COTTON HARVEST MANAGEMENT: Use and Influence of Harvest Aids

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The Cotton Foundation

Edited by
James R. Supak
and Charles E. Snipes

COTTON HARVEST MANAGEMENT:

Use and Influence of Harvest Aids

The Cotton Foundation

THE COTTON FOUNDATION

Reference Book Series

The Cotton Foundation is dedicated to the advancement and economic viability of the cotton industry. Created in 1955 to foster innovative research and education, the Foundation is supported by membership dues and special grants from commercial agriculture. Members include many of North America's finest manufacturers and suppliers of machinery, crop protection products, seed, diagnostic equipment, consulting and financial services, trade media, processing materials, and other inputs used to enhance cotton production, processing, and marketing.

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5. ***Cotton Harvest Management: Use and Influence of Harvest Aids***

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The CDWG, in 1992, implemented a research protocol guided by a single objective:

> **To develop effective, contemporary harvest-aid recommendations that contribute to harvest efficiency and high-quality fiber, by evaluating performance of standard defoliation treatments on a uniform basis and relating this performance to biotic and environmental factors.**

In essence, the CDWG was striving to bring a higher level of science and technology to the art of defoliation. Over the following five years, the CDWG continued to refine and improve its research protocols. The knowledge gained from the effort annually has been applied on-farm and in the marketplace through state-by-state recommendations from the researchers and Extension specialists who participated in the CDWG. The group continues to operate as a self-sustaining entity, gaining funding from commercial companies for uniform testing of various harvest-aid materials and tank mixes.

Administration of the CDWG and budgets to facilitate annual meetings has been and continues to be underwritten by Uniroyal Chemical, a longtime supplier of crop protection products to the cotton industry. Uniroyal Chemical is a leading worldwide manufacturer of agricultural and specialty chemicals and polymers, serving customers in 120 countries. The company's products are used in many markets, including agriculture, rubber processing, plastics, paints and coatings, petroleum, and construction.

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FOREWORD AND DEDICATION

The production of cotton has fascinated and intrigued many for generations. The more effort put into controlling the growth and production of this perennial plant, typically grown as an annual, the more it seems in control.

Man often humanizes inanimate objects. We do this for the cotton plant, either affectionately or with disgust: We commonly refer to cotton as "King Cotton" – does this indicate its upper hand in our motivations?

At one point in history, it could have been said that cotton had us Southerners thinking we could go it alone – without the North. Our struggle to perfect the production of cotton often has left us confounded, except to say that the very nature of cotton production is "to beat it before it beats you."

This certainly is the case during the production phase commonly referred to as defoliation. More appropriately termed crop termination, defoliation is the procedure in which a chemical product, or harvest aid, is applied to cotton at an appropriate physiological stage to remove or desiccate leaves and immature fruiting structures to avoid their interference with harvesting and ginning procedures. As late as the mid 1980s, chemical crop termination using various harvest aids largely was considered an art.

The practice of crop termination came into vogue with the advent of the mechanical harvester during the 1950s. The nature of this practice required the reduction or desiccation of leaf material and foreign matter prior to the harvesting process to minimize negative effects on quality of the finished commodity.

As harvesting practices improved with larger and faster machines, the need for harvest aids intensified. Along with improvements in harvesting, ginning procedures were developed that also emphasized the need for proper preparation of the crop prior to harvest. Today, with earlier-maturing varieties, even faster harvesting and ginning procedures, modules for storage, escalating production costs, and increased scrutiny in the consumer market, emphasis on crop termination has made it one of the most perplexing and difficult decisions a grower faces.

"Defoliation" has become a practice used to capture crop yield and quality produced during the growing season and to ensure timely harvest. The practice is part of an overall effort to meet the demands of a marketplace that requires ever-increasing standards in order to maintain a competitive edge in a global marketplace.

The nature of the cotton plant and the environment in which it is grown often makes the process of crop termination unreliable; it is difficult to predict the effectiveness or outcome of a chemical harvest-aid application.

In the mid to late 1980s, research in the area of chemical termination often was secondary to other factors and relied more on "hearsay" than on actual research results. The wide range of environmental conditions across the Cotton Belt resulted in inconsistent conclusions about similar practices. The "Art and Science of Defoliation" largely was art, with little science. The limited number of products available for the practice with various limitations for effective chemical termination contributed further to the indecisive nature of crop termination.

Concerns about the imperfect nature of the chemical crop termination process were confounded further with the introduction of High-Volume Instrumentation (HVI) for fiber-quality analysis. Such analyses heightened awareness of the need for more reliable information concerning the effects of harvest aids on fiber quality.

At an informal meeting on defoliation and crop termination early in 1991, a group of cotton specialists and researchers voiced a concern over the inexact nature of defoliation. The need for a uniform assessment of defoliation practices was recognized. This need fostered what has become known as the Cotton Defoliation Work Group (CDWG). The Group's well-planned, uniform approach over a five-year period has provided a benchmark for harvest-aid assessment.

This monograph, ***COTTON HARVEST MANAGEMENT: Use and Influence of Harvest Aids***, is, in part, the culmination of the CDWG's original effort in a form that will be useful to the entire cotton industry. It is intended to be a resource guide for growers, consultants, and industry professionals, as well as a comprehensive resource for academic institutions.

Many people made significant contributions to this effort; they are to be commended for their hard work. However, it was through the commitment of Dr. James Supak of Texas A&M University that this Monograph became reality. His leadership of and mentorship to a diverse group of cotton researchers and Extension professionals was the common thread that bound the group. It is with deep appreciation and fond affection that the CDWG dedicates this work to Dr. Supak on the occasion of his retirement after 31 years of devoted service to the cotton industry.

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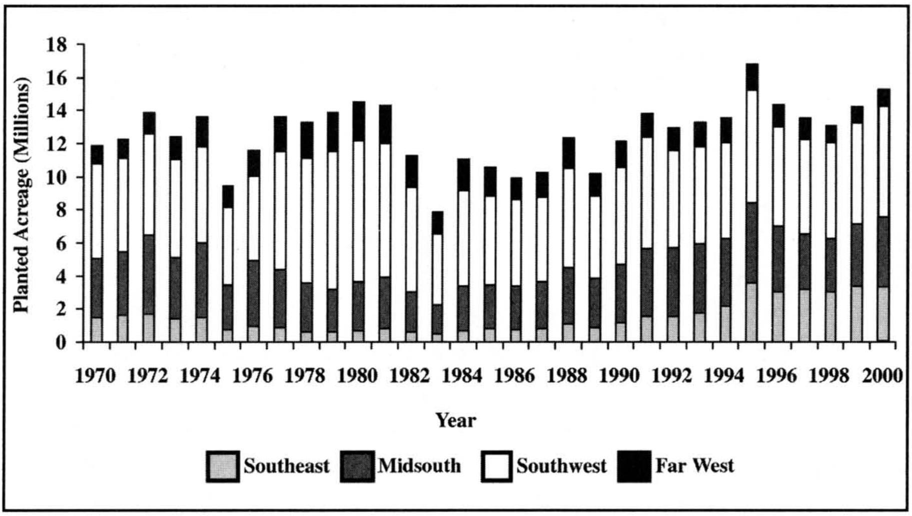
PREFACE

EVOLUTION OF COTTON HARVEST MANAGEMENT

For thousands of years, cotton has been grown widely for use in the manufacturing of domestic textiles. Over time, cotton culture evolved from gathering of the lint and seed from wild plants by indigenous people to the domestication and cultivation of selected species to provide textiles for people in organized agricultural societies. Innovations and improvements in textile manufacture led to increased demand for cotton fiber; as a result, acreage expanded and much progress was made in cotton culture. Presently, cotton is the primary cash crop for many farming operations throughout the world. It is among the most important agricultural commodities produced in the United States, with a recent high of 16.7 million planted acres in 1995 (Figure 1).



Source: Evans, 2000, and Anonymous, 2001.

Figure 1. U.S. upland cotton planted acreage by region, 1970-2000.

Cotton often is viewed as a labor-intensive, high-input crop with harvesting usually regarded as the single most expensive and labor-intensive operation associated with its production. Indeed, even today, about 75 percent of the cotton produced in the world is harvested by hand, one boll at a time. For more than 50 years, mechanical cotton pickers and strippers have provided viable alternatives to hand harvesting. Their rapid acceptance in the United States and elsewhere is attributable in part to the development of harvest-aid materials, which condition and prepare cotton for mechanical harvesting. The purpose of this monograph is to review the biological, environmental, economic, cultural, and societal factors that affect the art and science of cotton defoliation.

UNIQUE ATTRIBUTES OF COTTON

Botanically, cotton is a perennial shrub that originated in the relatively arid tropical and subtropical regions of Africa, the Americas, Australia, the Middle East, and elsewhere (Lewis and Richmond, 1968). Presently, it is grown mostly as an annual crop in environments that range from arid to tropical, with relatively long to very short growing seasons. Cotton typically requires a growing season of more than 160 days when minimum temperatures are above 60 F (15 C) (Waddle, 1984) to produce economically acceptable yields of lint and seed.

In the U.S. Cotton Belt, environments range from the arid West to the Rain Belt of the Midsouth and Southeast. Connecting the two extremes are the subtropical production area of South Texas and the relatively dry, short production seasons of the Southern Plains in Texas and Oklahoma. Growers on the northern fringes of the Cotton Belt, including Kansas and Virginia, also are challenged by short growing seasons.

Cotton is grown as an annual crop, leading to challenges in production management, especially harvest-aid management. Because of cotton's indeterminate growth habit, fruit and leaves do not mature uniformly. Consequently, uniform defoliation and boll opening depend on many factors, including crop and environmental conditions, timing of treatment applications, and the harvest-aid materials used.

The adoption of mechanical harvesting in the United States had a tremendous impact on the need for chemical defoliation. In 1947, 98 percent of the U.S. crop was handpicked or hand-snapped (Fortenberry, 1956). In 1957, only 68 percent was hand-harvested; and, by 1970, 98 percent of the crop was machine-harvested (Ghetti and Looney, 1972). The development of harvest aids in the 1940s and 1950s largely enabled this rapid transition from hand to mechanical harvesting (see Chapter 1).

EARLIER HARVEST

The ultimate goal of harvest-aid use is to protect the quality of the fiber and seed by enabling earlier harvest, in order to reduce field weathering losses, minimize trash content and staining of the lint, and allow for safe storage of seed cotton in trailers and modules. Harvest aids accelerate the physiological processes that induce or contribute to one or more of the following:

- Boll opening
- Removal of mature leaves
- Removal of immature leaves
- Regrowth suppression or inhibition
- Leaf desiccation (required for stripper harvest)
- Desiccation of weeds

Timely harvest of the most valuable fruit (generally the bolls on the lower one-half to two-thirds of the plants) allows the grower to capture much of the yield and quality potential of the crop. Economic value of the fiber is determined by its color, foreign matter content (trash), fiber length, strength, micronaire, and, possibly in the future, other traits, including fiber uniformity and maturity. The proper use of harvest aids primarily affects color and foreign-matter content.

Harvest aids also enable growers to better manage harvesting operations. Individual fields can be prepared and scheduled for harvest to accommodate equipment (farmer-owned or custom-operated) and manpower capacity and availability. Movement of equipment can be minimized by ensuring entire fields uniformly are ready for harvest. Seed cotton can be stored safely in modules, making harvesting operations independent of gin capacities.

SCIENCE COMPLEMENTS ART

Since the introduction of harvest aids, their successful use has been dependent in part on "art" and in part on science. Like the rest of the crop-protection industry, harvest-aid chemistry has changed dramatically in the last 50 years; today, producers have a relatively small, but effective, assortment of products to select from. The use of desiccants and defoliants has been explored and tested since the 1930s (Smith, 1950; Cathey, 1986; Walhood and Addicott, 1968), and harvest-aid management continues to be improved through application of scientific findings. Seasonal assessments of crop and environmental conditions, which constitute essential components of successful cotton harvest-aid programs, still are based largely on human judgement. However, computer-driven models and other techniques based on crop development now are available to assist growers with crop termination decisions.

The application of harvest-aid materials helps to terminate the crop and facilitate harvest scheduling. Improper choice or use of harvest-aid materials – or harvest-aid failures – can reduce quality and, ultimately, the economic value of the crop. Failures also increase costs, because of the need for re-treatment once an initial application has been deemed unacceptable. Ideally, for picker harvest, the harvest-aid treatment selected will promote boll opening and defoliate the entire plant with minimal drying or desiccation. For stripper harvest, high levels of boll opening and defoliation also are desirable, but complete desiccation of remaining green leaves is essential.

Successful harvest-aid performance depends on weather conditions, crop condition, and inherent properties of the materials used. Certain harvest aids have weaknesses that preclude their use under some conditions (e.g., cool temperatures). It has been determined that combinations of two or more harvest aids often provide a suitable hedge against the fallibility of single-product applications.

COTTON DEFOLIATION WORK GROUP

In 1992, a process was developed to uniformly assess harvest-aid performance under a wide range of cultural and environmental conditions. Initially formed as an ad hoc assembly of scientists interested in improving the predictability of harvest-aid practices, these cooperators agreed to form the Cotton Defoliation Work Group (CDWG), which planned, directed, and conducted an active, structured research effort. During the following five years, the CDWG developed a significant database of harvest-aid performance across the U.S. Cotton Belt. The National Cotton Council funded this multistate effort the first year; Cotton Incorporated continued funding in subsequent years. Operations of the CDWG were facilitated with support from Uniroyal Chemical.

The CDWG recognized that standardized practices and protocols were required in order to attain clearer understanding of boll opening, defoliation, and desiccation processes and to further complement the "art of defoliation" with science. The knowledge gained and the database generated during the course of the five-year project was used by CDWG members and others to develop or update numerous state and local harvest-aid guides for use by producers, consultants, certified applicators, and others. In addition to the crop production aspects of the research, the CDWG's efforts also documented that the proper use of harvest-aid materials has no adverse effects on fiber quality (Chapter 7; Anonymous, 1999).

There is a continuing need to evaluate new products and alternatives to current defoliation programs to ensure optimum harvest-aid performance and minimal impact on fiber quality. Procedures developed by the CDWG provide a proven format for conducting such evaluations at multiple locations across the entire U.S. Cotton Belt. In addition to product performance, findings from these trials also address concerns by cotton processors about possible detrimental effects of harvest aids on fiber quality (Anonymous, 1999).

The CDWG continues to operate as a self-sustaining, industry-supported entity; it comprises cooperators who are affiliated with state land grant institutions to ensure integrity of the research. The stated research objective of the CDWG is:

> **To develop effective, contemporary harvest-aid recommendations that contribute to harvest efficiency and high-quality fiber, by evaluating performance of standard defoliation treatments on a uniform basis and relating this performance to biotic and environmental factors.**

MONOGRAPH HIGHLIGHTS

The content appearing in the chapters of this Monograph was developed or supervised by members of the CDWG. Topics range from a history of cotton harvest aids to the economic impact of cotton defoliation to public and environmental issues.

CHAPTER 1 - A HISTORY OF COTTON HARVEST AIDS

Mechanical harvesting of cotton is a relatively new concept. The scarcity of labor during World War II played a large role in the transition from handpicking to machine harvesting. Mechanical harvesting also required chemical defoliation, with the 1938 commercial introduction of calcium cyanamide leading the way. Within 25 years, the transition from hand to mechanical harvest essentially was complete in the United States and other developed countries.

CHAPTER 2 - PHYSIOLOGY OF COTTON DEFOLIATION AND DESICCATION

An understanding of cotton growth and development is necessary to fully appreciate the physiological mechanism of defoliation. Perhaps the greatest challenge in dealing with cotton is its growth habit. Cotton is an indeterminate, deciduous perennial grown as an annual. The plant has a natural mechanism to shed mature leaves, although shedding is not necessarily synchronized with the most appropriate time to harvest lint. Hence, the need exists for harvest-aid technology for timely and efficient harvest, field storage, and ginning.

CHAPTER 3 - INFLUENCE OF ENVIRONMENT ON COTTON DEFOLIATION AND BOLL OPENING

The results obtained from the use of harvest aids on cotton are among the least predictable of the operations a farmer may perform (Cathey and Hacsklaylo, 1971). Factors influencing harvest-aid performance include weather conditions, spray coverage, and absorption and translocation of the materials, all of which are influenced by the environment. The chapter summarizes knowledge about environmental effects on harvest-aid performance and provides perspectives from different regions of the U.S. Cotton Belt.

CHAPTER 4 - INFLUENCE OF CROP CONDITION ON HARVEST-AID ACTIVITY

Although environmental factors have a significant impact on crop termination, crop condition can influence the success or failure of a harvest-aid decision. By applying sound management decisions throughout the growing season, growers can improve the likelihood of successful crop termination in the fall. This chapter explores how the efficacy of harvest aids is influenced by growth habits of the cotton plant and the agronomic practices and decisions made during the growing season.

Assessing Regrowth After Defoliation – A supplement to the chapter offers assessment criteria for rating cotton regrowth after application of harvest aids.

CHAPTER 5 - HARVEST-AID TREATMENTS: PRODUCTS AND APPLICATION TIMING

Harvest aids are applied to enhance boll opening, facilitate leaf removal, or desiccate the crop prior to mechanical harvest. Benefits of this process include a more efficient harvest of a mature crop and a preservation of yield and fiber quality. When cotton is properly treated, ginning efficiency also is enhanced. This chapter discusses different types of harvest aids and their applications and advantages.

CHAPTER 6 - HARVEST-AID APPLICATION TECHNOLOGY

Regardless of harvest-aid type, accurate application to the plant for uptake through the stomates and by penetrating the leaf cuticle is critical to success of the operation. Application decisions largely are based on crop maturity, crop condition, weather conditions, desired harvest schedule, and harvest-aid choices and rates. In addition, adjuvant usage, spray volume and pressure, physical drift, and application equipment are critical aspects that must be considered prior to use of cotton harvest aids.

CHAPTER 7 - UNIFORM HARVEST-AID PERFORMANCE AND LINT QUALITY EVALUATION

Successful cotton production largely depends on the proper use of harvest-aid products designed to defoliate plant leaves, accelerate boll opening, enhance seed cotton drying in the field, and, in some cases, desiccate green plant material. Harvest aids are needed to maintain the highest fiber quality possible by facilitating timely harvest and reducing plant trash created by mechanical harvesting procedures. This chapter provides an analysis and discussion of lint quality (foreign matter, color, strength, maturity, and neps) related to the harvest-aid treatments from the five-year study conducted by the CDWG.

CHAPTER 8 - FACTORS INFLUENCING NET RETURNS TO COTTON HARVEST AIDS

Because of frequent fluctuations in prices and profitability, producers are concerned about reducing the cost of production (Anonymous, 1998). One input that may improve net returns for cotton farmers is applying a harvest aid, at the correct timing, prior to harvest. The purpose of this chapter is twofold: 1) to identify some of the factors that may influence the costs and returns to alternative harvest aids, and 2) to analyze the costs and returns for selected harvest-aid treatments from the five-year field study conducted by the CDWG.

CHAPTER 9 - OVERVIEW OF REGIONAL DEFOLIATION PRACTICES

Cotton production and management practices, such as defoliation, vary significantly across the U.S. Cotton Belt. The five-year study conducted by the CDWG applied a standardized protocol to field research, which recognized and evaluated regional variations in environmental and crop growing conditions. These variances and a summary of the standard and regionally specific treatments evaluated by the CDWG are presented in four segments of this chapter. The regions include the Southeast, Midsouth, Southwest, and Far West. The chapter segments also address variances in harvest-aid use within regions – particularly northern versus southern locales.

CHAPTER 10 - PUBLIC AND ENVIRONMENTAL ISSUES

Many individuals and groups in the United States have developed strong concerns about the potential social, economic, and environmental issues modern U.S. agriculture can raise that relate to food safety, air and water quality, and solid waste. These concerns have resulted in passage of numerous state and federal regulations that affect crop protection, including product use and availability, emissions from processing facilities, and disposal of wastes. Additional issues currently are emerging; others undoubtedly will surface in the future. These issues have affected – and will continue to affect – U.S. farmers and farm economies, as well as those of allied industries. Producers must be knowledgeable of potential problems and concerns and must work to minimize downstream effects. Inappropriate practices, or even inattention, could hurt the availability of agricultural products – including harvest aids – and the U.S. cotton industry as a whole.

CHAPTER 11 - COTTON HARVEST AIDS AND BIOTECHNOLOGY: THE POSSIBILITIES

Use of genetically modified crops has grown dramatically over the past five years; they have revolutionized crop production. Recent advancements in cotton biotechnology predominately have been in the area of transgenic varieties possessing such characteristics as herbicide and insect resistance. Little biotechnological advancement has occurred in the area of cotton harvesting; however, many plant processes lend themselves to genetic modification for the improved efficiency of cotton harvest aids. This chapter discusses how biotechnology can be used to modify plant processes and the potential role of biotechnology in cotton harvesting in years to come.

FUTURE DIRECTION AND NEEDS

The successful development and introduction of new products and technologies for cotton production have advanced the industry in the past and will continue to do so in the future. Challenges to this effort, however, will be significant. Meeting the research and development needs of a vibrant, output-oriented cotton industry will be complicated compared to the previous three or four decades.

Capitalizing public and even private research will become an even bigger issue in the future than it is today. Therefore, it is incumbent on growers, consultants, manufacturers, and others in production agriculture to become better stewards of the products currently available. The industry must keep the present products in the marketplace for the indeterminate future, because higher costs of development and registration, resulting from increased and more restrictive government regulations, have narrowed the pipeline for new products considerably.

New technologies, especially biotechnology, are essential for agriculture to prosper and for the industry to meet the needs of a rapidly growing global population. From the U.S. perspective, bringing these new technologies into production agriculture must add value by decreasing production costs, increasing production, enhancing fiber qualities, and contributing to a safer environment and workplace.

The information age created by a proliferation of the Internet technology platform throughout everyday life provides a conduit for educating and training all audiences, from growers to consumers. It is incumbent on the research and Extension communities, and on the private sector, to educate and train all audiences as advances in agricultural technologies are transferred to the marketplace. The CDWG will participate actively in meeting research-based information needs. This Monograph underscores that commitment.

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