Cotton
Defoliation

Mississippi State University Extension Service

Application Timing

Harvest-aid application is largely determined by the maturity of the crop, weather conditions, and the harvest schedule. Studies show boll maturity is the single most important factor to consider in timing defoliant applications. Little or no boll maturation occurs after the leaves are removed; therefore, premature leaf removal can reduce yield and quality.

It is generally safe to defoliate when 50 to 60 percent of the bolls are open and the youngest boll you expect to harvest is mature (generally 36 to 40 days old). Under high levels of management, this may occur as early as 45 percent open.

To check boll maturity, cut it in cross section with a sharp knife. When mature, it should be difficult to cut with a sharp knife and the seed will be completely filled out with no jelly in the center. The presence of a thin, brown line around the seed indicates the seed coat is reaching maturity and the boll is mature enough not to be adversely affected by application of a harvest-aid chemical.

Growers monitoring crop development by plant mapping or by keeping track of heat unit (DD60) accumulation may want to use this data to help predict the approximate time to apply defoliants. In doing this, the last effective bloom must be identified. Generally, the last effective bloom occurs at what is referred to as "cut-out," which normally occurs when the crop is at 5 nodes above white flower (NAWF). When the last effective bloom has accumulated 750 DD60's, it generally will be mature enough to defoliate; however, this may vary from year to year and from field to field due to differences in rainfall, soil types, or daily high temperatures.

In general, a boll must be at least 36 to 40 days old (from day of white bloom) before it is safe to defoliate the plants. Bolls less than 36 days old when a harvest aid is applied generally will be reduced in weight, micronaire of its fiber will be reduced, and fiber strength may also be reduced.

Nodes Above Cracked Boll – Nodes above the uppermost first position cracked boll is a technique used for aiding defoliation timing decisions. This technique involves frequent plant mapping to determine the node of the first position cracked boll and the number of fruiting branches above the cracked boll. Research indicates at least four nodes above the highest first position cracked boll will be mature enough not to be adversely affected by the application of a harvest aid. Therefore, when the first position cracked boll is within four nodes of the last boll you want to harvest, the field can be defoliated. For this system to work, map fields regularly and sample enough plants to make data reliable. This is one of several techniques to help in timing decisions; use accordingly to validate or supplement other techniques. As with any technique, a physical examination of the bolls should precede an application of defoliant.

Plant mapping and DD60's to help time defoliation are good tools and you can learn much about cotton growth and development through them. Make the final decision to apply a harvest aid only after a physical examination of the field in question.

Apply Defoliants Properly

When possible, apply defoliants in late afternoon or early morning when humidity is high and winds are calm. Defoliants work best when nighttime temperatures are 60 ºF or higher and the plants are not drought-stressed. You can often have better defoliation by delaying application until periods of cool weather have moderated.

Defoliation materials do not move within the plant, so adequate coverage of the foliage is essential.

Aerial Application

Good aerial applications begin with the pilot's having thorough knowledge of equipment, climatic conditions, the material being applied, and the target organism. Aerial applicators should first pattern test their planes to determine the effective swath width and uniformity. Removing all active nozzles from the outer 30 percent of the aircraft wing is recommended to reduce drift and improve swath uniformity by reducing the amount of material being entrained into the wingtip vortex.

Pilots should review and practice pre-1986 phenoxy herbicide application recommendations as a guide to reduce drift. The pilot and the customer must understand the most uniform application occurs when the aircraft's boom is operated at a height of approximately one-fourth of the plane's wing span above the target – that is, 8 to 12 feet above the crop for most ag spray planes. Modify

this height only for special crop and weather conditions.

To reduce drift, avoid applications during periods of high winds, high temperatures, and low humidity or dead calm conditions. Be very careful when making applications near susceptible crops, commercial fish ponds or other bodies of water, and densely populated areas. Some defoliants have a characteristic offensive odor, but consideration of materials and timing of the applications might prevent complaints from neighbors. **Read the product label carefully before making applications.**

The most effective application occurs when all of the intended rate of active ingredient is delivered to the target—with reasonable plant coverage and canopy penetration and with a medium droplet size (275-400 microns VMD spray at the release point). Because of coverage and droplet size requirements of defoliants, total application volumes by air usually are in the 4 to 8 gallons/acre range. Larger finished spray volumes generally improve coverage and result in better defoliation, especially on larger plants with lush foliage (caused by heavy insect pressures, excessive or late-applied nitrogen, or untimely irrigations and/or rainfall).

Most applicators use a D6-46 or D8-46 nozzle and core combination to apply these volumes and to get good coverage, droplet size, and canopy penetration. For aircraft operating 115 mph or faster, the nozzle should be oriented spraying straight back (i.e., with the airstream). For fixed-wing planes operated below 115 mph, nozzles should be smaller (D6-46) or oriented 45 degrees down and back into the airstream. You can also use a larger nozzle (D12-46) with straight-down orientation to generate the desired droplet size by shear; however, this causes variation in droplet size and contributes significantly to driftable fines in the spray cloud.

Ground Applications

Conventional high-clearance spray rigs with wheel shields are capable of good defoliant applications with minimum crop damage. Small cone tips (Spraying Systems TX-6 to TX-18), flat fan nozzles (Spraying Systems 80015 to 8004), and twin jet tips (TJ60-8002EVS to TJ60-8004EVS) produce the desired droplet size and coverage for nozzle spacings of 18 to 20 inches. Maintain boom height during application at 80 percent of nozzle spacing above the crop for proper overlap.

Sprayer speed normally will be 3-7 mph but should be dictated by crop and field conditions, equipment capabilities, and operator skills. Pressures should be within the manufacturer's specified range for the nozzle tip used, usually 40-60 psi for small cone tips and 20-40 psi for fan tips. These operating conditions will result in finished spray rates of 5-15 gallons/acre, with most applicators targeting for a finished spray volume of 10 gallons/acre.

Calibrate the equipment before spraying begins; check and clean nozzles and strainers daily. Flush and clean spray equipment daily according to the label directions for the material being applied. **Read and follow label directions and recommended application and safety practices before, during, and after applications.**

Problem Situations

When it becomes apparent certain areas in the field (borders and low areas) are not defoliating as well as the majority of the field, re-treat these areas with a standard defoliation approach. To decide on re-treatment, determine if there are enough fully developed leaves on the plants to justify defoliation.

Second growth after first defoliation is frequently a problem. Reapplying any of the recommended defoliants is permitted, but it may provide less than desired results due to poor coverage on small leaves and the continuing emergence of new leaves. If the regrowth problem is field wide, consider treating with a desiccant such as sodium chlorate or Starfire. In this case, treat at the earliest possible date to avoid new leaves' reaching size enough to cause downgrading of the sample grade. Under conditions where second growth is a potential problem, consider Dropp in the initial treatment, since it inhibits regrowth.

Diapause and Defoliation

If you choose to supplement the boll weevil eradication program by adding an insecticide, choose one compatible with the defoliant used. Most insecticides commonly applied as a diapause treatment (methyl parathion or Guthion) are thought to be compatible with all the defoliants except sodium chlorate. **Do not mix an insecticide with sodium chlorate.** Be careful, however, not to apply the defoliant-insecticide mixture earlier than the time the cotton should be defoliated, since this may reduce yield and quality. **Read the defoliant label before mixing insecticides and defoliants.**

Material and Rate Selection

Direct selection of proper defoliants or tank mix combinations of materials toward specific objectives. To accelerate boll opening, you can use ethephon/Prep/ Finish/ Super Boll, others, or a combination of ethephon with a compatible defoliant. If regrowth is a concern, Dropp, or a combination including Dropp, is appropriate. If nighttime temperatures are beginning to drop into the 60's, Harvade or Harvade plus ethephon is a good choice. Select the material that fits the situation in the field as well as projected weather conditions.

Select with care the rate of defoliant. The response of plants to defoliants is affected by temperature (at time

of application and for 3-4 days thereafter), condition of the plant, rate of material used, and coverage. Temperature and plant condition need careful consideration. Higher rates are also required when plants are growing vigorously with excessive immature leaves. Too little defoliant usually reduces the percentage of leaf drop. Too much defoliant may cause desiccation of leaves and increase pin trash.

Generally, under good conditions, when you use tank mixes, the lowest label rate of each material should give good results; for the most part, avoid using full label rates when you use mixes. The objective is to have plants as free of leaves as possible at the time of picking. Under warm, humid conditions and nighttime temperatures above 60 °F just before treatment and for 2-3 days after treatment, two defoliants mixed at one-half the standard-labeled rate provide defoliation equal to or better than either defoliant alone.

Harvest-Aid Materials

CottonQuik–CottonQuik weighs 12.45 pounds per gallon and contains 2.28 pounds of ethephon per gallon and 7.30 pounds aminomethanamide dihydrogen tetraoxo-sulfate per gallon.

Typically, satisfactory defoliation is achieved within 7 days. Adverse conditions such as low temperatures and/or toughened plants may require up to 14 days. CottonQuik also provides limited control of cotton terminalregrowth. **Do not exceed a maximum of 3.5 quarts per acre per year.**

After application of CottonQuik, thorough rinsing of application equipment is strongly recommended. **Refer to the label for additional instructions**.

Def 6 and Folex–These phosphate-type materials have been the standard defoliants for a number of years. Their performances are equal. The lower label rates have performed well only under near-ideal plant and temperature conditions. Under cooler temperatures or less favorable plant conditions, the higher label rates tend to perform best. These materials are labeled for combination with Dropp 50 WP or ethephon. When combinations are used, the lower rate of Def 6 or Folex seems to perform well. These materials are not good regrowth inhibitors and are more rain fast than are other materials. Always follow the mixing instructions on the label.

Finish–Finish is a product from Aventis Crop Science that contains ethephon and cyclanilide per gallon. When used at the rates labeled for expected field conditions, Finish may serve as a defoliant and boll opener. In some cases, such as rank growth, weed infestations, or insect infestations, the inclusion of other products is required.

Finish may shorten the time internal between application and harvest as compared to ethephon used alone. Activity against juvenile growth and terminal regrowth suppression is good. Do not apply more than two quarts per acre per year.

Harvade 5F is the only defoliant that states on the label that it is to be used with crop oil concentrate. Some recommended additives are listed on the Harvade label. It seems to be less sensitive to low temperatures than other defoliants and performs better than other materials when average temperatures are below 70 °F. It is essentially odorless and provides limited desiccation of morningglories. **Give special attention to the use precautions stated on the label.**

Dropp 50 WP significantly suppresses or delays regrowth. The degree of regrowth control depends on the rate, plant conditions, and weather. Dropp performs best under warm, humid conditions. When nighttime temperatures (at treatment or for 2-3 days after treatment) drop into the low 60's, performance is reduced. Under **cool conditions**, tank mixing reduced rates of Dropp with methyl parathion, the phosphate defoliants, ethephon, or a recommended crop oil concentrate will enhance defoliant activity while maintaining adequate regrowth inhibition. Under warm to hot conditions, Dropp is effective when used alone, at low label rates. When combinations are used, rate selection of materials in the mixture is important because higher rates may cause desiccation of some leaves. **Refer to the label for mixing and clean-up instructions.**

Ginstar is formulated as an emulsifiable concentrate. It may take several days before the effect of Ginstar becomes noticeable. Adverse conditions such as low temperatures may require higher dosages and/or longer times for more complete defoliation. Ginstar inhibits regrowth after defoliation.

Response of the cotton plant to an application of Ginstar slows under temperatures below 60 °F. Ideally, nighttime temperatures 2 to 3 days before and following application should be no less than 60 °F or defoliation and/or regrowth inhibition can be reduced.

Use of Ginstar on heat and drought-stressed cotton (low leaf moisture, thick cuticle, etc.) can result in less that satisfactory defoliation and regrowth inhibition. **Important: Read and follow all instructions on the label, especially Use Precautions, Mixing Instructions, Use of Adjuvants, and Directions for Use.**

Ethephon–Ethephon is the active ingredient in Prep/Super Boll and is formulated to contain 6 pounds per gallon of active ingredient. Prep/Super Boll is primarily a boll opener. It has exhibited positive benefits in increasing the degree of defoliation under adverse conditions and in speeding boll opening. Increasing the rate of boll opening has permitted harvesting operations to start several days earlier, increased the percentage of the crop harvested during the first picking, and made picking a once-over operation in many fields.

The recommended rate for boll opening is 1 to 2 pounds of active ingredient per acre. The higher rate sometimes acts as a defoliant under optimum conditions. Use the lower rate in combination with other defoliants. Ethephon is compatible with Def, Folex, Dropp, and

Harvade. Good agitation is a must. **Do not mix ethephon with sodium chlorate.**

Desiccants generally are not used as harvest aids for cotton to be picked by a spindle-type picker. If desiccation of weeds or regrowth vegetation is necessary, it generally is best to apply a defoliant, wait until leaf drop has occurred, and then apply the desiccant material.

Sodium chlorate acts as a desiccant at higher rates of application, tending to stick leaves to the cotton plants. At the normal use rates for defoliation, the chlorates are not as effective as the phosphates. Chlorates are not good inhibitors of regrowth. Do not mix the chlorates with phosphate defoliants, phosphate insecticides, or Prep. Sodium chlorate is usually a good follow-up treatment if the initial treatment provides less than desirable results and generally performs well under cool conditions.

Starfire is labeled for desiccation and as a harvest aid. For harvest-aid applications, the label recommends 11 ounces of Starfire plus 1 pint of a phosphate defoliant, or 3 to 6 pounds active ingredient of chlorate per acre in a minimum of 10 gallons total volume by ground, or 3 gallons total volume by air, applied when 80 percent or more of the bolls are open and the remaining bolls to be harvested are mature. Starfire is also labeled at 4 to 6 ounces per acre tank- mixed with Def, Folex, Dropp, Harvade, or Prep/Super Boll for defoliation and boll opening. Apply in a minimum total volume of 10 gallons per acre by ground or 3 gallons per acre by air. Apply when a minimum of 60 percent of the bolls are open and the remaining bolls to be harvested are mature. Starfire applied at the 4- to 6-ounce rate in combination with defoliants may improve defoliation under adverse conditions. Starfire is also labeled as a desiccant to be applied after defoliation applications. For this purpose, apply 11 to 21 ounces per acre in a minimum total volume of 10 gallons per acre by ground or 3 gallons per acre by air. Apply when at least 75 percent of the bolls are open. Development of immature bolls will be inhibited. **Follow the use precautions as stated on the label.**

Roundup Ultra can be used in a tank-mix with various defoliants to achieve late-season control of weeds and to reduce populations of perennial grasses and vines. Apply after 60 percent open bolls at 16-64 ounces Roundup Ultra per acre in a tank-mix, with a suitable defoliant at recommended rates. Apply in 3 to 10 gallons by air or 10 to 20 gallons by ground. **Do not apply to crops grown for seed. Do not apply more than 1 quart of Roundup Ultra by air.**

Table 1. Materials for use as harvest aids or desiccants on cotton

Material	Maximum registered dosage lb a.i./a	Precautions
Sodium chlorate	5.00	Do not apply within 7 days of harvest. Do not graze treated areas or feed gin waste to livestock.
Starfire	0.47 (see Starfire, Table 3)	Do not apply within 3 days of harvest. May apply as split application. Do not pasture lactating dairy animals. Do not pasture livestock in treated fields within 15 days after treatment. Remove livestock from treated area 30 days before slaughter. Do not feed gin trash to livestock. Development of immature bolls will be inhibited.
Roundup Ultra	2.00*	Allow a minimum of 7 days between application and harvest. **Do not apply to cotton grown for seed**. Do not feed or graze treated cottonseed, forage, or hay following preharvest applications. *Ground application only at this rate.

Table 2. Guide for use of defoliants and harvest aids

Defoliant	Rate/acre formulated product unless specified	Recommended rates under favorable conditions*	Application information
Sodium chlorate	3-5 lb a.i.	3 lb	Apply in 4-10 gallons per acre by air; 5-30 gallons by ground.
DEF 6	1.3-2 pt	1.5 pt	Apply in 5-10 gallons per acre by air; 15-25 gallons by ground.
Folex	1.5-2 pt	1.5 pt	Apply in 5-12 gallons per acre by air; 15-25 gallons by ground.
Dropp	0.2-0.4 lb	0.25 lb	Apply in 2-10 gallons per acre by air; 10-25 gallons by ground.
Harvade + COC**	0.5 pt + 1-2 pt	0.5 pt + 1 pt	Apply in minimum of 5 gallons per acre by air; a minimum of 10 gallons by ground.
Finish 4	2-4 pt	3 pt	Apply in minimum of 10 gallons by ground; 3 gallons by air.
Finish 4+ Dropp	2-4 pt + 0.1-0.05 lb	2 pt + 0.07 lb	Apply in minimum of 10 gallons by ground; 3 gallons by air.
Finish 4+ Folex	2-4 pt + 0.25-0.5 pt	2 pt + 0.25 pt	Apply in minimum of 10 gallons by ground; 3 gallons by air.
Harvade + Prep + COC**	0.5 pt + 1.3 pt + 1 pt	0.4 pt + 1.3 pt + 1 pt	Apply in minimum of 5 gallons per acre by air; a minimum of 10 gallons by ground.
CottonQuik + Dropp	1.75-3.5 qt + 0.1 lb	1.75 qt 0.1 lb	Apply in 15-30 gallons per acre by ground; 3-10 gallons per acre by air.
Dropp 50 WP + Def 6 (Dropp Label)	0.1-0.2 lb + 0.5-1.0 pt	0.125 lb +*** 0.75 pt	Apply in 5-10 gallons per acre by air; 15-25 gallons by ground.
Def 6 + (Def 6 Label) Dropp 50 WP	1-1.3 pt + 0.066-0.1 lb	0.75 pt + 0.125 lb ***	Apply in 5-10 gallons per acre by air; 15-25 gallons by ground.
Dropp 50 WP + Prep/Super Boll	0.1-0.2 lb + 1.3-2.6 pt	0.125 lb + *** 1.3 pt	Apply in 5-10 gallons per acre by air; 15-20 gallons by ground.
Ginstar	4-6 oz	4oz	Apply in 2-10 gallons per acre by air; 10-25 gallons by ground.
Folex or Def 6 + Prep/Super Boll	1.5-2 pt + 1.3-2.6 pt	0.75 pt + 1.3 pt	Apply in 5-10 gallons per acre by air; 15-25 gallons by ground.
Folex + Dropp 50 WP	1-1.5 pt + 0.1-0.2 lb	0.75 pt + 0.125 lb***	Apply in 5-10 gallons per acre by air; 15-25 gallons by ground.
Roundup Ultra + suitable defoliant	16-64 oz	32 oz	Apply in 3-10 gallons by air or 10-20 gallons by ground. Use higher rates for perennial vines.
Starfire + Folex or Def 6	4-6 0.5-1.0 pt	6 oz 0.75 pt	Apply in 10 gallons by ground or 3 gallons by air with nonionic surfactant at .25 percent v/v.

*Favorable conditions are warm, humid conditions with nighttime temperatures above 60 °F.
**COC = Crop oil concentrate (83-17).
***The 0.125 rate of Dropp 50 WP may be marginal for regrowth control.

Table 3. Expected performance of various defoliant mixtures when applied under favorable conditions and at recommended rates listed in Table 2

Material	Defoliation			Regrowth removal	Boll opening	Weed desiccation
	Mature leaves	Immature leaves	Regrowth inhibition			
CottonQuik + Def/Folex	E	G	F	F	E	P
CottonQuik + Dropp	E	E	E	G	E	P
Def 6/Folex	G	G	P	F	P	P
Def/Folex + Dropp	E	E	E	G	P	P
Def/Folex + Prep	E	G	F	G	E	P
Def/Folex + Roundup	G	G	G	F	P	G
Dropp	G	E	E	G	P	P
Dropp + Prep	E	E	E	G	E	P
Finish	G	G	G	G	E	P
Finish + Dropp	E	E	E	G	E	P
Finish + Folex	E	G	G	G	E	P
Harvade + COC*	G	G	F	P	P	G
Harvade + Prep + COC*	E	G	F	F	E	G
Harvade + Roundup + COC*	G	G	G	P	P	E
Prep/Super Boll	F	G	F	G	E	P
Roundup	P	P	F	P	P	E
Starfire + NIS**	F	F	F	G	F	E
Sodium chlorate	G	F	P	G	P	F
Ginstar	G	E	E	E	P	P

P = poor, F = fair, G = good, E = excellent

* COC – Crop Oil Concentrate

** NIS – Nonionic Surfactant

Caution: If you handle or apply defoliants improperly, or if you do not dispose of unused portions safely, you may suffer injury. Domestic animals, desirable plants, and fish or other wildlife may also be harmed and water supplies may be contaminated. Use defoliants only when needed and handle them with care. **Follow directions and heed all precautions on the container label.**

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