Gramoxone Max/ Firestorm/Parazone	3.0/2.5	1-4 oz ¹ 5.5 oz to 1.5 pt ²	10-20	5
Sodium Chlorate	4-6	3 to 6 lb A	15-30	5-10

¹For addition to defoliant mixtures in cotton at least 75% open. Improves activity in colder, late-season conditions. May cause crop dessication (90°F and above) and damage to immature bolls.

²For dessication of weeds and cotton regrowth **after** defoliation. Rates of 8-16 oz are usually sufficient. Add surfactant at 1-2 qts/100 gals spray solution. Be prepared to harvest in a timely manner to minimize bark problems.

Table 2. Performance Rating of Harvest Aids by Function (P=poor. F=fair. G=good. E=excellent.)

Product	Function				
	Remove Mature Foliage	Remove Juvenile Foliage	Open Bolls	Suppress Regrowth	Dessicate Weeds ²
Aim/ET	G	G-E	P	P	F
DEF/Foalex	G-E	P-F	P	P	P
Dropp/Thidiazuron/Klean-Pik	G-E	G	P	G-E	P
Ginstar	G-E	G	P	G-E	P
Ethephon ¹	F-G	P-F	E	P	P
Sodium Chlorate	F	P	P	P	F-G
Roundup/Glyphosate	P	F	P	F-G	G
Gramoxone Max/ Firestorm/Parazone	F	F	F	P	G
FirstPick	G	P-F	E+	P	F
Finish	G-E	P-F	E+	F	P

¹Ethephon (Prep, Ethephon 6, Bolld, etc.)

²Refers to weed defoliation plus dry down to reduce harvest interference, green stain, and moisture.