

COTTON PHYSIOLOGY

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REFERENCE BOOK SERIES



Edited by
Jack R. Mauney
and
James McD. Stewart

COTTON PHYSIOLOGY

THE COTTON FOUNDATION

Reference Book Series

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COTTON PHYSIOLOGY

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Number One

**THE COTTON FOUNDATION
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FOREWORD

From virtually every aspect, cotton is one of the most interesting higher organisms in the plant kingdom. It is rather unique in that it produces both fiber and food.

In its wild state, cotton is basically a perennial woody shrub in a semi-desert habitat. As an economic crop, it is now grown in the United States as a herbaceous annual under both semi-arid and humid conditions. Cotton also has been grown commercially as a perennial in areas of this country with mild winters. Only a few years ago about 50,000 acres of stub cotton were grown in Arizona. It has since been banned because it intensifies boll weevil and pink bollworm problems. However, in some parts of the world, some cotton is still grown commercially as a perennial.

Cotton belongs to the genus *Gossypium* which is in the Malvaceae or Mallow family. Other members of this family include okra, hollyhock, rose of sharon, and even such plants as teaweed, spurred anoda, and velvetleaf that are weed pests in cotton. The 39 species in the genus *Gossypium* are quite diverse. Only four of them produce commercial-type lint. *G. hirsutum*, to which the upland varieties belong, and *G. barbadense*, which includes the extra long staple or Pima varieties, are the only ones grown commercially in the United States.

Even though cotton is grown as an annual, its reproductive and growth habits are controlled by a "perennial" physiological system programmed for maximum seed production and survival over a number of years rather than just one.

Compared with most crop plants, cotton adapts quite well to adverse conditions. For example, it is considerably more tolerant to high salinity soils than corn. Cotton's vegetative and fruiting balance adjusts both during and after periods of stress (moisture stress, light stress, etc.) preserving the potential for good yield if sufficient growing season remains.

One interesting physiological aspect of cotton is the way fibers begin and develop. A single epidermal cell of the seed gives rise to a fiber. Some cells produce lint fibers and others shorter fuzz fibers. A relatively small percentage of the epidermal cells on a seed develop into fiber even though they all have the same genetic makeup. What controls which ones develop into fibers? What determines which fibers will be lint and which will be fuzz fibers? Someday we will have the answers to these and other questions about cotton. With such knowledge, we may be able to trigger initiation of fibers from more of the epidermal cells. This presumably projects to higher yields, but other factors such as inadequate photosynthate might limit the expression of more fibers per seed to higher yields.

There are numerous other interesting facets about cotton's physiology. For example, a lint fiber's elongation period lasts up to about 18 to 20 days postanthesis. After elongation ceases, deposition of secondary fiber wall material begins. Also, at about 18-20 days postanthesis, the endosperm begins to disappear. It is completely gone by the time the boll opens.

With some varieties, the lint and fuzz fibers are restricted to specific and sometimes separate areas of the seed surface. With the so-called naked seed varieties, the fuzz fibers are totally absent. Some wild species produce no fibers.

The physiological and biochemical events that take place in cotton's growth and development are highly regulated—much as if cotton is programmed by a highly sophisticated, built-in computer.

It is no wonder that many scientists working with cotton get caught up in its mystique and become deeply dedicated to unlocking its mysteries by finding the correct physiological/biochemical keys.

The National Cotton Council is pleased to have played a significant role in initiating The Cotton Foundation Reference Book Series and is particularly happy that the first book in the series is on cotton physiology.

The usefulness of **COTTON PHYSIOLOGY** as a reference book goes beyond the traditional researcher, teacher, and student users. Private agricultural consultants and representatives of the agricultural chemicals industry will find it to be a valuable source of information. Modern-day cotton producers also will find this book useful. Today's educated and innovative producers want to know more than just "what to do" and "when to do it." They want to know the reasons for doing things at certain times. They are interested in the cotton plant's fruiting and vegetative development as related to environmental conditions, cultural practices, etc. They realize that the more that is known about the cotton plant, the more successful they will be in culturing it as a commercial crop.

The National Cotton Council and The Cotton Foundation are indebted to Drs. Jack R. Mauney and James McD. Stewart, two outstanding scientists who have dedicated so much time and effort as editors in bringing this book to fruition. The Council and Foundation also recognize the major contributions of the 48 other scientists who were authors of the 40 chapters.

James M. Brown
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PREFACE

The cotton plant is unique among major agricultural crops in the number of its actual and potential uses. Not only does it produce the fiber with which everyone is intimately familiar as a consumer, but it also produces a high quality oil and a protein meal equivalent to or better than soybean. The cotton plant is also unique for its service as a multifaceted experimental system. Notable in this vein are: (1) the early work on abscission, defoliation and the discovery of abscisin; (2) studies on the physics and biochemistry of cellulose deposition in fibers; (3) mathematical simulation of crop growth and productivity; (4) the ultramicrographic description of pollen tube growth and fertilization; (5) the *in vitro* culture of ovules and fibers; and (6) the *in ovulo* culture of interspecific hybrid embryos. Cotton continues to be used as a model plant in the molecular biology of embryogenesis and gene regulation, in crop modeling, in cellulose synthesis and in cell differentiation. Many individuals have spent their careers studying various aspects of cotton growth and production, but progress has been slow and many perplexing problems remain.

Cotton does not readily yield its secrets. Anecdotally, it is said that there are two types of individuals who have worked with cotton. There are those who start a research program and become so frustrated with the crop that they will never work with it again. Then, there are those who become so fascinated with the peculiarities and idiosyncracies of the plant that they will never work with anything else.

It is in the spirit of and for the enthusiasts that we have attempted to create this book which is the culmination of several years of effort, hope and frustration. The inception of the idea for a comprehensive treatise on cotton physiology began in early 1978 during informal discussions among Earl King, who was USDA's Research Leader for Cotton Physiology at Stoneville, Mississippi, Jim Brown of the National Cotton Council, and the two of us. We recognized that there was a large body of information on cotton physiology, but that there was no source or reference from which one could readily obtain information. Those discussions led to the decision to conduct a series of symposia that would concentrate on specific aspects of the life history of the cotton plant. The intent was to generate a series of review and research papers that would provide the bulk of a reference book.

The format of the symposia conducted over a four-year period as a part of the Cotton Physiology Conference program during the Annual Beltwide Cotton Conferences strongly influenced the character of the book. Each year, three or four individuals considered as experts in the specific topic areas were asked to make major presentations. They, in turn, selected 2 to 4 additional researchers to provide expertise in related areas that deserved emphasis. All individuals submitted manuscripts covering their assigned topics. Our decision was to make each contribution a chapter. Consequently, considerable variety in length and content will be found in the various texts. At the end of the fourth symposium, all authors were given an opportunity to update their contributions. Since there were obvious

deficiencies in the subjects covered, we asked for additional chapters from experts in the deficient areas. The final result is contained herein.

We hope this book will serve as a background resource and starting point for future research into the physiology of the cotton plant. Its physical bulk and its more than 2200 citations should be an eloquent testimony to the complexity of the developmental processes in the cotton plant and, by inference, all plants. Attempts to reduce this plant to simplistic experiments and unequivocal statements about its behavior are naive at best and foolhardy at worst. In the truest sense, the crop is a four-dimensional entity. There is an immediacy of its daily reaction, but it has a distinct "memory" of its past (both recent and evolutionary) which is the basis for its future. Until physiologists and agronomists can integrate those reactions in the same way the plants do, our understanding will lack the dimension of time which has such a profound impact on the productivity of the crop.

Though the primary use of symposia books of this type is as a reference gathering dust until a specific question is asked, we think that it can serve usefully as a mystery story read from cover to cover. The mystery is, "What is a cotton plant?" In much the same way as the blind professors describing the elephant, each author experiences the cotton plant from a different perspective. Collecting their accounts so that a composite picture of the whole emerges is the purpose of this treatise. All who want to know the plant completely should be anxious to read every facet.

We are indebted to the many authors who contributed their time and expertise without compensation to make the symposia so successful. Ultimately, this resource volume is a tribute to them and to cotton physiology.

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