Defoliation - Efficacy on Cotton and Effects on Late Season Weeds

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INTRODUCTION

Although it is one of the last management decisions in the cotton production cycle, defoliation timing and application are critical to producing a profitable crop. Improper timing will compromise both seed cotton yield and quality. In light of the premiums and discounts for fiber quality brought about with High Volume Instrumentation (HVI) measurements, proper choice and timing of harvest aid chemicals are of paramount importance. Ideally, the proper harvest aid materials should defoliate the entire plant within 14 days after application with minimal desiccation. However, plant maturity, moisture status, nitrogen status and environmental conditions dictate this response. The tight economics of cotton production today dictate that grower's do all that is possible to properly set up the crop for effective, reduced-cost defoliation that still protects lint quality and price. The best conditions for effective defoliation include the following: 1) Air temperatures from moderate to high (day time - >10^{B}C; 2) Relatively low plant and soil nitrogen levels; 3) Moderate soil water levels (plants can't be water stressed); 4) uniform crop development with crop at cutout; 5) Weeds, insect and disease under control; 6) Complete defoliant coverage with good penetration within the canopy.

IMPORTANCE OF PROPER TIMING FOR HARVEST AID APPLICATIONS

Defoliation decisions have to be made on a field-by-field basis due to the wide range of crop maturities experienced within and across fields, and the impacts of weather and crop conditions that prevail at the time when the crop is acceptably mature for harvest preparation. Fields that have gone through a relatively even vegetative cutout and have a good boll load will be much easier to defoliate than fields with a non-uniform fruit set (for example, early and late bolls and a poor middle crop) or where there is substantial late vegetative growth due to factors such as late plantings, late irrigations or high late season soil nitrogen.

Timing and techniques for determining boll maturity

Generalizations. Understanding of the sequence of boll maturation and knowledge of how to assess boll
maturity are necessary in order to effectively use any of the following approaches to assess proper timing
for harvest aid applications. The standard recommendation is to apply defoliation treatments when 95% of green bolls are mature or when 65% of expected harvestable bolls are open. A mature green boll cannot be easily cut with a sharp knife. The seed coat of seeds within mature bolls also has a tan color as opposed to the milky white color in immature bolls. In California, counting nodes above cracked bolls (NACB) is the recommended technique to determine the proper application timing. If defoliation is delayed until the recommended NACB, fiber quality and yield will not be affected

Specific Factors to Consider. Different approaches to the assessment of boll maturity and crop readiness for harvest aid applications will be reviewed in the following discussion. In the late-season, not all green bolls will have the right conditions and adequate time to mature and open prior to harvest aid applications, so it is important to be able to assess both boll maturity and the amount of

time and heat units required to finish out and open mature bolls. Mature harvestable bolls have the following general characteristics:

- Difficult to slice boll open across the suture lines of the boll wall even with a sharp knife
- Hard to "dent" or depress the boll wall with your fingers when pressing on it
- Seed coats range from yellowish to tan, even dark tan in color (in mature bolls, no seeds will have the milky-white seed coat color seen in immature bolls)
- When boll is cut open, lint can begin to string out rather than feeling wet
- Gelatinous material around seeds is mostly or completely gone

Percent Open/Assessment of Mature Bolls:

This approach has been in use for many years across the U.S. cotton belt, and it involves specific percentages of (a) mature green bolls; or (b) open bolls for harvest aid applications:

- 90 to 95 percent of the green bolls are "mature" as defined above
- 60 to 65 percent of the expected harvestable bolls are open is used as a target for defoliant application
- 80 to 85 percent of the expected harvestable bolls are open is used as a target for desiccant applications

There are advantages and disadvantages to use of this approach. Examples can be used to identify problems with this approach, including the following two examples: (1) a crop set over an extremely long time period; versus (2) a compressed boll setting period. With the crop set over a long period, it would be possible to have a poor set of mid-canopy bolls, with bolls split between early-season and late-season bolls. Under this circumstance, it could be too early to defoliate even with 60 percent open bolls, since a significant part of the crop is in late-maturing bolls. In a crop with a compressed boll setting period, with bolls set early, on most successive fruiting branches, and with a relatively early vegetative cutout, it could be safe to defoliate at much less than 60 percent open boll. Under these types of situations, other evaluation techniques can prove useful. The following discussion addresses some other useful relative indicators of readiness for harvest aid applications.

Sharp Knife Technique/Seed Development Evaluations:

In this method, seed and lint development and appearance are evaluated as a tool to assess maturity. This technique is called the "sharp knife" method by many people since it requires cutting bolls expected to be "mature" in half (perpendicular to the carpel wall suture lines) with a sharp knife. The evaluation technique can involve both: (a) ability to cut through the lint and (b) seed maturity. More "mature" fibers can be more easily cut with a sharp knife. This characteristic can be used as an index of boll maturity, but this can be fairly imprecise since knives differ in "sharpness," and this is at best a "relative" term difficult to quantify. Inspection of the seeds for maturity can be done more consistently once the bolls are cut in half, and this can be done without removing the seeds from the boll. Seeds in mature bolls will have the characteristics mentioned at the beginning of this section. If the seeds remain immature, they will have the following characteristics:

- Appearance of "free" water in the boll
- "Jelly-like" appearance in material around seeds in the boll
- Seed coat still white instead of tan or brown

- Cotyledons white instead of green

If cutting bolls is used as an estimate of boll maturity, efforts must be made to cut bolls of different ages /positions on the plant to gain a field average when assessing uppermost bolls likely to mature and open.

Nodes Above Cracked Boll (NACB) Approach

This technique is based upon the idea that bolls will "crack" open (split along the boll suture lines) and be ready for harvest in roughly the same sequence that flowers were produced on the plant (ie. there will be a fairly regular progression in opening of bolls from the bottom of the plant towards the top). In general, the recommended time that harvest aid applications can be made on Acala and CA Upland varieties is 4 NACB and for Pima 3 NACB. If defoliant applications are timed to match these stages of boll opening in the crop, fiber quality and yield will not be affected. The first step is to determine the last first position boll on the main stem that you determine will be carried all the way to harvest, and begin counting down the stem to the first cracked boll (boll starting to open and dry). The number of nodes above cracked boll will be calculated as the node position difference between that uppermost last boll to carry to harvest and that of the uppermost first position cracked boll.

Fields best-suited to this approach are those in which plant populations are moderate to high, and where plant populations and growth are relatively uniform. The NACB approach is less easy to use in fields or with varieties where a high proportion of the boll set is on vegetative branches, or where there are large gaps in position of fruit on the plant. When retained bolls are not evenly distributed within the plants (due to pest impacts or weather-related problems), there can be special cases to consider when evaluating the use of NACB for determining defoliation timing. Particularly when there are late-season boll losses, the last harvestable boll on the plant may not be in the first position on the fruiting branch.

FACTORS TO CONSIDER IN SELECTING A DEFOLIATION STRATEGY

Growers need defoliants with different modes of action to insure continued best results under a variety of environmental and crop conditions. However, it also is important to consider the importance of prevailing environmental and crop conditions in determining a cost-effective approach for each field.

Weather Conditions. It might seem a straight-forward decision to determine what to use and how much to spend on harvest preparation, but factors such as crop late-season vigor, nitrogen status, and water status can exert a big influence on success in defoliation. In many years, the often dominant factor going into each harvest season is typically hard to guess, and that is, the weather. Efficacy of harvest aids with different chemistries, the importance of adjuvants, and the need for repeat applications can be strongly influenced by both the weather (primarily temperature) as well as by crop vigor and levels of water or nutrient stress. Defoliants are much more effective when temperatures are warm, with daytime high temperatures greater than 80F. In general, earlier harvests, with longer, warmer days, are much more effective and time efficient and allow much more picker "power" than during the shorter, cooler and possibly wet days of November. Earlier harvests also make it easier to help preserve fiber quality.

Crop Vigor and Boll Load Impacts. In general, most harvest aids will do best, often even with lower labeled rates, in fields with a uniform boll load, strong cutout and little late-season vegetative growth. Choices become more complicated in fields with low and/or extended boll loads, where non-uniform cutout and rank vegetative growth

have to be considered. For a more thorough discussion of the relationships between crop condition (cutout, rankness of growth, relative boll load) and choice of approach for harvest aid applications, see the August, 2000 issue of the "CA Cotton Review Newsletter" available through your University of CA Cooperative Extension county office or at http://cottoninfo.ucdavis.edu.

Harvest Aid Chemical Choices. Several harvest aid chemicals are registered for use in California (Table 1 and 2). Primary defoliant materials are generally limited to the organosphosphate (OP) defoliants (DEF / Folex), or sodium chlorate, Ginstar and Dropp. Long-term UC studies, however, have identified some specific conditions which influence the performance of some materials versus others. With OP's, best results are usually obtained when they're applied in combination with ethephon. In University studies, Dropp when used alone has been more inconsistent in performance, especially with Acala Upland varieties. Sodium chlorate and Ginstar, when applied at high rates in combination with warm to hot temperatures, can cause leaves to freeze or desiccate on the plant.

Multiple applications of sodium chlorate can be used effectively for defoliation under some conditions, but it is most often used as a second application following an OP to desiccate remaining leaves before harvest. There are many defoliant enhancers, such as Accelerate, Cotton-Aid, Harvade and Starfire. Under some situations - rank growth, poor boll set, excessive moisture and/or nitrogen - these enhancers will increase efficacy when used in combination with Ginstar or OP's.

Late Season Weeds

Fields with significant population of weeds can present problems for defoliation and harvest operations. Late season weed problems can include field bindweed, johnsongrass, bermudagrass, nutsedge, annual morningglory, pigweed and nightshade. If the weeds are tall and grow into the upper canopy, such as johnsongrass, pigweed and nightshade, they can intercept some of the applied defoliant, reducing its effectiveness. Weeds that twine up through the cotton canopy such as annual morningglory and field bindweed can also intercept applied defoliants and reduce application and harvest efficience. Any type of weed at harvest will likely increase the trash content of lint resulting in "grassy bales" and reduced value of lint. If weed tissue that is green and hydrated at harvest time is not removed with defoliants or dehydrated with desicants, it may stain the cotton lint. Seed berries of nightshade can also cause lint staining all resulting in lower quality lint. Weed populations in fields grown for foundation, certified or registered seed can be very problematic. Weed control efforts need to be intensified much earlier in the growing season for seed fields.

Herbicide options for late season weeds are limited mainly to glyphosate applied alone at 8 NACB or later (4 NACB) in combination with defoliants. University studies (Table 3) have shown significantly increased control of johnsongrass, annual morningglory and black nightshade when glyphosate was applied tank mix with either Def or sodium chlorate when compared with either applied alone. Although the weeds are controlled, the desiccated weed skeletons still remain and reduce lint quality at harvest. Glyphosate cannot be used on fields grown for seed as cotton seed from fields treated at or near defoliation have shown reduced seedling vigor.

Just recently registered in 2003 for cotton defoliation, Shark (carfentrazone) will provide growers with another option for pre harvest weed problems. When used as a defoliant, Shark provides effective burn down of annual morningglory and many others weeds.

Table 1

Harvest Aid Chemicals		
Type	**Common Name**	**Trade Name**
Boll Openers/Conditioners	Ethephon	Prep
Boll Openers/Defoliants	Ethephon + Cyclanilide Ethephon + AMADS	Finish Cotton Quik
Defoliants	Tibufos Thidazuron Thidazuron + diuron Demethipin carfentrazone Sodium chorate	Def, Folex Dropp Ginstaar Harvade Shark Defol 6

Table 2

Harvest Aid Chemicals		
Type	**Common Name**	**Trade Name**
Desicants	Paraquat Sodium chlorate	Starfire Gramozone Max Defol 6
Other/Enhances	Endothall Cacodylic acid Glyphosate	Accelerate Cotton aid Roundup Ultra Max Touchdown IQ

Table 3

Percent Control Preharvest Weed Control 1986 - Steve Wright, UCCE Tulare County				
Treatments	**Rate/A**	**Johnsongrass**	**Annual Morningglory**	**Black Nightshade**
Roundup fb Sodium Chlorate	2 pt + 2 gal	97	85	67
Roundup + Def	2 pt + 2 pt	88	70	40
Sodium Chlorate	2 gal	55	25	25
DEF	2 pt	30	10	10

References

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