



PHYSIOLOGY OF COTTON DEFOLIATION

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This bulletin deals with the physiology of cotton defoliation and attempts to describe what conditions must exist inside the plant in order for defoliation to occur. It is important to understand the basic physiological processes involved in order for best crop management practices to accomplish a successful defoliation. The objectives of defoliating a cotton crop can be simply stated as: 1) to remove leaves to facilitate mechanical picking, 2) to maintain the quality of the lint, and 3) to complete defoliation with a single application of chemicals.

For this discussion, it would first be appropriate to define two terms frequently used interchangeably, defoliation and senescence:

- **DEFOLIATION**, or Leaf Abscission, in cotton is usually a result of maturity, senescence, or injury. Defoliation differs from desiccation in that the leaf does not desiccate – the water conducting tissue remains alive until the leaf drops.
- **SENESCENCE** is the process of plant tissue deterioration that accompanies aging and that ultimately leads to the death of an organ or organism.

Induced Defoliation

Defoliation is a natural physiological process which usually is inadequate or not timely enough for a complete mechanical cotton harvest. Therefore, defoliation is often induced in cotton by managing the crop so that senescence, abscission (separation) layer development and leaf drop are encouraged.

Crop senescence and defoliation are encouraged most heavily by a substantial fruit load. Maturing bolls are the first priority in the plant's allocation of nutrients. As a heavily-loaded cotton plant matures, it will transfer nutrients from the leaves to the bolls. This helps to complete the maturation of the bolls, but it also makes the leaves easier to remove with a defoliant. Plant water relations, nitrogen (N) management and defoliant applications are three other crop management factors that affect crop defoliation.

Why Induce defoliation?

We often consider Pima cotton as a “worst-case scenario” for defoliation. Pima is very difficult to defoliate because of its strong indeterminate pattern of growth and its characteristic robust, late season growth tendencies. Still, good defoliation is desirable in Pima cotton because of steep price discounts for lower grades of lint.

Changes That Occur With Plant Aging and Senescence

1. The leaves lose RNA and chlorophyll. Ribonucleic acids (RNA) are very important in protein synthesis. Chlorophyll is the pigment that makes the plants look green, and it also captures the light energy from the sun to produce chemical energy in the form of carbohydrates.
2. Protein, carbohydrate and inorganic ion levels in the leaf drop. The plant converts proteins and carbohydrates in the leaves into simpler forms and then transports them along with inorganic ions out of the leaves to the bolls, which are the highest priority locations (or sinks).
3. Anthocyanins increase in the leaves. The anthocyanins are colored pigments that commonly occur in red, purple, and blue flowers. They are also present in various other plant parts.
4. Hormone concentrations change. As summarized in Figure 1, the environment in which a plant is growing plays an important role in the hormone balance within the plant. Hormones (Table 1) affect defoliation by stimulating or inhibiting the production of enzymes.

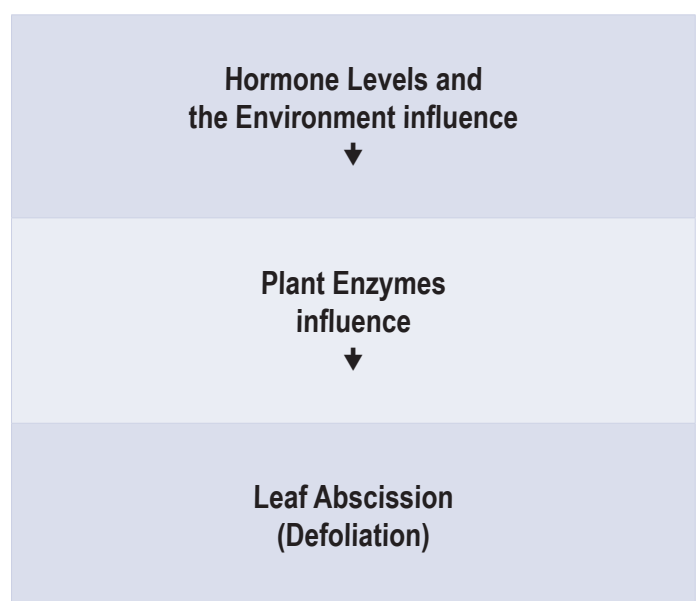


Figure 1. What Factors Control Leaf Abscission?

Table 1. Groups of Plant Hormones and Their Effect on Defoliation

Plant Hormone	Effect
Auxins [Indole-acetic acid (IAA)]	retard abscission
Abscissic Acid (ABA)	promote abscission
Ethylene	promote abscission
Gibberelins	variable effect
Cytokinins	variable effect

Summary of the Defoliation Process

1. Shift in the internal hormonal balance within the plant.
2. The abscission zone or abscission layer forms across the petiole near its junction with the stem (Fig. 2).
3. Synthesis and secretion of the enzymes cellulases and pectinases.
4. The enzymes digest the cell walls and middle lamella (Fig. 3) between certain cells of the abscission zone.
5. Cells on the stem side of the abscission layer expand, while they shrink on the leaf side. This causes the petiole to break off from the stem.

It is important to note from Fig. 2 that while the abscission zone consists of several layers of cells across the petiole, the vascular bundles remain intact, allowing water and nutrients to travel in and out of the leaf. In practice, the water status of the plant is important. A small amount of water stress on the plant can reduce growth and facilitate defoliation to some extent. On the other hand, too much water stress on the plant can cause the leaf to desiccate, reducing the weight necessary to drop or break through the abscission layer. If defoliant are applied, they would have a difficult time penetrating the leaf due to a thicker cuticle and closed pores on the leaf surface due to water stress.

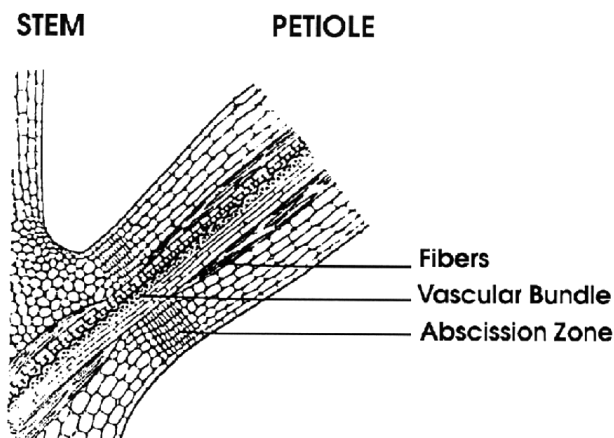


Figure 2. The abscission zone (layer) forms at the base of the petiole

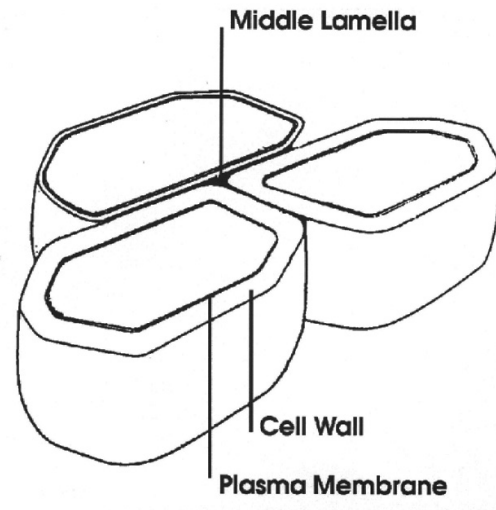


Figure 3. Enzymes digest the cell walls and the middle lamella of cells in the abscission zone, leading to leaf drop

Auxin-Gradient Theory of Abscission

The auxin-gradient theory of abscission holds that the gradient, or relative concentrations of auxins in the plant, is more important for defoliation than the absolute amount of auxins present in the plant. The auxin indole acetic acid (IAA) inhibits leaf abscission when it is concentrated on the petiole side of the abscission zone. This same auxin stimulates abscission when it is concentrated on the stem side of the abscission zone. The gradient can be affected by ethylene and abscissic acid.

Ethylene and Abscissic Acid

Ethylene and abscissic acid (ABA) are the plant hormones that commonly promote leaf abscission. It would be worthwhile to look at their effects in more detail.

ETHYLENE

Indirect effects:

- Stimulates the activity of IAA-oxidase system, reducing the auxin concentration and promoting abscission.
- Decreases and inhibits auxin transport, promoting abscission.

Direct effects:

- Stimulates the synthesis of pectinases and cellulases and increases the secretion of these two enzymes into cell walls.

ABSCISSIC ACID

Indirect effects:

- Promotes ethylene production, hastens of senescence, and reduces auxin transport.

Direct effect:

- Increases cellulase activity.

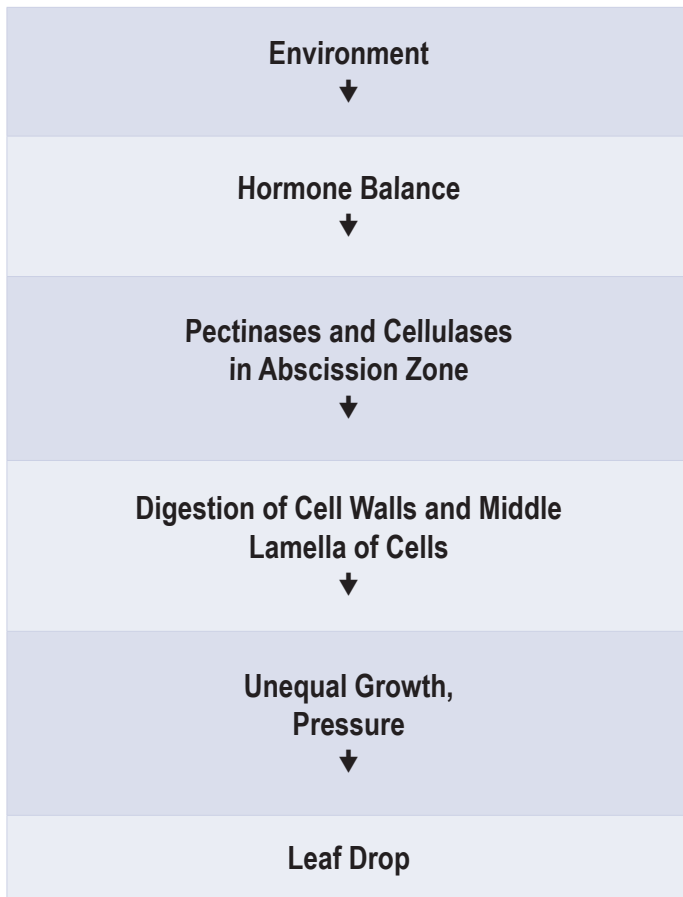


Figure 4. Summary of Defoliation Events

Summary

It is not essential that a cotton farmer develops a thorough understanding of the physiological or biochemical mechanisms associated with leaf abscission and plant senescence in order to accomplish a successful crop defoliation. However, as most farmers realize, the better someone understands how a piece of machinery works, the better chance they have in making it work correctly and to repair or correct any problems that develop. Similarly with crop management, the better we understand how a plant grows and functions, the better we can carry out operations such as cotton defoliation. As an act of controlled crop physiology, a successful defoliation takes place as outlined in Figure 4, in a balanced and directed process leading to leaf drop. The combinations of crop management (plant-water relations, N fertility status, and boll load), environmental conditions, and the choice and timing of chemical defoliant serve to affect, and hopefully accelerate, the overall defoliation process.

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