Harvest Aid Chemicals for New Mexico Cotton

John Idowu and Leslie Beck[1]

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Figure 1. **A cotton field in Las Cruces, NM.**

INTRODUCTION

Harvest aid chemicals are used in cotton production to prepare the crop for mechanical harvest so that a good lint yield and fiber quality can be attained (Figure 1). Different harvest aid chemicals are available on the market and, depending on what chemical is chosen, they can be used to control plant growth, cause defoliation or desiccation, and stimulate the opening of cotton bolls.

When these chemicals are applied to cotton properly and according to label directions, the time between boll maturity and crop harvest can be reduced. Reducing the time it takes for the bolls to mature enough to be harvested is important for minimizing crop yield and quality losses due to weathering and other environmental conditions (Figure 2).

The primary function of these harvest aid chemicals is to target the physiological processes within the cotton plant that can lead to specific symptoms of injury. Harvest aid chemicals affect specific plant growth hormones, which in turn trigger symptoms of desiccation, senescence,

[1]Respectively, Extension Agronomist and Extension Weed Specialist, Department of Extension Plant Sciences, New Mexico State University.

Figure 2. **Cotton plants in active boll-forming stage.**

and/or abscission (falling off) of the leaves; growth regulation of the cotton plant; or premature opening of the cotton bolls. Plant growth hormones that affect senescence and abscission include:

- **Ethylene**: This plant hormone triggers senescence of leaves by causing chlorophyll (green pigmentation used for photosynthesis) and proteins in the leaves to degrade, leading to the leaves' eventual death.

- **Abscisic acid**: A natural plant hormone directly involved in abscission, dormancy, stomatal closure, growth inhibition, and other plant responses.

- **Cytokinins**: These plant hormones can delay leaf senescence. Cytokinins sprayed on leaves can prolong the time that the leaves stay attached to the plant by promoting nutrient mobilization into the treated leaves. This enables them to live longer than non-treated leaves. Cytokinins may also prolong storage life of flowers, initiate bud development, and stimulate root growth of the plant.

- **Auxins**: A class of plant growth regulators chemically and functionally related to the natural hormone indoleacetic acid (IAA), which controls plant growth, development, and metabolism at low concentrations. Applications of these hormones can increase flower development and stimulate root growth. Auxins are generally high in younger leaves and low in older leaves. IAA can hasten the process of leaf abscission, especially when applied late after the abscission process has already started.

- **Gibberellins**: These are another class of growth hormones that stimulate growth and delay senescence. They may also stimulate elongation of the plant stalk and increase flower size.

Cotton crops in New Mexico are mechanically harvested using spindle and stripper harvesters. Defoliants and desiccants are used to reduce and remove foliage from cotton prior to harvest (although producers still depend on frost for defoliation). Growth regulators are primarily used to open bolls and to alter the vegetative and reproductive development of cotton. Producers have also used these chemicals to increase harvest efficiency, reduce lodging, reduce trash and lint staining, reduce cotton seed moisture, and decrease insect populations. Thus, defoliants, desiccants, and growth regulators can have an important role in preparing cotton grown in New Mexico for harvest.

However, producers must take care when using these harvest aid chemicals because their efficacy can be affected by multiple factors, such as weather conditions, stage of cotton maturity, water/nutrient management, and the variety of cotton being grown.

It is important to always consider the economics of using harvest aids since their use can have an impact on cotton production costs. Under the following conditions, the cost of harvest aids may exceed their benefits: 1) the fruit set is light, 2) cotton plants are small, 3) plants have a large number of immature bolls, 4) extensive natural defoliation has already taken place, and 5) a killing frost is imminent (Cathey, 1980). Consequently, producers are advised to carefully consider the economics, benefits, and drawbacks of applications before using harvest aid chemicals.

Table 1. Examples of Defoliants/Regrowth Inhibitors Labeled for Use in New Mexico Cotton as of May 2017*		
Trade Names (Manufacturer)	**Active Ingredients**	**Considerations**
Organophosphates		
Folex 6 EC (AMVAC)	Tribufos	Works to remove matured leaves; not effective for regrowth control or defoliating younger leaves.
PPO Inhibitors		
ETX (Nichino)	Pyraflufen-ethyl	Can act as defoliant and desiccant; add COC** at 1% volume per volume; good coverage essential for defoliation.
Aim EC (FMC)	Carfentrazone-ethyl	Can act as defoliant and desiccant; NIS required at higher temps, COC required at lower temps; good coverage essential for defoliation.
Display (FMC)	Carfentrazone-ethyl + fluthiacet-methyl	
Resource (Valent)	Flumiclorac pentyl ester	Add COC or MSO; add NIS if conditions are warm, sunny.
Sharpen (BASF)	Saflufenacil	Addition of MSO + AMS or UAN required.
Klean-Pik (MANA)	Thidiazuron	Works by controlling regrowth and younger leaves; add adjuvants for maximum efficacy.
Takedown (Loveland)		
Thidiazuron 4SC (Arysta)		
Ginstar EC (Bayer)	Thidiazuron + diuron	Tank mixes may improve efficacy; requires a minimum of 12 hours without rain after application for optimal performance; higher rates required if humidity is low; persistent in soil (refer to label).
Cutout (Nufarm)		
Adios (Arysta)		
Redi-Pik 1.5EC (MANA)		
*Table based on Byrd et al. (2016) and Wright and Hutmacher (2013).		
**COC = crop oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, AMS = ammonium sulfate, UAN = urea ammonium nitrate.		

DEFOLIANTS

Defoliants are herbicides or hormonal chemicals that cause the leaves of a plant to abscise. Defoliants are applied to cotton to facilitate and improve mechanical harvest by reducing leaf litter (trash) that can accumulate in the cotton lint and reduce product quality. Defoliants can have either an herbicidal effect (sodium chlorate, tribufos) or hormonal effect (ethephon, thidiazuron) on the cotton plant.

Defoliants that are commercially available and labeled for use in New Mexico as of May 2017, along with their active ingredients and other relevant information, are presented in Table 1.

Advantages and Disadvantages

In addition to reducing foliage trash, defoliants can decrease seed moisture and boll rotting; however, improper use of defoliants can reduce yields and fiber quality and cause low micronaire and fiber strength from regrowth. Multiple applications may be necessary in some cases, which can contribute to an increase in production costs.

Other Considerations

The major limitation of using chemical defoliants has been their inconsistent effects in the field. The efficacy of a defoliant depends on timing and rate of application; environmental conditions; absorption, degradation, and translocation; plant uniformity; and effective coverage.

When to Defoliate Cotton

It is critical to determine the correct time to defoliate cotton because the wrong timing can lead to both reduced lint yield and fiber quality (Bednarz et al., 2002). Generally, defoliation decisions can be made based on the following criteria:

1. Percent of open bolls: Defoliate when at least 60% of the bolls are open. Mark out defined areas in the field (3 feet within a row in at least 10 places within a uniformly managed field), then count the total number of bolls and the number

Table 2. Examples of Desiccants Labeled for Use in New Mexico Cotton as of May 2017*		
Trade Names (Manufacturer)	**Active Ingredients**	**Considerations**
Gramoxone Inteon (Syngenta)	Paraquat	Can be used both as a desiccant or defoliant; addition of NIS** recommended; apply when more than 80% of bolls are open because it interferes with further boll development after application; restricted-use herbicide.
Gramoxone SL (Syngenta)		
Gramoxone 2.0 (Syngenta)		
Firestorm (MacDermid)		
Parazone 3SL (Adama)		
Defol 750 (Drexel)	Sodium chlorate	Can be used both as a desiccant or defoliant depending on timing and application rate; low cost, low mammalian toxicity, and less damaging to other crops compared to paraquat; NIS enhances performance.
Defol 5 (Drexel)		
*Table based on Byrd et al. (2016) and Wright and Hutmacher (2013). **NIS = nonionic surfactant		

Table 3. Examples of Plant Growth Regulators Labeled for Use in New Mexico Cotton as of May 2017*		
Trade Names (Manufacturer)	**Active Ingredients**	**Considerations**
Super Boll (Nufarm)	Ethephon	7-day PHI**; requires a minimum of 6 hours without rain after application for optimal performance; use higher rates under cool and/or dry conditions, or on toughened/drought-stressed foliage.
Boll'd (WinField)		
Boll Buster (Loveland)		
Ethephon 6 (Arysta)		
Flash (Helena)		
Finsh 6 Pro (Bayer)	Ethephon + cyclanilide	
FirstPick (Nufarm)	Ethephon + urea sulfate	
Pix Ultra (Arysta)	Mepiquat chloride	
Pix WSG (Arysta)		
*Table based on Byrd et al. (2016) and Wright and Hutmacher (2013). **PHI = post-harvest interval		

of open bolls on the cotton plants within each specific area. The percent open bolls is number of open bolls divided by total bolls multiplied by 100. An estimate that is representative of the entire field requires sampling for percent open bolls at multiple sites within a field.

2. Nodes above cracked boll (NACB): Count the number of nodes with harvestable bolls above the uppermost first cracked boll (Figure 3). There should be no more than four such nodes above the cracked boll. For pima cotton, the NACB should be three or less. The larger the NACB when defoliants are applied, the higher the reduction in yield.

DESICCANTS

Desiccants are contact herbicides that quickly kill the leaves on the cotton plant by causing rapid water loss. Unlike defoliants, leaves damaged by desiccants remain attached to the stem and do not abscise. The damage to the leaves occurs so quickly that desiccants can also be used to kill cotton regrowth prior to harvest with mechanical strippers. Applications of defoliants under high temperatures can also provide effective desiccation of the cotton leaves. There are multiple harvest aide products classified as desiccants that are registered for use in New Mexico (Table 2).

Advantages and Disadvantages

The advantages of using desiccants include the ability to schedule harvests, increased stripper harvester

***Figure 3*. Example of a cracked boll.**

efficiency, decreased seed moisture, and control of late-season weeds. Disadvantages include reduced cotton quality and yield when applied improperly, as well as delayed harvest that can result in stalk deterioration and increased production costs.

Other Considerations

The major risk of using desiccants is improper application timing. For example, desiccants should be applied when more than 80% of the bolls are open; otherwise, the application could result in a significant reduction in cotton yield. Increased levels of desiccation have traditionally been observed when the active ingredients paraquat and sodium chlorate are tank mixed together prior to application.

GROWTH REGULATORS/BOLL OPENERS

Growth regulators are natural or synthetic plant hormones (phytohormones) that influence growth responses, such as germination, abscission, dormancy, and stomatal closure, as well as inhibit growth and other plant responses (see ***Introduction*** section). Mepiquat chloride and ethephon are the common active ingredients in growth regulators used in New Mexico. Mepiquat chloride is commonly used to increase boll retention, reduce vegetative growth, and stimulate earlier maturity, while ethephon is used to synthetically ripen the immature boll so that it will open early. However, ethephon may also provide effective defoliation when environmental conditions are favorable during and immediately after application. Examples of plant growth regulators labeled for use for New Mexico are listed in Table 3.

Advantages and Disadvantages

Advantages of using growth regulators include earlier harvest dates, reduced vegetative growth, increased quality of lint with once-over harvesting, improved defoliation, and reduced gin trash. However, growth regulators can cause erratic crop responses, reduced yields and fiber quality, and increased production costs when applied at improper rates and timing.

Other Considerations

The major limitation of plant growth regulators has been their inconsistent response in the field. The severity of these inconsistencies is generally related to application rates and timing, as well as environmental conditions at the time of application. Mepiquat chloride and ethephon applications generally are not recommended as standard management practices for use as a growth regulator or a boll opener. Both active ingredients can be effective under certain circumstances, although they may or may not result in increased yields. As always, cotton producers should evaluate their objectives for management and harvest as well as the economics (i.e., costs, effects on yield) of using these active ingredients prior to application.

RESEARCH

Researchers studying the use of plant growth regulators (PGRs) in cotton in the desert Southwest often encounter mixed results, with many trials showing no significant differences in yields between the nontreated checks and treatments with PGRs (Norton and Clark, 2004; Norton and Hatch, 2007). Norton and Clark (2004) tested different formulations of mepiquat chloride (Pix) at different rates (standard rate and sequential applications at a low rate) on upland cotton in southeastern Arizona. They found that the nontreated control plots had significantly higher yields than the plot treated with the PGR for both the standard and the sequential application treatments. This study also highlighted the differences in effectiveness of different formulations of

Pix; for example, Pentia (BASF), which was one of the Pix formulations tested, had the highest cotton yield compared to the regular Pix, Pix Plus, and Pix Ultra (Norton and Clark, 2004). These results show that the effectiveness of defoliant applications varies between years, locations, and environmental and crop conditions (Norton, 2005; Norton and Borrego, 2006). Although additional research is needed, growth regulators can be useful in preparing cotton for harvest; however, results have yet to demonstrate consistent and significant increases in cotton yields.

SAFE USE AND NEW MEXICO LAW

Suggested uses of defoliants, desiccants, and growth regulators in New Mexico are based on the manufacturer's label. Application rates and intervals from application to harvest are based on tolerances established by the Environmental Protection Agency for these chemical residues. The use of trade names does not indicate an endorsement of, or discrimination against, other products by the NMSU Cooperative Extension Service. We do not claim that this list is complete. Please use all agricultural chemicals safely and read and follow all label directions. Wear protective clothing when mixing and applying defoliants, desiccants, and growth regulators according to label instructions.

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John Idowu *is an Extension Agronomist in the Department of Extension Plant Sciences at NMSU. He earned his master's in agronomy from the University of Gottingen in Germany and his Ph.D. in land management from Cranfield University in the UK. His research and Extension activities are focused on sustainable crop production and soil management in New Mexico.*

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