

**COTTON INSECTS AND MITES:
Characterization and Management**

THE COTTON FOUNDATION

Reference Book Series

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We are pleased to publish **COTTON INSECTS AND MITES: Characterization and Management**, the third in the series of cotton reference books. The first volume, **COTTON PHYSIOLOGY** was published in 1986, the second, **WEEDS OF COTTON: Characterization and Control** was published in 1992 and the fourth volume, **VEGETABLE OILS AND AGRICHEMICALS** became available in 1994.

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COTTON INSECTS AND MITES: Characterization and Management

Editors

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FOREWORD

To appreciate the impact of insect and mite pests on cotton production one needs to consider the cotton plant itself and the environment and conditions under which it is grown. For in-depth knowledge of the cotton plant—its botanical, physiological, and reproductive, etc. characteristics—the reader is referred to **COTTON PHYSIOLOGY**, Number 1 in The Cotton Foundation Reference Book Series.

Commercial production of cotton in the United States and most production areas of the World is as an annual crop with each season starting from planting the seed and ending with harvest. This is true even though the cotton plant botanically is a perennial.

In commercial production of cotton, the balance between vegetative and fruiting development at most stages throughout the growing season is critical to successful production. Among the major categories of stress factors that influence this balance is insect and mite pests.

There are hundreds of insect and mite species that are potential cotton pests. However, as recognized by professional cotton entomologists and producers, the major economic cotton insect and mite pests in the United States are considered in twenty one groups, some groups consisting of more than one species.

This book on **COTTON INSECTS AND MITES** was conceived in 1985 as a joint project of the annual Cotton Insect Research and Control Conference and The Cotton Foundation. A proposed contents outline for the Book was submitted to a distinguished Advisory Committee to help formulate its contents; the project was officially begun in 1987. Advisory Committee members, classified by their 1986 positions, were Perry L. Adkisson, Deputy Chancellor, Texas A&M University, College Station, TX; T. Don Canerday, Chairman, Division of Economic Entomology, University of Georgia, Athens, GA; Robroy Fisher, Cotton Producer, Glen Allan, MS; T. J. Henneberry, Director, Western Cotton Research Laboratory, U. S. Department of Agriculture, Agricultural Research Service, Phoenix, AZ; Louise Henry, Co-Owner, Henry Agri-Scientific, Bishop, GA; Harry L. McMenemy, Regional Technical Manager, Agricultural Division, Mobay Chemical Corporation, Memphis, TN; Leon Moore, Extension Entomologist, Cooperative Extension Service, University of Arizona, Tucson, AZ; H. T. Reynolds, University of California (Retired), Riverside, CA; and Ronald H. Smith, Extension Entomologist, Cooperative Extension Service, Auburn University, Auburn University, AL.

In an early stage of its development, **COTTON INSECTS AND MITES** was designated as Number 3 in the Cotton Foundation Reference Book Series. Number 1, **COTTON PHYSIOLOGY**, was already published (1986), and Number 2, **WEEDS OF COTTON** (1992) was much further advanced in development at that time. As it turned out, Number 4, **VEGETABLE OILS AND AGRICHEMICALS**, was developed much faster and was published in 1994 ahead of **COTTON INSECTS AND MITES**. Factors contributing to this were the much more extensive and comprehensive treatment of the subject and the involvement of a much larger

number of authors with **COTTON INSECTS AND MITES**.

I have had the pleasure of serving as executive editor and publishing coordinator for all four of these cotton reference books. My work has been mainly with the editors and the printing companies. The editors, in working with the authors, have done most of the work. In the case of **COTTON INSECTS AND MITES**, this has meant working on thirty chapters involving eighty contributors.

Drs. Edgar G. King and Jacob R. Phillips were selected originally by their peers to edit this book. Both have had distinguished and fruitful careers as cotton research entomologists. Dr. Phillips was recipient of the prestigious Mobay Cotton Research Recognition Award for 1990. This award program was administered by The Cotton Foundation. In 1993 Dr. King was recognized with the Outstanding Scientist of the Year Award presented by the Agricultural Research Service of the U. S. Department of Agriculture. Dr. Phillips retired from the University of Arkansas before publication of this book was completed. Dr. King still serves as a researcher and research administrator with USDA's Agricultural Research Service.

Mr. Randy J. Coleman, a co-worker of Dr. King, became heavily involved in editing soon after this book was started. He became a major contributor to its development. The addition of Mr. Coleman as one of the editors is most deserving in recognition of his dedicated efforts and many contributions.

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PREFACE

The book **COTTON INSECTS AND MITES: Characterization and Management** is the most comprehensive review and synthesis of knowledge and technology on United States cotton insects and mites available today. The book includes an introductory "Commemoration" reviewing the fifty-year history of the Cotton Insect Research and Control Conference followed by 30 chapters. Chapter 1, "Major Developments in Management of Insect and Mite Pests in Cotton," summarizes key events leading to the state-of-the-art for managing insect and mite pests in cotton. The other 29 chapters are divided into seven sections [Section I "Characterization of Insect and Mites" (four chapters); Section II "Technological Components of Insect and Mite Management" (seven chapters); Section III "Suppression Components" (five chapters); Section IV "Concepts of Population Management" (two chapters); Section V "Implementation of Insect and Mite Pest Management Programs" (four chapters); Section VI "Economics of Insect and Mite Pest Control" (three chapters); and Section VII "Perspectives" (four chapters)].

The concept of publishing a book on "Cotton Insects and Mites..." to commemorate and complement the Cotton Insect Research and Control Conference was first conceived in 1985. The intent was to update and expand the control, biological, and survey information heretofore given in pre-1985 Conference reports, as well as to synthesize information for cotton entomology in the United States. An expectation was to publish a book on cotton insects and mites that would be useful to growers as well as the scientific and technological community. Our hope is that this book will serve as a springboard for improved management of cotton insects and mites.

Eighty of the United States leading authorities on "Cotton Insects and Mites" contributed to the development of this book. It reflects pioneering research conducted by hundreds of scientists, the rich history of the cotton industry, the efforts of extension personnel, economists, and consultants to communicate and transfer the technologies, and the indomitable spirit of cotton growers, who each year must produce a profitable crop despite competition by insects and mites and other pests for the seed and fiber. This book, reflecting the extraordinary complexity of the interactions between the plant, insects and mites, and the cotton production and utilization community, truly was an interdisciplinary accomplishment involving the public and private sector. Consequently, it is not surprising that it cites 3200 references and is over 1000 pages in length.

These contributions summarize and synthesize knowledge by many of the United States most recognized cotton insect and mite authorities. And, in some cases, they are among their last major scientific contributions. One scientist, C. A. (Mr. Charlie) Parencia, lead author of the "Commemorative" paper and chronicler of the Cotton Insect Research and Control Conference for sixteen years and a participant for 35 of its 50-year existence passed away in 1987. One of the United States most eminent authorities on the "Biology and Ecology of Important Insect and Mite Pests of Cotton," (Chapter 2), T. F. (Tom) Leigh, passed away in 1993. Other chapters were

coauthored by authorities who have since retired, but many have continued their work in other roles within the cotton industry. On the other hand, the search for new information, new and improved technology, and the communication and transfer of this information and technology is being continued by a new generation of research scientists, extension entomologists, and consultants as exemplified in their contributions to this book.

The cotton field is home for hundreds of insect and mite species, but only a relatively few actually can be termed pests, i.e., competitors with people for seed and fiber. Most of the organisms inhabiting these fields are, in fact, beneficial, either as predators or parasites of potential pests or serving as food for the predators and parasites. Many microbials, including viruses, bacteria, fungi, microsporidia, and nematodes also function as beneficials attacking potential pests. Nevertheless, according to the 1996 Cotton Insect Research and Control Conference Proceedings, estimated management costs and revenue losses to insect and mite pests in 1995 were \$1.68 billion, despite the application of insecticides and miticides.

As stated by Dr. J. R. Bradley in Chapter 1, "The entry of the boll weevil into the United States [in 1892] is probably the single most important entomological event to have occurred in cotton." It was largely responsible for the shift of cotton production from the Southeast to the Southwest. Efforts to control this exotic pest that arrived without a complement of co-evolved natural enemies has driven cotton insect and mite management practices for over 100 years. The pink bollworm is a similar force in the Far West and plant bugs often serve as key pests in the Mid-South. These insects are often labeled as key pests because they are not effectively controlled by natural enemies and consequently each growing season they are among the first pests requiring insecticide application.

The evolution of plant insect and mite management practices and the use of synthetic chemical pesticides in cotton often has been in the forefront of technological developments in plant entomology in the United States. The development of short-season cotton varieties and stalk destruction was initiated to avoid late-season damage by boll weevil and bollworm populations. The cotton industry began using arsenicals to control the boll weevil in the 1920s, and cotton was one of the first crops where pesticides were applied aerially. Synthetic organic insecticides have been used extensively since their discovery in the 1940s. However, resistance to these chemicals quickly evolved with the occurrence of organochlorine resistance in the boll weevil in 1955 and shortly thereafter in the bollworm and tobacco budworm to organochlorines and organophosphate compounds. The trend of introduction of new chemicals, development of resistant insect and mite populations, outbreaks of secondary pests (often as a consequence of the elimination of natural enemies), and the research and development of new chemicals to manage the ever evolving complex of insect and mite pests is a constant challenge to the grower, industry, and researchers to evolve new and improved control technologies.

The National Cotton Council of America recognized the futility of this treadmill of discovery, obsolescence, and increasing cost and complexity and the key role of

the boll weevil as a pest in the Southeast, Mid-South, and Southwest in this evolutionary sequence. They enlisted the support of the federal, state, and private sector as early as 1957 in their efforts to eradicate the boll weevil from the United States. The successful elimination of the boll weevil as a pest of cotton in Virginia, the Carolinas, Georgia, north Florida, California and Arizona is a major entomological success story, rivaling the successful eradication of the screwworm from North America. Nevertheless, elimination of the boll weevil from the Mid-South and Southwest has been more intractable and the search continues for new and improved technologies to aid efforts in eliminating the weevil as a pest in the rest of the United States and northern Mexico. The evolution of these efforts is detailed in Chapter 19.

COTTON INSECTS AND MITES: Characterization and Management establishes a foundation on the biology, ecology, and systematics of pests and their natural enemies, discusses technological tools for managing pests and their natural enemies, reviews field-by-field and population management tactics, and integrates this information into implementation programs for four broadly defined production regions of the United States. Extension entomologists collaborated in authoring the chapter for their respective region. The economics of these pest suppression and elimination strategies are discussed and placed in context with environmental issues and the cotton production and utilization community. The interaction between the grower, research, extension, and consultant communities was of particular interest.

The 1989 Entomological Society of America "Common Name of Insects and Related Organisms" was the guide for species nomenclature used in this book. Accordingly, the scientific names *Helicoverpa zea* and *Heliothis virescens* refer to the bollworm and the tobacco budworm, respectively, thereby acknowledging that these two pests differ considerably and are not collectively "heliothis" or "bollworms." Another potential area of confusion involved the common term "plant bugs" to describe several genera of bugs in the family Miridae. The genus *Lygus* contains several species, and one in particular, *Lygus hesperus* has no approved common name, however, it is referred to as the western lygus bug throughout the monograph. Recently, differences in enzyme patterns, biology, extended host range, crossing experiments, and mating behavior observations within populations of the sweetpotato whitefly, *Bemisia tabaci*, have indicated that strains or biotypes exist for this species. Perring *et al.* (1993) suggested that the sweetpotato whitefly strain B is truly a distinct species and named it the silverleaf whitefly, *Bemisia argentifolii*. Where appropriate, this terminology has been adopted in discussing this organism.

We express our appreciation to the many authors who contributed their time to make this book possible, to the Bayer Corporation, Agriculture Division for support in publication of the book, and to The Cotton Foundation and the National Cotton Council of America for their leadership and support throughout the development and completion of the book. Dr. James M. Brown, in his role as consultant to The Cotton Foundation, deserves a special thanks for facilitating completion of this book and in maintaining the continuity of The Cotton Foundation Reference Book Series.

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COMMEMORATION

The monograph **COTTON INSECTS AND MITES: Characterization and Management** would not be complete without a brief historical review of the Cotton Insect Research and Control Conference. The Conference has been held annually since its beginning in 1947. This monograph has been written in commemoration of the conference.

Each year cotton research and extension entomologists from sixteen cotton growing State Agricultural Experiment Stations, the United States Department of Agriculture, the National Cotton Council of America, Cotton Incorporated, consultant organizations, and the chemical industry meet to review research and experiences of the current year. Special topics, such as insecticide resistance are often treated to develop guidelines for the upcoming year.

The Conference was initiated on November 17-19, 1947 and brought to fruition the desire of the late R. W. Harned (Chief of Cotton Insect Research for the U. S. Department of Agriculture from 1931 to 1953) to develop a conference for fostering cooperation and understanding among cotton entomologists. The advent of the synthetic organic insecticides, which were so much more effective than those previously available, generated a favorable climate for the conference; rapid evaluation of the new materials was imperative.

Fifty-two conferees attended the first conference with the number escalating to well over several hundred in subsequent years. The annual report of the conference came to be known as the cotton insect bible of the world, and it was distributed throughout the world wherever cotton was grown. So, R. W. Harned may be considered to be the Father of the conference.

The first five conferences did not include representatives from states where cotton was irrigated, viz. New Mexico, Arizona and California. However, the head of the Agriculture Research Agency (ARA) Laboratory, U. S. Department of Agriculture, Tucson, Arizona sat in on one of the conferences as an observer. Thereafter, representatives from all cotton growing states and Puerto Rico (for some years) participated in the conference.

The Agricultural Research Service (ARS) and its predecessor, ARA, have, in the past, had major responsibility for the management and coordination of the conference. R. W. Harned served as Chairman for the first six conferences, K. P. Ewing for the next four, C. F. Rainwater for the next eight, and C. R. Parencia, who participated in the first thirty-five conferences, for the next sixteen. With the latter's retirement, J. R. Phillips (University of Arkansas) and M. E. Merkl (ARS) became Co-Chairmen for the 35th and subsequent conferences with the former responsible for the conference and the latter for revision, publication and distribution of the report. Phillips was replaced by G. A. Herzog (University of Georgia) after the 42nd Conference, and when Merkl retired after the 36th Conference, he was replaced by D. L. Bull (ARS) who left cotton insects after the 38th Conference. Bull was replaced by E. G. King (ARS) for the 39th-43rd, and D. D. Hardee (ARS) succeeded King. As of the 46th Conference, Herzog and Hardee are Co-Chairmen.

Initially, the Conference was conducted over a three-day period with detailed reports being presented by research and extension personnel from each of the states. More recently, this time has been reduced to two days with the first half day being occupied by symposia on selected topics and the subsequent one and one-half days devoted to contributed papers and a business meeting.

R. W. Harned, the first Conference Chairman, called time on no one. Consequently, discussions were often prolonged. Then, too, the early reports of the conferences were written and revised during the conferences. In retrospect, valuable time was expended over the choice of a word or the efficacy of a compound at a certain dose against an insect. Regardless, Professor Harned wanted a unanimous decision.

The success of the conferences depended on the airing of all views. Under Professor Harned's patient guidance, a diverse group of strong-willed, independent professionals joined together for the common good. It took time and sometimes the issue, unresolved, was tabled until the following year. Professional convictions and personal feelings were kept apart and insults were rare, although tempers often flared. Once the dust had settled, conferees were friends and fellow professionals, not adversaries. As time progressed, timing of discussion was expedited.

In the early years it was the policy of conferees to meet in closed sessions excluding members from the chemical industry because new materials were coming into the picture rapidly and conferees felt that full and complete discussions of their efficacy could be held in no other way. As it was, participants exceeded desirable numbers, and addition of other personnel, especially those interested in promotion, could result in chaos. A concession to alleviate the exclusion was made in that once the insecticide efficacy section of the annual report was approved, it would be mimeographed and distributed to attendees of the subsequent Beltwide Cotton Production Conference. Distribution of this section took precedence over the regular program. It was anxiously awaited by farmers and ginners as much as by representatives of chemical companies. Members of industry thus did not have to wait until the report was published to receive the information; this was an important consideration when one realized that the future of a new insecticide might be affected by the conference report.

The first several conferences included detailed oral reporting of research results and experiences of conferees. In addition, copies of research results of a laboratory or experiences of extension personnel were brought to the conference for distribution. Data often were confidential, which was another reason for closed sessions. Although the chemical industry supported open sessions, it did not want data relating to certain compounds to be released until it was ready to release their chemistry. The policy was established that no compound was to be listed in the annual report until its chemistry was removed from the confidential status list.

Procedures for revising the Conference Report were changed in 1960 in preparation for the 14th Annual Conference on Cotton Insect Research and Control resulting in less time being needed to consider and adopt the report at the conference. Thus, one of the half-day sessions was devoted to current topics of interest presented by invited speakers. This usually was on the last one-half day of the conference. This session of

the 18th conference (1965) was not billed as an open session but word was passed that the general public was welcome to attend. This session has been open to general attendance since that time.

Southern Experiment Station Directors appointed a representative to the conference beginning with the 18th conference (1965). The representatives were Dr. E. V. Smith, Director, Alabama Agricultural Experiment Station for conferences 18 (1965) to 20 (1967); Dr. John H. Owen, Director, Georgia Agricultural Experiment Station for conferences 21 (1968) to 23 (1970); Dr. Walter K. Porter, Associate Director, Mississippi Agricultural and Forestry Experiment Station for conferences 24 (1971) to 38 (1985), and Dr. Gerald J. Musick, Dean of Agriculture and Director, Arkansas Agricultural Experiment Station for conferences 39 (1986) to date.

Beginning with the 14th conference (1965), one day was devoted to the discussion of research results and experiences, one-half day for the consideration and approval of the conference report, and one-half day for presentations on items of current interest (an open session beginning with the 18th conference). The next change was made with the 24th conference (1971) when a program committee was appointed. In this conference, the oral reporting session was reduced from one to one-half day; one-half day was devoted to concurrent sessions on current topics, one-fourth day to a summary of previous day's topics, one-fourth day to consideration and adoption of the conference report, and one-half day to open session on current topics.

Beginning with the 25th conference (1972), one-half day was devoted to oral reports, one-half day to consideration and adoption of the report, one-half day to the discussion of current topics in the open session, and one-half day joint session with other research conferences. The latter continued through the 33rd conference (1980) when it was discontinued.

Beginning with the 27th conference (1974), the program committee system was reorganized. The committee consisted of two representatives from the state experiment stations, one from the state extension services, and one from the U. S. Department of Agriculture. The members serve two-year terms on a rotating basis. The conference chairman continued to serve as chairman of the program committee.

Beginning with the 30th conference (1977), the program committee was expanded to include a representative from the chemical industry and from the consultant organizations. They were to present oral reports for their groups and were to serve as their representatives in the closed session for consideration and adoption of the conference report.

In recent years the program has consisted of submitted papers and the one-half day invited paper session with one-half day devoted to the adoption of the insect loss data, changes in control recommendations and the airing of mutual problems. All sessions of the conference are now open.

The conference has done much toward keeping the various segments aware of the progress that is being made in the cotton insect research and control picture. The conference has expanded from the original concept of improvements in chemical control to encompass alternative methods of controlling insects. Insect population management continues to be practiced but with less reliance on insecticides.

As indicated in the preceding discussion, the first report was actually written and unanimously adopted by conferees during the conference. The draft was taken to Washington, D. C., submitted for cursory editing to available editors and published through agency procedures of USDA'S Agricultural Research Service. Similarly, in the next few conferences, the report was started anew. Each topic was assigned to a committee of two to five members which completely revised or updated it from the preceding report based on the added year of research and experience. Thereafter, until the 14th conference (1961), a committee of two experiment station entomologists and a representative of the National Cotton Council met with ARS and other USDA entomologists in late October or November in Beltsville to prepare a working draft of the report which was considered and adopted at the ensuing conference. Beginning with the fourth conference (1950), a copy of the report was mailed to registrants of the Annual Cotton Production Conference which later became the Annual Cotton Production-Mechanization Conference. The Insecticide Sections of the reports of the 4th (1950) through the 12th conferences (1958) were typed, mimeographed and distributed to the conferees of the Annual Cotton Production Conference.

The first report (1974) of 16 pages consisted of an introduction and sections on insecticides, insects, bug catching machines, application equipment and conferees. Subsequent reports became longer as topics were added. In the interest of space, only the most significant additions are mentioned.

Resistance of Insects to Insecticides was added to the 9th report (1955), following a disastrous boll weevil outbreak in the Lower Delta of Mississippi and both the Mississippi and Red River Deltas of Louisiana.

The procedure for revising the report was changed for the fourteenth conference (1961). A series of questionnaires applicable to various sections of the report developed by a committee that met in Beltsville, Maryland were mailed to prospective conferees in September. The information in the returned questionnaires was compiled in the USDA, ARS Beltsville office and was included in the tentative draft of the conference report mailed to the conferees before the conference. The conferees were asked to suggest changes and additions to the chairman by mail. This procedure expedited the consideration and adoption of the report and made additional time available for other conference activities.

The thirty-first report of 75 pages added a section on conference highlights which was an important improvement in it and subsequent reports.

The thirty-third report (1980) of 77 pages added a table on yield losses to the cotton crop caused by various cotton insects and spider mites. This, too, was a valuable addition to the report. Past experience showed that such losses developed by the U. S. Department of Agriculture invite considerable criticism. Estimates under the auspices of the annual conference invite less criticism even though the same scientists are involved in their development. From the beginning, the development of annual estimates on cotton yield losses has been financially supported in part by The Cotton Foundation.

While the general chairman was responsible for revising, publishing, and distributing the report, it was standard procedure to have the revised report on camera copy

delivered by the end of January to the technical editor who in turn delivered it to the Office of Communication in the Department of Agriculture for publication with expected delivery of the published report by the end of February. The report was hand carried to the technical editor and to the Office of Communication, U. S. Department of Agriculture in Washington, D. C.

It might be added here that technical editors at headquarters provided cursory editing. Before tape and mag card machines became available, the changes in the report were pieced in so that it had blank spaces which affected the continuity of the report. Also, before sophisticated duplicating equipment became available, trouble was experienced in putting together and assembling the tentative drafts of the report.

In 1976, the conference chairman moved from headquarters in Beltsville, Maryland to an assignment in Stoneville, Mississippi. Thus, the thirtieth report (1977) was edited and publication arrangements were made in the ARS Southern Region Office, New Orleans, Louisiana. With the thirty-first report (1978) the technical editors made suggestions on tightening the report and that and other editions were considerably improved in appearance as well as content.

The last formal report was issued in 1984 as the 37th Annual Conference Report on Cotton Insect Research and Control. Since that time the highlights of the annual conference, changes in insect control recommendations, and insect loss data have been published in the Cotton Insect Section of the Annual Proceedings of the Beltwide Cotton Research Conferences. The conferees planned to publish and update a report after every five annual conferences have been held.

As a result of the Annual Conferences on Cotton Insect Research and Control, there is no other agricultural area with as much compatibility among State, ARS, consultant and industry personnel in the research, extension and control efforts for insects than those that attack cotton. Conferees can be justly proud of the accomplishments of the conference in its forty plus year history. No less should be expected from conferences of the future.

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