TEXAS A&M AGRILIFE

Texas High and Rolling Plains Cotton Harvest Aid Guide

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Harvest aids are utilized in commercial cotton production in cotton to remove foliage, suppress or remove regrowth, and to enhance boll opening (dehiscence) to allow for timely harvest to maximize yield and minimize fiber quality losses from prolonged weathering as well as extraneous matter content. Cotton is a deciduous species with dehisent fruit (seed on the outside of the fruit upon ripening), defoliation and boll opening are natural processes controlled by the balance of plant hormones. Application of harvest aid chemistries are utilized to accelerate boll opening, desiccation, and defoliation to improve harvest efficieny and maintain fiber quailty. The effectiveness of harvest aids can be influenced by crop maturity, crop condition, rainfall, wind, relative humidity, solar radiation, and temperature.

Physiology of Leaf Abscission

Optimal leaf drop occurs when an abscission layer is formed at the base of a leaf petiole, such that cell walls deteriorate in the abscission zone and the petiole physically separates from the mainstem, fruiting branch, or vegetative branch. This process is controlled by the balance of two naturally occurring hormones: auxins and ethylene. Auxins are generally growth promoters, whereas ethylene is considered a growth inhibitor.

During maintenance phase, or prior to applying a defoliant, the leaf is healthy and fully functional, with relatively high auxin levels which promotes physiological processes like photosynthesis and suppresses the transport of ethylene (Figure 1). Once a defoliant has been applied (or if environmental conditions exist that promote leaf drop), the shedding induction phase initiates. During this phase, the relative balance between auxins and ethylene begins to change favoring the increase of ethylene. During the final phase of leaf abscission, auxin levels continue to decrease while ethylene levels continue to increase, causing chlorophyll degradation and the formation of the abscission layer at the base of the petiole. Soon after, the leaf abscises or separates from the plant.

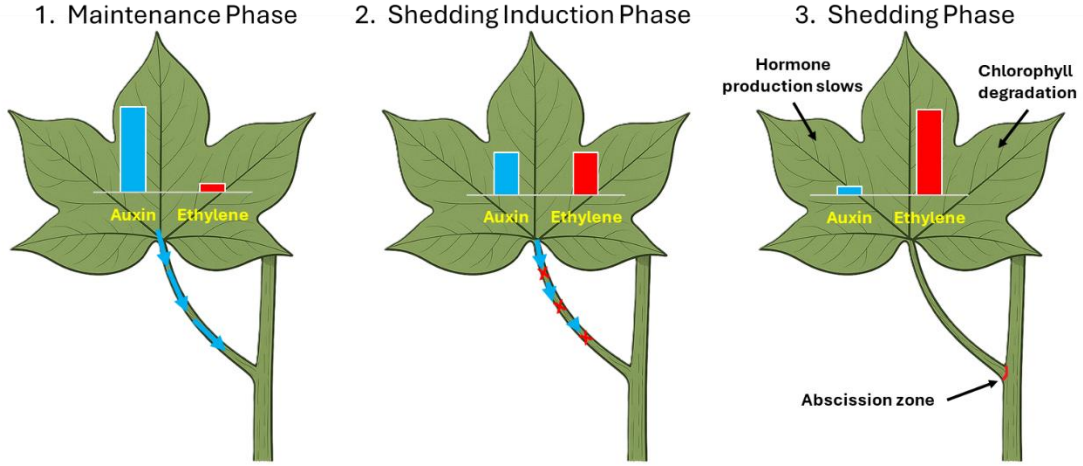


Figure 1. The three phases of the hormonal control of leaf abscission (adapted from Morgan, 1984; leaf/stem sketches via Microsoft Co-Pilot; annotations by Ken Legé).

Harvest Aid Types

Harvest aid chemistries can be classified as either hormonal or herbicidal. Hormonal products are those that have growth regulator activity and alter the balance between auxins and ethylene to trigger leaf abscission and/or boll dehiscence by increasing the activity of cell wall-degrading enzymes. Herbicidal harvest aids injure the plant, causing it to produce ethylene, a key plant hormone that signals the leaf abscission process.

Defoliants

Examples of hormonal defoliants include ethephon and thidiazuron. Tribufos, diuron, carfentrazone, pyraflufen, flumiclorac, fluthiacet, saflufenacil, tiafenacil, and paraquat are herbicidal defoliants. In general, hormonal defoliants tend to be less harsh than herbicidal defoliants. At higher rates and under stressful environmental conditions (e.g., hot, dry), herbicidal defoliants can potentially desiccate leaf tissue prior to the formation of an abscission layer, resulting in 'stuck' leaves that adhere to the plant in a necrotic state. However, herbicidal defoliants tend to have better activity under cooler conditions compared to hormonal defoliants, enhancing defoliant activity when cold fronts complicate harvest aid applications (Table 1).

Table 1. Minimum temperatures for optimum performance of selected harvest aids (adapted from Hake et al., 1996).

Harvest Aid Material	Minimum Temperature (F^o)
Hormonal materials	
Ethephon	60
Thidiazuron	65
Herbicidal materials	
Paraquat	<55[1]
Tribufos	55-60

1. Activity slows but performance is maintained below this temperature.

Desiccants

Stripper harvest requires that the plant be desiccated to allow branches, burrs, and any remaining leaves to be pulverized during the harvest process. Some of the herbicidal harvest aids have effective desiccation activity, including paraquat and tiafenacil.

Boll Openers

Boll dehiscence, or opening, is due to a physiological process similar to leaf abscission. Cell walls degrade along sutures in the boll wall, consistent with the location of locules in the boll after the application of some types of harvest aids, or as a result of the natural dehiscence process. Harvest aids accelerate this process by enhancing the ethylene levels in the boll. Once the sutures have formed in the boll wall, the remainder of the process requires drying of the boll interior and the boll wall itself. As the boll is drying down, the boll walls invert and fold outward. Forming the desiccated burr and exposing the drying seedcotton in the process. The similar balance shift between auxins and ethylene discussed in the Physiology of Leaf Abscission section above occurs for suture formation

as well. Physical forces also contribute to boll opening, since the maturation and drying of seed and fiber inside the boll create internal pressure as the boll wall is drying, aiding in the opening process.

Regrowth Suppressors and Removers.

New leaf growth can occur following the application of some defoliants from various growing points throughout the plant, potentially causing deterioration of color grades (yellowness) due to green stains during the harvest process. Some harvest aid chemistries have the ability to suppress or inhibit regrowth formation; some are effective at removing regrowth when it occurs. These generally desiccate existing regrowth, reducing the potential for staining fiber during the harvest process; however, excessive desiccated regrowth remaining on the plant at

Table 2. Expected harvest aid activity in the high and rolling plains of Texas (adapted from Maeda and Keeling, 2021).

Active Ingredient	Trade Names[1]	Common Use Rate (oz/A)[2]	Juvenile Growth	Mature Leaves	Regrowth Suppression	Boll Opening
Ethephon	Numerous (6 lb products)	32	Poor	Fair	Poor	Good
Ethephon + Cyclanilide	Finish® 6 Pro	32	Poor	Good	Fair	Good
Ethephon + Urea Sulfate	First Pick®, Cotton Quick®	50 to 60	Poor	Good	Fair	Good
Thidiazuron + Diuron	Ginstar®, Cutout®, Adios®, Dropp Ultra®	6 to 8	Good	Good	Good	None
Thidiazuron	Dropp®, Thidiazuron® SC, FreeFall®, Daze®	5 to 6	Good	Good	Good	None
Tribufos	Folex® 6 EC	12 to 16	Poor	Good	Poor	None
Carfentrazone	Aim® EC	1	Good	Good	Poor	None
Pyraflufen Ethyl	ETX®	1.25	Good	Good	Poor	None
Saflufenacil	Sharpen®	0.75 to 1	Good	Good	Poor	None
Flumiclorac	Action®	6 to 8	Poor	Good	Poor	None
Tiafencil	Reviton®	1 to 3	Good	Good	Fair	None
Glyphosate (on non-glyphosate tolerant varieties)	Numerous (4.5 lb products)	16 to 44	None	None	Fair	None
Paraquat[3] (3 lb products)	Gramaxone®, Firestorm®, Parazone®	4 to 32	Poor	Fair	Poor	Fair

1. *List is not comprehensive. Mention/omission does not imply endorsement/discrimination.*
2. *Follow labels for restrictions, appropriate tank-mix partners, and need for adjuvants.*
3. *Lower paraquat rates can initiate defoliation; use higher rates for desiccation.*

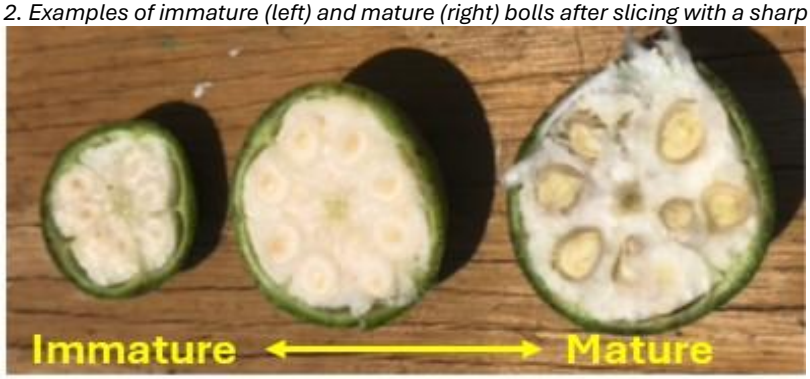
harvest may increase leaf trash in the harvested seedcotton. Table 2 details expected harvest aid activity for defoliation of juvenile and mature leaves, suppression of regrowth, and boll opening. Table 3 provides recommended rates according to yield potential, plant stature, and crop condition.

Table 3. Rate considerations (fluid ounces per acre) for various canopy densities and yield potential levels (adapted from Byrd et al., 2021).

	Defoliation[1]		
Product	**Excessive green leaves; large plants; moderate to high yield potential**	**Moderately dense canopy with some natural senscence; medium plant stature; moderate yield potential**	**Less dense canopy with advanced natural senescence; short plant stature; low to moderate yield potential**
Action®	6 to 8	6 to 8	4 to 6
Aim® EC	1.2 to 1.6	1.0 to 1.5	1.0 to 1.2
Thidiazuron® 4 SC and other brands[2]	4.0 to 6.4	4.0 to 6.4	1.6 to 3.2
Ethephon® and other 6 lb brands[3]	Not recommended	32 to 42.7	24 to 43
ETX®	1.4 to 1.7	1.25 to 1.5	0.9 to 1.25
Finish® 6 Pro	32 to 42.7	32 to 42.7	21.3 to 32
Folex® 6 EC	12 to 24	8 to 16	6 to 12
Ginstar® and other brands	8 to 16	6 to 10	4 to 8
Gramaxone®, other 3 lb paraquats[4]	Not recommended	Not recommended	3 to 4
Reviton®	Not recommended	Not recommended	1 to 3
Sharpen®	1 to 2	0.8 to 1.2	0.5 to 1
	Boll Opening		
	Large stature, immature crop (<60% open bolls)	Moderate stature, 60 to 75% open bolls	Short stature, >75% open bolls
CottonQuick®, First Pick®	56 to 64	48 to 64	48 to 56
Ethephon® and other 6 lb brands[3]	32 to 42.7	24 to 32	16 to 24
Finish® 6 Pro	32 to 42.7	24 to 32	16 to 24
Flash®	56 to 86	43 to 64	32 to 43
	Regrowth Removal	*(for removal of regrowth occurring after initial harvest aid applicaton)*	
Action®	3 to 5		
Aim® EC	1		
ETX®	1 to 1.25		
Ginstar® and other brands	2 to 6		
		(applied at 2 nodes above cracked boll in preparation for stripper harvest)	**Desiccation**
Gramaxone®, other 3 lb paraquats			21 to 32
Reviton®			1 to 3

1. *Many of the products listed under Defoliation section are recommended to be tank-mixed with an ethephon product.*
2. *Thidiazuron has better efficacy in warmer temperatures (>65F).*
3. *These recommendations assume when ethephon is applied alone for defoliaton and/or boll opening.*
4. *Avoid using paraquat products as defoliants if <80% of harvestable bolls are not open, as dehiscence may be inhibited by paraquat.*

Figure 2. Examples of immature (left) and mature (right) bolls after slicing with a sharp knife.



Harvest Aid Timing

Application timing of harvest aids can be as important as chemistry choice. Poor timing, either too early or too late, can negatively impact lint yield and fiber quality. Three commonly used methods to time harvest aid applications are available:

1. % open boll
2. Nodes above cracked boll (NACB)
3. Sharp knife method

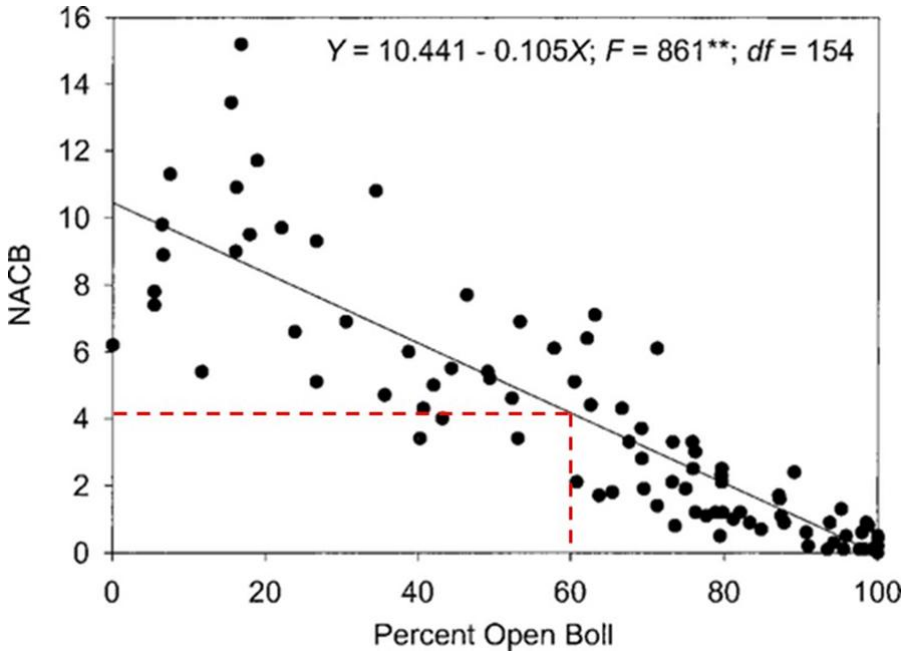


Figure 3. Nodes from the uppermost first position cracked boll to the uppermost harvestable boll (NACB) versus percent open boll. Red dashed line indicates 60% open boll occurred at NACB 4.1. (Adapted from Bednarz et al., 2002)

To calculate % open boll, count the total open bolls along a section of row, then count the number of unopen, yet harvestable bolls in that same section. Divide the number of open bolls by the total of open and unopen bolls and convert to percentage. The general recommendation is to apply defoliants and/or boll opener materials no sooner than 60% open boll.

What is a harvestable boll? Harvestable bolls should be difficult to cut in cross section with a sharp knife. The seed should be well formed and the seed coats

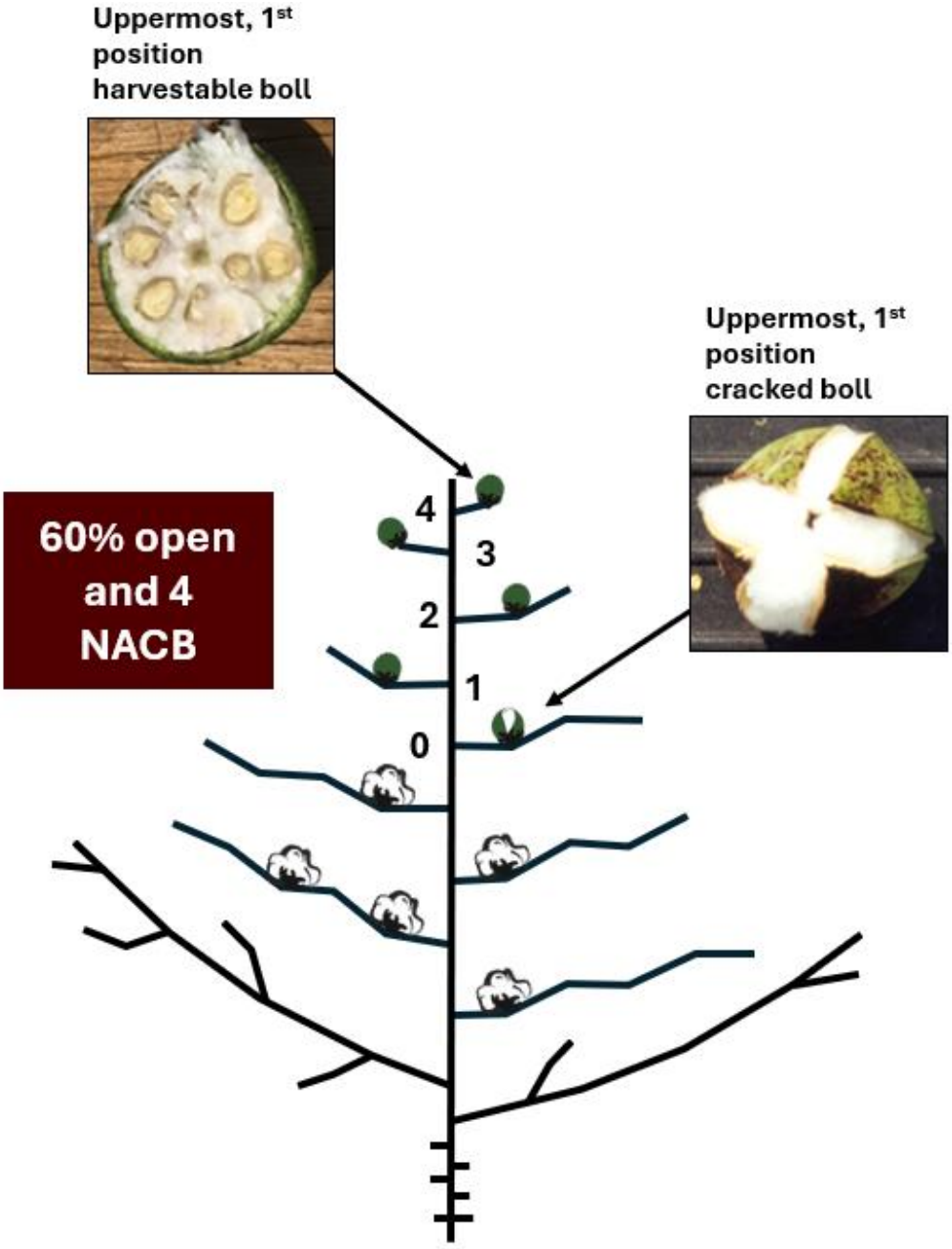


Figure 4. Diagram of a cotton plant that is 60% open and 4 NACB. Note the locations of the uppermost first position cracked boll and the uppermost first position harvestable boll.

should be dark (Figure 2). The presence of excessive liquid, jelly, or light-colored seed coats indicate a boll that may not be harvestable, and that boll should be excluded from the % open calculation. Nodes above cracked boll is a measure that requires less time to collect in the field and is highly correlated to % open (Bednarz et al., 2002). For most cotton crops, 60% open boll occurs approximately 4 NACB (Figure 3). To calculate NACB, locate the uppermost open boll (sufficiently cracked to place the end of your finger in the tip) at the first position on a fruiting branch. Count the corresponding mainstem node as 'zero.' Then count up the mainstem node where the uppermost unopen, yet harvestable boll is located at the first position to determine NACB. Figure 4 shows a diagram of a plant that is 60% open and 4 NACB. In cases where there is a fruit retention gap in the middle of the cotton canopy, the NACB method is superior to the % open boll method, since the NACB calculation would take into account the missing fruiting positions, whereas the % open boll method may not. Kerby et al., 1992 demonstrated that defoliating at 4 NACB maintained yield potential (Figure 5) while not compromising fiber quality, especially micronaire (Figure 6). Additionally, it is safe to desiccate cotton for stripper harvest at 2 NACB.

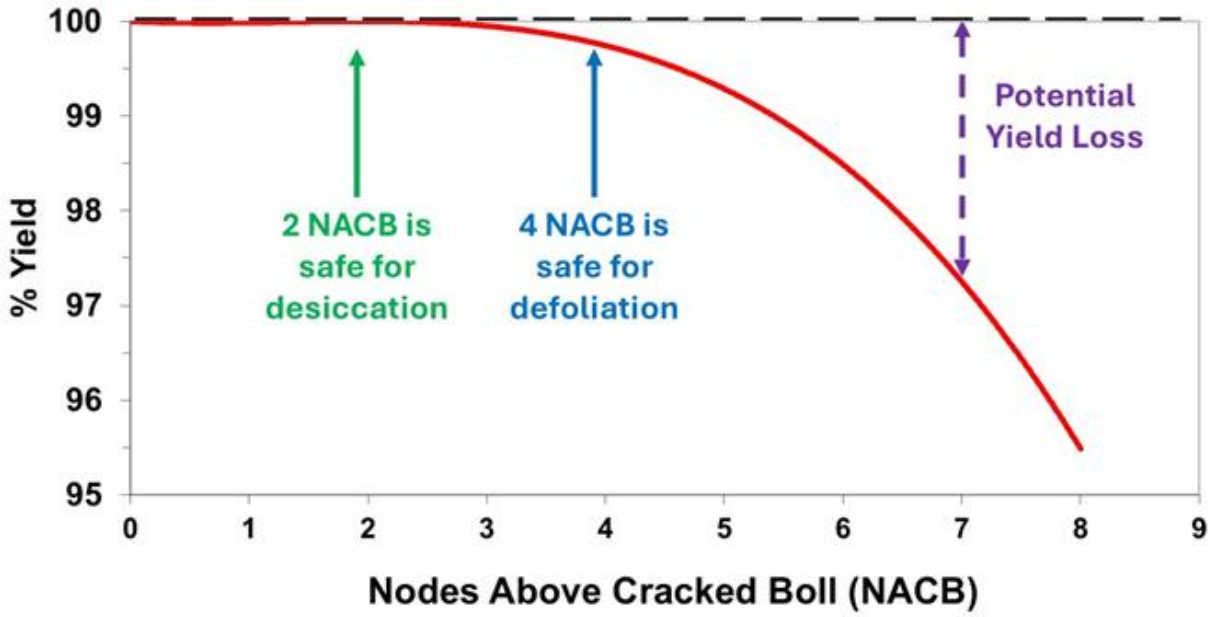


Figure 5. Relationship between nodes above cracked boll and yield potential. (adapted from Kerby et al., 1992)

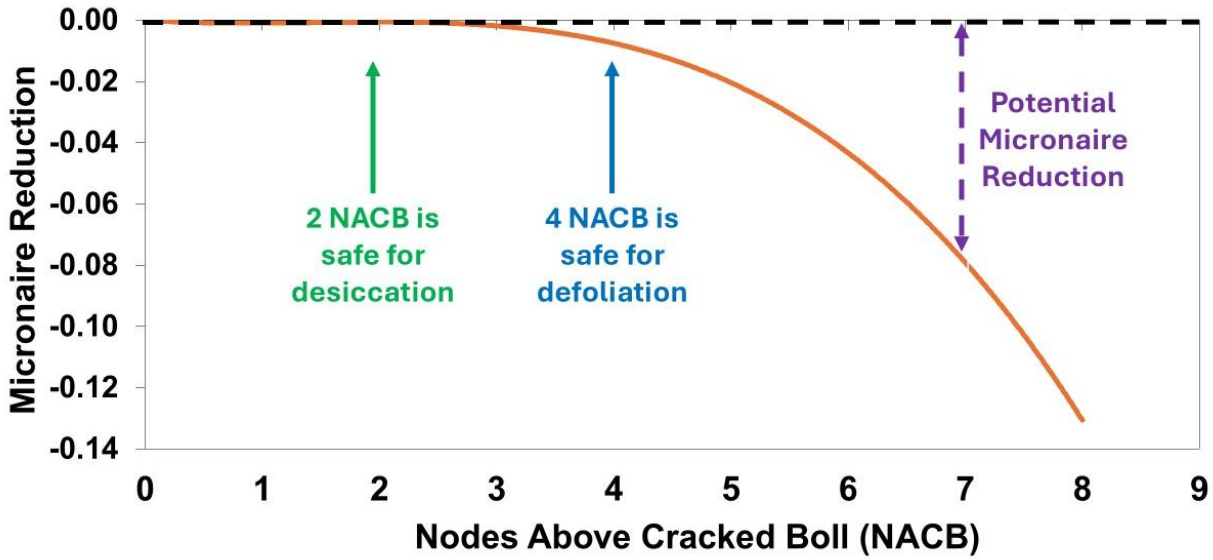


Figure 5. Relationship between nodes above cracked boll and micronaire. (adapted from Kerby et al., 1992)

Important Considerations

- Delaying harvest aid applications can increase weathering losses.
- Harvest aid chemicals generally do not translocate very well; good coverage is important.
- When determining maturity, avoid relying on a single method.
- Cooler weather reduces plant metabolism and therefore harvest aid activity; higher rates may be required in cooler conditions.
- Most irrigated cotton will require a two-shot approach: boll opener + defoliant followed by a desiccant ~7-10 days later.
- Match harvest aid application to harvesting capacity.
- High rates of defoliants or desiccants, especially in warm weather, can potentially cause leaves to 'stick.'
- Avoid excessive late season fertilization and irrigation that encourages rank, vegetative growth.
- Drought stressed cotton is more difficult to defoliate.
- Desiccants will interrupt development of immature bolls.
- Always follow harvest aid labels for rates, timing, rainfastness, application details, crop and personal safety, and plant-back restrictions for subsequent crops, especially small grains.

References

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