



Physiology of Cotton Harvest Aids "How They Work"



Dan D. Fromme
Associate Professor & State Cotton/Corn Specialist
Dean Lee Research & Extension Center
LSU AgCenter
Alexandria, La

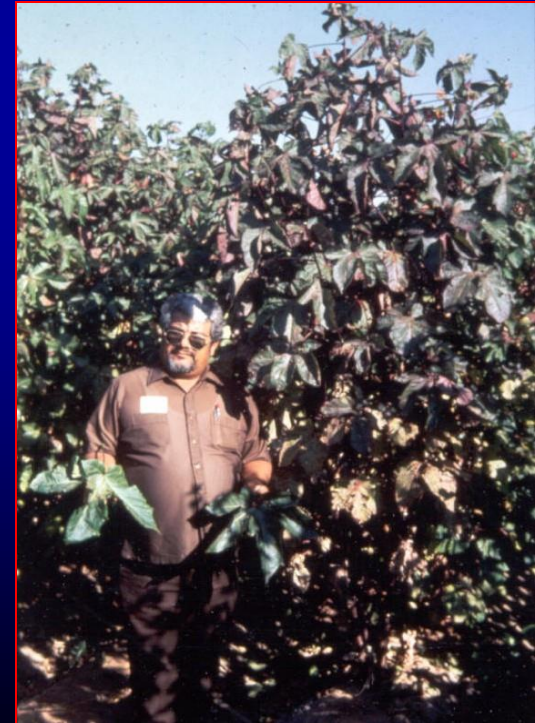


Topics

- **Physiology of harvest aids**
- **Modes of action**
- **Products**
- **Influence of crop condition on harvest aid activity**
- **Basics of defoliation**
- **Preconditioning**
- **Nitrogen issues**
- **Regrowth issues**
- **Are all the products the same**
- **2014 plans**
- **Resources**

Growth Habit

- Cotton is grown as an annual crop
- Inherently it is a deciduous perennial
- Plant possesses a natural mechanism for shedding its mature leaves
- Natural shedding is not necessarily synchronized with most appropriate time for harvesting lint



Leaf Duration



- ❖ Active life very short
- ❖ A 20 day old leaf shows highest photosynthetic activity
- ❖ Leaf ceases major functioning after about 40 to 60 days
- ❖ As leaves age, the plant is naturally conditioned for senescence (i.e. leaf abscission)
- ❖ Young leaves very resistant to defoliation

Senescence

- Programmed genetic event
- Proceeds from juvenile to mature plant
- Latter part leads to ultimate loss of function
- **Hormonally controlled ratios of promoters : inhibitors**
- Environmental interactions

Three Phases of Senescence

Phase 1 - Initiation phase

Phase 2 - Degeneration phase

Phase 3 - Final or Culminating phase

Three Phases of Senescence

- Phase 1 - Initiation
 - Results in potential shutdown of cell maintenance function
 - Paralleled with increase in key degradative enzymes
 - Several senescence-associated genes (SAGs) involved in this phase have been identified
 - SAGs are similar to cysteine proteases which are required for programmed cell death (PCD)
 - PCD is the process by which individual cells activate an intrinsic senescence program

Phases of Senescence

- Phase 2 - Degeneration
 - Key metabolic processes are disassembled
- Phase 3 - Final
 - Loss of homeostasis and cell membrane integrity
 - An oxidative process that involves a general deterioration of cellular metabolism
 - Increased activation of cell-wall degrading enzymes, such as cellulase and pectinase, at the abscission layer
 - Eventually leads to cell death

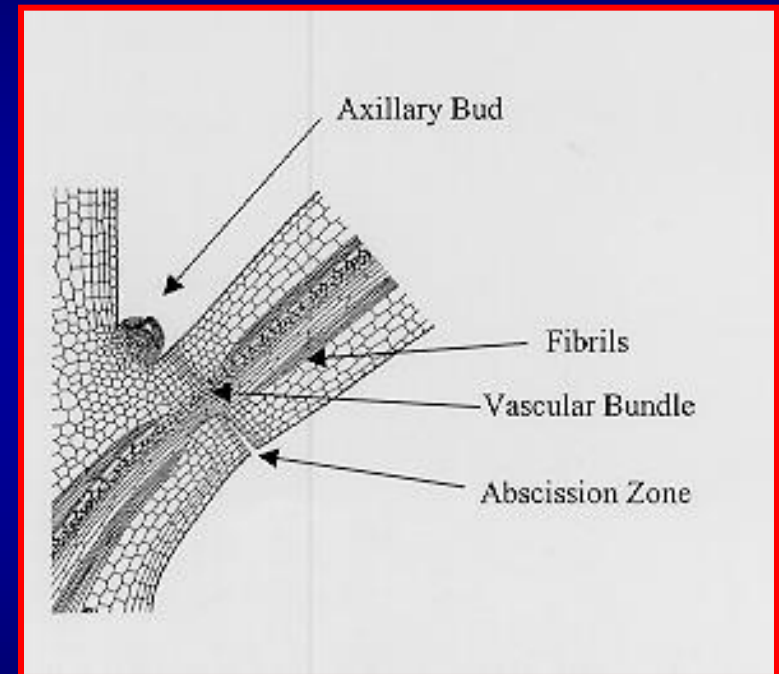
Senescence Leads to Abscission

- Abscission is usually preceded by:
 - Loss of chlorophyll
 - Temporary buildup of anthocyanin
 - Breakdown of proteins and carbohydrates to amino acids and sugar... resulting in a remobilization of these constituents`



Abscission

- ❖ Usually occurs as a result of maturity, senescence, or injury
- ❖ A physiological process that involves an active separation of living tissue from the plant
- ❖ Separation of the leaf from the plant occurs at the base of the leaf petiole in an area called the abscission zone
- ❖ Located at the base of the petiole of a leaf where the petiole joins the stem



Role of Hormones in Abscission

- ❖ Auxins, such as IAA, are strong inhibitors of abscission
- ❖ Abscisic acid and ethylene are promotive
- ❖ Gibberellic acids and cytokinins have variable effects
- ❖ Hormonal influence (overall)
 - ❖ Concentration dependent
 - ❖ Site of application
 - ❖ Type of tissue involved

Sequential Phases of the Hormonal Control of Leaf Abscission

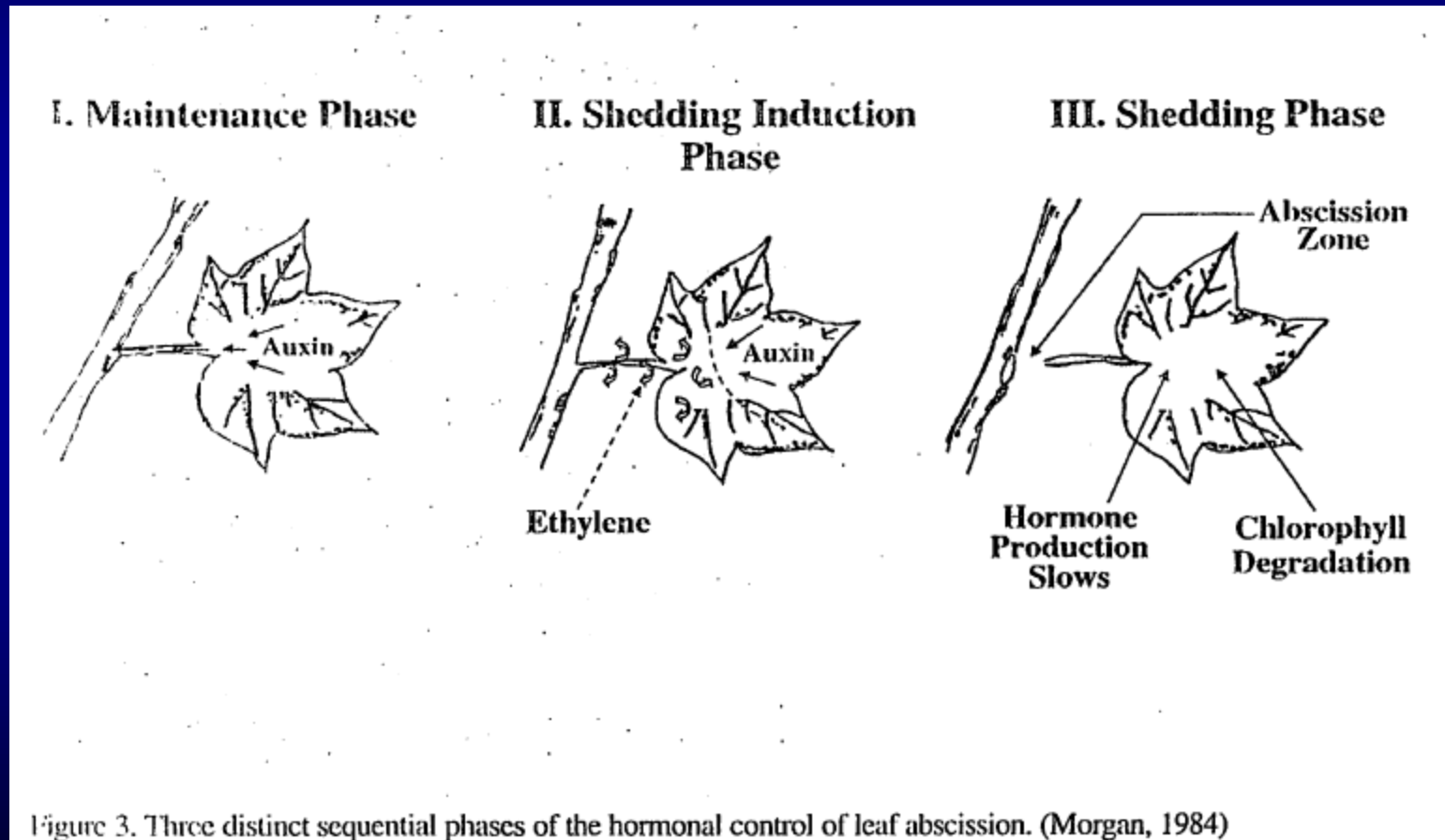


Figure 3. Three distinct sequential phases of the hormonal control of leaf abscission. (Morgan, 1984)

How Harvest Aids Work?

- ❑ Mimic 'Mother Nature'
 - ❑ Causing abscission zone formation

- ❑ Types of Harvest Aids and Modes of Action:
 - ❑ Defoliant - (Hormonal and Herbicidal)
 - ❑ Desiccant - (Herbicidal)
 - ❑ Boll openers - (Hormonal)

Role of Harvest Aids

- ❖ Artificially stress or injure the leaves of a cotton plant
- ❖ Induce a change in the hormonal balance between the leaf petiole and stem
- ❖ Leaf abscission occurs
- ❖ Enhance boll opening

Harvest Aid Modes of Action

- Herbicidal (Chemical shock / contact)
- Hormonal (physiological)
- Alone or combined
- Herbicidal
 - Def[®] / Folex[®], Chlorates, Gramoxone, **Ginstar[®]**
- Hormone-like
 - Dropp[®], Ethephon products, **Ginstar[®]**

Defoliation and Boll Opening

- Achieved in two ways:
 - Herbicidal - application of a chemical that injures the leaf, resulting in increased concentrations of plant hormones...such as ethylene and abscisic acid, which promote abscission **example: Def, Aim, ET**
 - Hormonal - application of chemicals that act as plant growth regulators, which directly stimulate ethylene production **example: Dropp, Ginstar, Prep**

Summary

- Senescence is a programmed event
- Final stage of senescence leads to alteration of hormone levels inducing activation of enzymes associated with cell wall breakdown (e.g. pectinase and cellulase) in abscission zone
- Harvest aids mimic 'Mother Nature' in altering hormone ratios to cause abscission

Products

Def[®] /Folex[®] (tribufos)

- Often referred to as “phosphate-type” defoliants
- Most effective at removing mature leaves in cool weather and new growth in hot weather
- Does not inhibit regrowth
- Works in both warm and cool temperatures
- Can be tank-mixed with most harvest aids and boll weevil insecticides
- Mode of action:
 - Triggers quick water loss and subsequent leaf abscission

Dropp® (thidiazuron)

- A non-phosphate; true hormonal defoliant
- Generally regarded as an early-season defoliant- reduced activity under cool conditions
- Provides good removal of juvenile growth and inhibits terminal regrowth by promoting the premature formation of the abscission layers of petioles
- A cytokinin-like compound
- Depending on dose, cytokinin can inhibit or accelerate leaf growth

Dropp® (thidiazuron)

- As a harvest aid, cytokinin induces a slow but steady buildup of ethylene relative to auxin
- Thus ethylene stimulates pectinase and cellulase enzymes, inducing the breakdown of cell wall material that leads to the formation of the abscission layer and eventual leaf-fall

Thidiazuron

- **Cutout**
- **Redi-Pik**
- **Klean Pik 500 sc**
- **Daze**
- **FreeFall**
- **Takedown sc**
- **Thidiazuron 4sc**

Ginstar® (thidiazuron & diuron)

- Removes mature leaves, juvenile growth, and regrowth
- Effective leaf penetration increases performance on thick, healthy foliage
- Activity in both hot and cool conditions activity present into the low and mid 50s
- Mode of action:
 - Both hormonal and herbicidal; combined modes of action

Thidiazuron & Diuron

- **Adios**

Desiccants



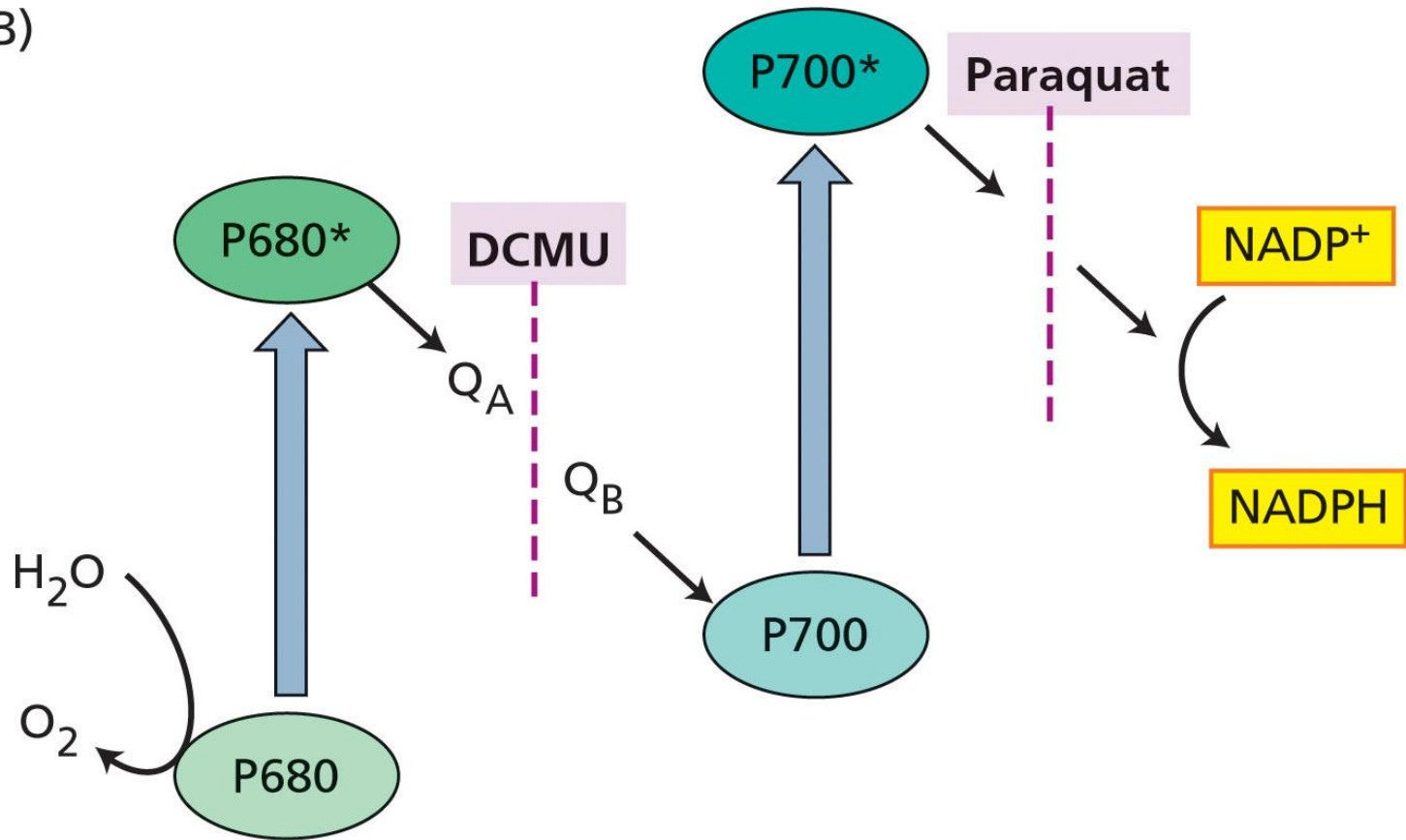
- Contact type herbicide which produces free oxygen radicals in the chloroplast that destroy cell membranes leading to rapid moisture loss and leaf desiccation

Gramoxone/Paraquat

- Performs as defoliant and desiccant
- Used for effective defoliation and desiccation of stripper cotton
- Economic defoliation of mature leaves in cool weather
- Apply under cool to moderate temps, high rates and high temps may cause desiccated leaves to 'stick'
- Mode of action:
 - Acts as a non-selective leaf desiccant

Photosystem II & I block and accept electron flow

(B)



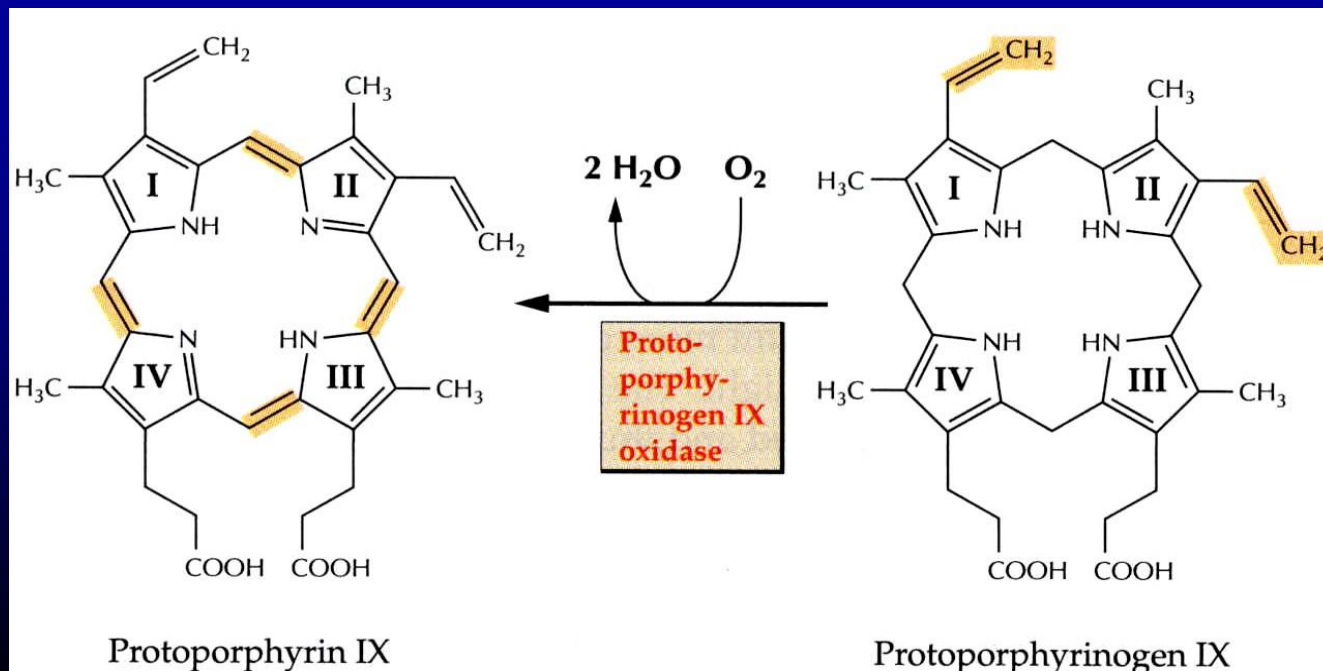
PPO Inhibitors

- **ET**
- **Aim**
- **Display**
- **Sharpen**
- **Blizzard**

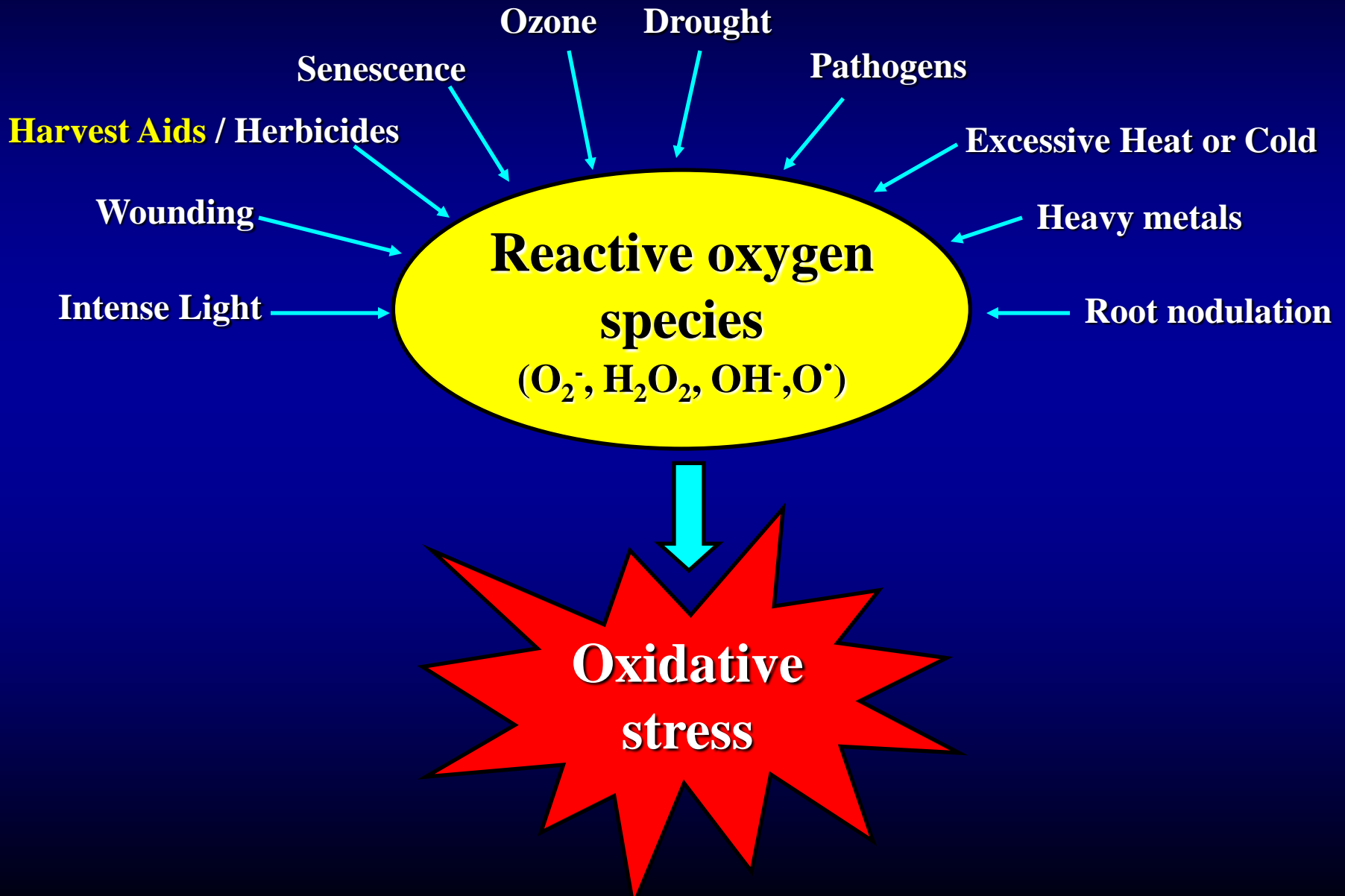
PPO Inhibitors

Cell Membrane Disruptors

- **Mode of Action**
 - Inhibition of protoporphyrinogen oxidase (also called **Protox**)
- **Inhibiting Protox results in accumulation of singlet oxygen in the presence of light**



Oxidative Stress



PPO Inhibiting Compounds

- Absorbed mostly by leaves
 - Some limited root absorption
- Mainly contact-type herbicide
- Translocated mainly in xylem
 - Movement within plant from leaf absorption is limited
- Degradation in the plant is through conjugation with glutathione and/or glucose

PPO Inhibitors

Cell Membrane Disruptors

- Subsequently leads to a light-induced breakdown of cell components
- Cell membranes are destroyed by this light peroxidation reaction which results in:
 - Cell leakage
 - Inhibited photosynthesis
 - Bleaching of chloroplast pigments
- Primary site of action
 - Cellular membranes

Boll Openers / Conditioners

Dehiscence



Boll Openers / Conditioners

- Ethephon (Prep™)
 - An ethylene precursor
- Ethephon + cyclanilide (Finish®)
 - An ethylene precursor plus an ethylene synergist
- Ethephon + AMADS (Cotton Quik®)
- Used in conjunction with defoliants

Prep™ (ethephon)

- Trade name for 2-chloroethyl phosphonic acid
- Affects hormonal activity (ethylene) to enhance boll opening
- Possesses some hormonal defoliation properties but is not classified as a defoliant
- Helps synchronize optimum harvest timing
- Best response at night temps > 60°F and day temps between 85 and 95°F
- Mode of action:
 - Application to green tissue results in its being absorbed into the plant where it breaks down to ethylene; enhances cellulase and pectinase activity; promotes maturity

Cotton Quik™ (ethephon & AMADS)

- **Combination of ethephon and 1-aminomethanamide dihydrogen tetra oxo sulfate**
- **Promotes hormonal activity (ethylene)**
- **Works best under dry, hot conditions**
- **Night temps < 60°F and daytime temp < 75°F slow plant responses**
- **Mode of action:**
 - **Same as ethephon, except AMADS act as a synergist to enhance activity**

Finish™ (ethephon & cyclanilide)

- **Ethephon products stimulate ethylene production**
- **Cyclanilide is a synergist that promotes defoliation and inhibits terminal regrowth**
- **Thorough spray coverage essential to good performance**
- **Cyclanilide inhibits auxin transport**
- **Works best under hot, dry conditions**
- **Night temp < 60°F and daytime temp < 75°F slow response**

Boll Openers

- Super Boll (ethephon)
- Setup 6SL (ethephon)
- Prep (ethephon)
- Flash Plant Regulator (ethephon)
- Ethephon-6 (ethephon)
- Boll'D6 (ethephon)
- Boll'D (ethephon)
- Boll Buster (ethephon)
- **First Pick (ethephon + monocarbamide dihydrogen sulfate)**
- **Finish 6 Pro (ethephon + cyclanilide)**

Boll Openers

- **To be effective, bolls must receive spray coverage.**
- **Sequential applications**
 - **Apply on second shot to be most effective**
- **More effective in cooler regions**
- **Warmer regions-leaf removal allows the sun to warm maturing bolls sufficiently to stimulate ethylene production and accelerate boll opening.**

Conclusions

- **Physiology of Harvest Aids**
 - Senescence is a highly ordered genetically programmed process.
 - Hormonal levels influence senescence and abscission.
 - Harvest aids mimic 'Mother Nature' in altering hormone ratios to cause abscission
 - Harvest aid modes of action
 - Herbicidal
 - Hormonal
 - Herbicidal/Hormonal

Influence of Crop Condition on Harvest-Aid Activity and Timing

- **Varietal Differences**
- **Plant Density**
- **Crop Stature and PGRS**
- **Water**
- **Maturity and boll load**
- **Nitrogen**
- **Temperature**
- **Number of applications**
- **Art not a science!**

Lets not forget the basics of defoliation

- **Methods**
 - % open boll
 - 60%?
 - NACB
 - 4 NACB?
 - NAWF = 5 + 850 HU?
 - **Cut boll method**
- **Application**
 - Single
 - Sequentials
- **Products of choice**

Cut Boll Method

Visual Inspection



Immature Boll.....Fully Mature Boll

Preconditioning

2003

Preconditioned at 11% open boll (Lint Yield)

Treatment	Rate/acre	Defol. @ 55% OB	Defol. @ 70% OB	Defol. @ 80% OB	PR>F 0.0194
UTC	--	1640	1598	1532	1590 a
Prep	4 oz	1601	1528	1532	1554 ab
Aim	.33 oz	1554	1569	1425	1516 bc
Harvade	8.16 oz	1546	1450	1494	1497 bc
Dropp	.02 lbs	1466	1481	1447	1465 c
Pr>F.0709		1561 a	1525 a	1486 a	

Cut Boll Method

Visual Inspection



Immature Boll.....Fully Mature Boll

Nitrogen Issues

Colorado County Nitrogen Fertility Study, 2006

Mahalitc Farms

Available Nitrogen in Soil Profile Sampled Prior to Planting

0 - 6 inches	52 lbs N	
6 - 12 inches	47 lbs N	99 lbs N
<hr/>		
12 - 24 inches	54 lbs N	153 lbs N
<hr/>		
24 - 36 inches	37 lbs N	
36 - 48 inches	39 lbs N	
<hr/>		
Total	229 lbs N	

Colorado County Nitrogen Fertility Study, 2006 Mahalitic Farms

Treatment	Lint Yield Lbs/acre	Loan Value cents/lb	Net Return/acre
80 lbs N/acre	1286	56.57	728
0 lbs N/acre	1281	57.68	739
P>F	0.7146	0.1790	0.5143
LSD	NS	NS	NS
CV%	1.21	1.18	2.34

80 lbs N/A

0 lbs N/A

Yield = 2.83 bales/acre
80 lbs/A less fertilizer

Other possible advantages:

- Less PGR?
- Less insecticide?
- Less harvest aid?
- Earlier harvest?



Regrowth Issues

- Robust varieties
- N rates increasing?
- High ethephon rates + low thidiazuron rates?
- Solutions
 - Water volume?
 - Nozzles?

Are all products the same?

Ginstar versus Adios 2013-El Campo, TX 11 DAT

Product	Rate/Acre	% Defol.	% Dess.	% Gr. Leaves
Ginstar + Ethephon	3.20 + 21.00	95	1	4
Adios + Ethephon	3.20 + 21.00	79	1	20

Ginstar versus Adios 2013-Weslaco, TX 12 DAT

Product	Rate/Acre	% Defol.	% Dess.	% Gr. Leaves
Ginstar + Ethephon	3.20 + 21.00	95	1	4
Adios + Ethephon	3.20 + 21.00	80	1	19

2014 Plans

- **Defoliation Trials**

Resource

- **Cotton Harvest Management: Use and Influence of Harvest Aids**
 - The Cotton Foundation
 - Reference Book Series Number Five
- **National Cotton Council of America**
 - Education
 - Cotton Foundation Reference Book Series

Resource

- **2013 Cotton Harvest Aid Guidelines for Louisiana**

A large field of bluebonnets stretches across the foreground and middle ground. In the distance, a combine harvester is visible, silhouetted against the bright, low sun. The sky is a mix of yellow, orange, and pink, indicating a sunset or sunrise. The overall scene is peaceful and agricultural.

Dan Fromme
dfromme@agcenter.lsu.edu
318-880-8079