

COTTON PHYSIOLOGY

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Edited by
Jack R. Mauney
and
James McD. Stewart

COTTON PHYSIOLOGY

THE COTTON FOUNDATION

Reference Book Series

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COTTON PHYSIOLOGY

Editors

JACK R. MAUNEY AND JAMES McD. STEWART

Executive Editor and Publishing Coordinator

JAMES M. BROWN

Number One

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TABLE OF CONTENTS

	Page
FOREWORD.....	xxii
PREFACE.....	xxiv
CONTRIBUTORS.....	xxvi

Chapter 1. Ecological Adaptations of Gossypium Species..... Paul A. Fryxell

Introduction.....	1
Habitats.....	1
Temperature.....	2
Precipitation.....	2
Sunlight.....	3
Soils.....	3
Biotic Factors.....	3
Adaptations.....	4
Summary.....	7

SECTION I

DEVELOPMENT OF THE PLANT

Chapter 2. Vegetative Growth and Development of Fruiting Sites..... Jack R. Mauney

Introduction.....	11
Morphological Development.....	11
Vegetative Growth.....	13
Initiation of Flowering.....	15
Flower Development.....	16
Prime Sites of Flowering.....	19
Earliness.....	24
Vegetative Reproductive Ratio.....	26
Growing-Degree Day Summations.....	27
Summary.....	28

Chapter 3. Growth of Roots..... Bobby L. McMichael

Introduction.....	29
The Anatomy of the Cotton Root.....	29
Methods for Measuring Root Growth in Cotton.....	31
The Development of the Cotton Root System.....	33
Factors Affecting Cotton Root Growth.....	34
Soil Temperature.....	34

Soil Strength.....	35
Soil Aeration.....	36
Soil Water.....	36
Root—Shoot Relationships.....	37
Chapter 4. Influence of Atmospheric Parameters on Growth and Development	<i>Meryl N. Christiansen</i>
Introduction.....	39
Flower Initiation	39
The Nature of Flower and Fruit Abscission.....	40
Photosynthesis and Respiration Response to Environment.....	41
Light, Temperature or Gaseous Stress Effect on Hormone Status	42
Basic Effects of Environment on Abscission.....	43
Effects of Environment on Fruiting.....	43
Environmental Stress and “Cut Out”	45
Summary	46
Chapter 5. Temperature Effects on Growth, Development and Fiber Properties	<i>Jack R. Gipson</i>
Introduction.....	47
Germination and Emergence.....	47
Vegetative Growth and Fruiting.....	48
Fruiting Limb Initiation and Flowering	49
Nodal Position of the First Fruiting Limb.....	50
Boll Development.....	51
Fiber Elongation.....	51
The Secondary Wall.....	52
Boll Maturation Period	54
Fiber Properties.....	54
Summary	56
Chapter 6. Effects of High Temperatures and Controlled Fruiting on Cotton Yield.....	<i>Carl F. Ehlig</i>
Introduction.....	57
Temperature	57
Controlled Fruiting.....	60
Summary	62
Chapter 7. Water Deficits and Reproduction	<i>Wayne R. Jordan</i>
Introduction.....	63
Control of Fruiting Processes.....	64
Soil Water Availability and Vegetative Growth.....	64
Water Deficit-induced Abscission.....	68
Summary	71

**Chapter 8. Source-sink Relations as Affected by Water Stress
During Boll Development.....Daniel R. Krieg & J.F.M. Sung**

Introduction	73
Response to Water Stress.....	74
Source Response.....	74
Sink Response.....	76
Summary	77

Chapter 9. Effects of Nutrient Elements on Fruiting Efficiency.....Howard E. Joham

Introduction.....	79
Nutrient Element Balance	79
Measurements of Fruiting, Fruiting Efficiency and Earliness	79
Effects of Nutrient on Flowering and Fruiting	81
Elements Effecting the Vegetative-Fruiting Ratio.....	81
Elements not Affecting Fruiting Indices	87
Summary	89

Chapter 10. The Nitrogen Stress SyndromeJohn W. Radin & Jack R. Mauney

Introduction.....	91
Photosynthesis	91
Leaf Expansion and Hydraulic Conductivity.....	94
Responses to Water Stress.....	96
Integration of Nitrogen Effects	98
Prospects for Crop Improvement	103
Summary	104

Chapter 11. Salinity and Fruiting.....James L. Fowler

Introduction.....	107
General Plant Response to Salinity.....	108
Cotton Tolerance to Salinity.....	108
Specific Effects of Salinity on Cotton.....	109
Physiological Functions of Cotton Influenced by Salinity	110
Summary	111

Chapter 12. Hormonal Relations During ReproductionGene Gunn

Introduction.....	113
Flower Initiation	113
Fruit Abscission	115
Enzymes Involved in Abscission	116
Hormonal Effects	117
Other Substances.....	121
Cutout.....	123

Sequential Changes and Interactions	127
Exogenous Modification	131
Summary	135

Chapter 13. Use of Plant Growth Regulators for Crop

Modification..... *George W. Cathey & Robert O. Thomas*

Introduction.....	137
Reproductive Development.....	137
Vegetative Development.....	139
Crop Termination.....	141
Summary.....	142

Chapter 14. Physiology of Defoliation in Cotton Production..... *George W. Cathey*

Introduction.....	143
The Nature of Defoliation.....	143
Hormonal Effects.....	146
Exogenous Chemical Defoliation.....	149
Summary.....	153

SECTION II

PHOTOSYNTHATE PRODUCTION & DISTRIBUTION

Chapter 15. The Biochemistry of Photosynthesis..... *Richard Jensen*

Introduction.....	157
Morphology of Higher Plant Chloroplasts.....	157
Fundamental Energy Processes in Photosynthesis.....	159
Role of the Pigment Systems.....	159
Spatial Orientation of the Photosystems.....	160
Flow of Electrons in Light.....	161
Photosystem II and Evolution of Oxygen.....	162
Photosystem I and the Reduction of NADP^+	163
Intermediates of Electron Transport.....	164
Photophosphorylation.....	165
Carbon Metabolism During Photosynthesis.....	167
Photosynthetic Carbon Reduction Pathway (Calvin cycle).....	167
Regulation of CO_2 Fixation.....	169
Ribulose- P_2 Carboxylase/Oxygenase.....	169
Other Enzymes Regulated by Light.....	172
Storage of Energy by Starch Accumulation.....	173
Photorespiration and Its Requirements.....	174
Biochemical Limitations of Whole Plant Photosynthesis.....	180
Summary.....	181

Chapter 16. Carbohydrate Production and Partitioning in the Canopy..... *Jack R. Mauney*

Introduction.....	183
Crop Growth Rate.....	183
Carbohydrate Formation.....	183
Maximum Growth Rates.....	184
Sunlight Interception.....	186
Boll Loading and Biomass Accumulation.....	187
Carbohydrate Distribution.....	188

Chapter 17. Photosynthesis, Dry Matter Production and Growth in CO₂ Enriched Atmospheres..... *Donald L. Krizek*

Introduction.....	193
CO ₂ Enrichment of the Atmosphere.....	194
Controlled Conditions.....	194
Field Conditions.....	195
Metabolic Effects of CO ₂ Enrichment.....	197
Photosynthesis.....	197
Carbohydrate Metabolism and Feedback Control of Photosynthesis.....	203
Growth and Dry Matter Production.....	209
Transpiration and Stomatal Activity.....	214
Reproductive Development.....	218
Senescence and Abscission.....	218
Interaction of CO ₂ and Other Environmental and Morphological Factors.....	222
Water Stress.....	222
Air Pollution.....	223
Implications of Projected Global Increases in Atmospheric CO ₂	223
Summary.....	224

Chapter 18. Feedback Control and Stress Effects on Photosynthesis..... *Daniel R. Krieg*

Introduction.....	227
The Photochemical Conversion of Light to Chemical Energy.....	229
The Physical Processes Controlling the Transfer of CO ₂ from the Atmosphere to the Illuminated Chloroplast.....	230
The Biochemical Conversion of CO ₂ to CH ₂ O and Its Disposition.....	232
Stress Effects on Photosynthesis.....	236
Direct Effects.....	237
Summary.....	242

Chapter 19. A Conceptual Model of Stress Effects.... *Donald N. Baker & Basil Acock*

Introduction.....	245
Carbohydrate Stress.....	252

Water Stress.....	254
Nitrogen Stress	256
Summary	257

SECTION III

BOLL DEVELOPMENT

Chapter 20. Integrated Events in the Flower and Fruit*James McD. Stewart*

Introduction.....	261
Square Period and the Flower	261
Square	261
Ovary.....	263
Stamen	267
Anthesis.....	269
The Boll Period.....	272
Seed and Boll Set.....	272
Dry Matter Distribution	275
Relative Weight Distribution and Developmental Events	275
Environmental Influences.....	287
Competitive Interactions	293
Summary	297

Chapter 21. Mineral Compartmentation Within the Boll*Harry R. Leffler*

Introduction.....	301
Major Elements.....	303
Nitrogen	303
Phosphorous	303
Potassium	304
Minor Elements.....	305
Calcium.....	305
Magnesium.....	307
Dynamic Relationships of Nutrient Compartmentation	307
Summary	309

Chapter 22. Carbohydrate Distribution in Bolls*A. Michael Schubert, C.R. Benedict, & Russell J. Kohel*

Introduction.....	311
Assimilate Supply	311
Sink Strength	314
Source-to-Sink Proximity	317
Duration of Assimilate Transport to Bolls.....	323
Summary	323

Chapter 23. Lint Development *Edmond A.L. Delanghe*

Introduction..... 325

Fiber Initiation..... 326

Fiber Elongation 327

 Morphogenetic Aspects 327

 Ultrastructural Aspects..... 329

 The Nucleolus: A Driving Force..... 329

 The Substrate Supply..... 331

The Primary Wall and its Extension..... 332

 Chemical Composition 332

 The Microfibril..... 332

 Primary Wall Extension..... 333

The Overlapping Phase 336

 Simultaneous Elongation and Wall Thickening 336

 Gradual and Abrupt Changes in Wall Composition 336

 The S₁-layer 337

The Secondary Wall..... 339

 Physical Composition 339

 Chemical Composition 340

 Process of Secondary Wall Formation..... 341

 The Cytoplasm..... 342

 Cellulose Biosynthesis..... 342

Dehydration of the Fiber..... 344

Fiber Population..... 344

 Normal Distribution of Fiber Length 344

 Morphogenetic Relation Between Lint Characteristics 346

Lint Production and Lint Quality..... 347

 Environmental and Genetic Stresses 347

 The Need for Lint Quality-Generating Models 348

Summary 349

Chapter 24. Stress Influences on Fiber Development *Harmon H. Ramey, Jr.*

Introduction..... 351

Morphological Properties..... 351

 Mineral Nutrients..... 352

 Temperature..... 352

 Moisture..... 354

 Light Intensity 354

 Pests and Pesticides..... 355

 Growth Regulators 355

 Genotype Interaction..... 355

Mechanical Properties 356

Discussion..... 358

Summary 358

Chapter 25. Hormonal Influences in Fiber

Development *K. Kosmidou-Dimitropoulou*

Introduction.....	361
Methods Used in the Hormonal Research.....	361
Effect of Hormones on Fiber Initiation	363
Hormonal Influences on Fiber Differentiation.....	363
Fiber Nucleolus Evolution and Hormones.....	365
Effect of Hormones on Fiber Elongation.....	368
Effect of Hormones on Secondary Wall Formation.....	371
Summary	373

Chapter 26. The Outer Epidermis of the Cottonseed *Jerry D. Berlin*

Introduction.....	375
Morphology of the Outer Epidermal Layer.....	376
Light Microscopy.....	376
Electron Microscopy.....	383
Autoradiographic Analyses of the Epidermal Layer.....	403
Thymidine	403
Uridine	405
Amino Acids	407
Phenylalanine.....	408
The Seed Surface.....	410
Summary	413

Chapter 27. Chemistry and Biology of Cottonseed

Globulins..... *Julius W. Dieckert, Robert W. Wallace & Mary C. Dieckert*

Introduction.....	415
Chemistry of Acalin A and Acalin B.....	416
Possible Homologies.....	418
A Provisional Model.....	422
Summary	422

Chapter 28. Differential Gene Activity in Cotton Embryogenesis *Glenn A. Galau*

Introduction.....	425
Analysis of Global Gene Activity in Embryogenesis.....	427
Storage Protein Messenger—RNA's.....	433
Late Embryo-abundant (Subset 5) mRNA's.....	436
Further Directions in the Study of Differential Gene Activity.....	438

Chapter 29. Synthesis and Compartmentation of Enzymes During

Seed Maturation *Richard N. Trelease,
Jan A. Miernyk, John S. Choinski, Jr. & Stephen J. Bortman*

Introduction.....	441
-------------------	-----

Methods	443
Growth and Selection of Plants	443
Organelle Isolation and Enzyme Assays	443
Embryo Culture	444
Enzyme Development and Organelle Localization	444
In Germinating Seeds	444
In Maturing Embryos	447
In Cultured Embryos	456
Summary	460

SECTION IV

SEED AND GERMINATION

Chapter 30. Developmental Aspects of Planting Seed Quality *Harry R. Leffler*

Introduction	465
Chronology of Seed Development	466
Effects of Date of Bloom on Seed Development	469
Estimations of Planting Seed Quality	470
Production of Quality Planting Seeds	472
Summary	474

Chapter 31. Weathering: Changes in Planting Seed Quality Between Ripening and Harvest *John M. Halloin*

Introduction	475
Increases in Vigor and Germinability	476
Decreases in Vigor and Germinability	476
Changes in Seeds Associated with Weathering	476
The Influences of Environmental Factors on Weathering	477
The Contribution of Biological Processes to Weathering	477
Resistance to and Avoidance of Weathering	480
Summary	480

Chapter 32. Post-Harvest Factors Affecting Seed Quality *James C. Delouche*

Introduction	483
Mechanical Damage	484
Harvesting	485
Ginning and Mechanical Delinting	486
Handling and Conveying	489
Mechanical Properties of the Cottonseed Coat	489
Consequences of Mechanical Damage	493
Delinting	495
Flame Delinting	495
Acid Delinting	496

Acid Delinted vs Mechanically Delinted Seed	499
Conditioning	502
Storage.....	504
Seed Quality.....	507
Evaluation of Seed Quality.....	509
Dormancy.....	514
Improving Seed Quality	515
Summary.....	517
Chapter 33. Techniques to Evaluate Planting Seed Quality	<i>Charles C. Baskin,</i>
	<i>Norman W. Hopper, Gordon R. Tupper, & Otto R. Kunze</i>
Introduction.....	519
Seed Storage	520
Hygroscopic Equilibrium	520
Seed Quality—Moisture—Temperature Relationship	521
Variation in Seed Moisture Content.....	522
Presence of High Moisture Foreign Material	522
Storage in Trailers	524
Storage in the Field.....	524
Drying and Aeration	524
Evaluating Seed Quality.....	525
Tetrazolium Evaluation.....	526
Electrical Conductivity.....	527
Relation of Density and Weight to Seed Quality	531
Separation of Seed Using the Density Factor	533
Chapter 34. Germination and Stand Establishment.....	<i>Meryl N. Christiansen &</i>
	<i>Randy Rowland</i>
Introduction.....	535
Cottonseed Germination	535
Enzymology of Germination	536
Environmental Effects on Germination.....	537
Temperature.....	537
Oxygen Requirements	539
Mineral Deficiencies and Toxicities.....	540
Chemical Aids to Germination and Stand Establishment	540
Stand Improvement	541
Chapter 35. Seed Quality and Stand Establishment.....	<i>Luther S. Bird</i>
Methods.....	543
The Seed Quality Curve.....	543
Application to Genetic Improvement.....	547
Chapter 36. Field Environment and Stand Establishment.....	<i>Donald F. Wanjura</i>

Introduction.....	551
Physical Factors.....	551
Planting Factors.....	552
Post-Planting Factors.....	552

SECTION V

SPECIAL TOPICS

Chapter 37. Food and Feeding Quality of Cottonseed *John P. Cherry,
Russell J. Kohel, Lynn A. Jones, & William H. Powell*

Introduction.....	557
Past Research Efforts on Seed Quality (1900-1970).....	557
Seed Quality Research in the Early 1970's.....	565
Seed Quality Research on Glandless Cottonseed.....	566
Comparison of Seed Quality Data Developed Through the Years.....	571
Recent Cottonseed Quality Research.....	571
Results by Locations.....	572
Other Factors Affecting Cottonseed Quality.....	583
Pink Bollworm Contamination.....	583
Module Storage of Seed Cotton.....	584
Cottonseed Maturity, Closed-Boll Harvesting and Artificial Drying of Cottonseeds.....	584
Wild <i>Gossypium</i> Species.....	587
Improving Cottonseed Use in Feed and Food.....	589
Discussions.....	590
Geneticists Viewpoint.....	590
Industry Viewpoint.....	592
Summary.....	595

Chapter 38. Physiology of Secondary Products *Alois A. Bell*

Introduction.....	597
Phenolic Acids.....	597
Flavonoids.....	599
Flavonols.....	599
Flavones and Anthocyanins.....	604
Flavanols (Tannins).....	605
Terpenes.....	609
Volatile Terpenes.....	609
Sesquiterpenoid Naphthols and Ketones.....	611
Terpenoid Aldehydes.....	614
Unique Fatty Acids and Lipids.....	619
Summary.....	621

Chapter 39. Organ and Tissue Cultures in Cotton.....*James McD. Stewart*

Introduction..... 623
Embryo Culture..... 623
Ovule Culture..... 624
 Culture for Seed and Fiber Development..... 625
 In Ovulo Embryo Culture..... 626
 In Vitro Fertilization..... 627
Tissue Culture..... 627
 Callus Induction and Culture..... 627
 Suspension Cell Culture..... 628
 Anther and Microspore Culture..... 629
 Protoplast..... 630
 Regeneration of Plants..... 630

Chapter 40. The Interface Between Plant Physiology and Genetics.....*Jerry E. Quisenberry*

Introduction..... 633
Plant Physiology..... 633
Plant Genetics..... 634
Physiological Genetics..... 634
Summary..... 639

LITERATURE CITED..... 641
INDEX..... 767

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
Manager, Production Technology
National Cotton Council

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.

Jack R. Mauney
James McD. Stewart
Editors

CONTRIBUTORS

Current Address if Different

Dr. Basil Acock
Plant Physiologist
USDA, Agricultural Research Service
Crop Simulation Research Unit
Mississippi State University
Mississippi State, MS 39762

Dr. Donald N. Baker
Agronomist
USDA, Agricultural Research Service
Crops Simulation Research Unit
Mississippi State University
Mississippi State, MS 39762

Dr. Charles C. Baskin
Associate Professor and Extension Specialist
Department of Agronomy
Mississippi State University
Mississippi State, MS 39762

Dr. Alois A. Bell
Pathologist
USDA, Agricultural Research Service
National Cotton Pathology Research
Laboratory
P.O. Drawer JF
College Station, TX 77841

Dr. C.R. Benedict
Professor
Department of Plant Sciences
Texas A & M University
College Station, TX 77843

Department of Biochemistry &
Biophysics
Texas A & M University
College Station, TX 77843

Dr. Jerry D. Berlin
Professor
Department of Biology
Texas Tech University
Lubbock, TX 79423

Dr. Luther S. Bird
Professor
Department of Plant Sciences
Texas A & M University
College Station, TX 77843

(Retired)

Stephen J. Bortman
Graduate Student
Department of Botany & Microbiology
Arizona State University
Tempe, AZ 85287

Dr. James M. Brown
Manager, Production Technology
National Cotton Council
P.O. Box 12285
Memphis, TN 38182

George W. Cathey
Plant Physiologist
USDA, Agricultural Research Service
Cotton Physiology & Genetics Research
Delta States Research Center
P.O. Box 225
Stoneville, MS 38776

Dr. John P. Cherry
Chemist
USDA, Agricultural Research Service
Southern Regional Research Center
1100 Robert E. Lee Boulevard
New Orleans, LA 70179

Director
Northeastern Regional Research Center
600 E. Mermaid Lane
Philadelphia, PA 19118

John S. Choinski, Jr.
Graduate Student
Department of Botany & Microbiology
Arizona State University
Tempe, AZ 85287

Assistant Professor
Department of Biology
University of Central Arkansas
Conway, AR 72032

Dr. Meryl N. Christiansen
Plant Physiologist
USDA, Agricultural Research Service
Plant Physiology Institute
Agricultural Research Center
Beltsville, MD 20705

(Retired)

Prof. Edmond A.L. DeLanghe
Lab. Tropische Plantenteelt
Katholieke Universiteit Leuven
Kardinaal Merierlaan, 92
3030 Heverlee, BELGIUM

Dr. James C. Delouche
Professor & Director of State
Seed Laboratory
Department of Agronomy
Mississippi State University
Mississippi State, MS 39762

Dr. Julius W. Dieckert
Professor
Dept. of Biochemistry and Biophysics
Texas A & M University
College Station, TX 77843

Department of Plant Pathology
& Microbiology
Texas A & M University
College Station, TX 77843

Mary C. Dieckert
Research Associate
Texas A & M Research Foundation
Texas A & M University
College Station, TX 77843

Dr. Carl F. Ehlig
Plant Physiologist
USDA, Agricultural Research Service
4151 Highway 86
Brawley, CA 92227

(Retired)

Dr. James L. Fowler
Associate Professor
Department of Crop & Soil Sciences
New Mexico State University
Las Cruces, NM 88003

Dr. Paul A. Fryxell
Botanist
USDA, Agricultural Research Service
Cotton & Grain Crops Genetics Research
P.O. Drawer DN
College Station, TX 77840

Dr. Glenn A. Galau
Assistant Professor
Department of Botany
University of Georgia
Athens, GA 30602

Dr. Jack R. Gipson
Associate Professor
Department of Plant & Soil Science
Texas Tech University
Lubbock, TX 79413

Dr. Gene Guinn
Plant Physiologist
USDA, Agricultural Research Service
Western Cotton Research Laboratory
4135 E. Broadway Rd.
Phoenix, AZ 85040

Dr. John M. Halloin
Plant Physiologist
USDA, Agricultural Research Service
National Cotton Pathology Laboratory
P.O. Drawer JF
College Station, TX 77841

Dr. Norman Hopper
Associate Professor
Department of Plant & Soil Science
Texas Tech University
Lubbock, TX 79409

Dr. Richard Jensen
Professor
Department of Biochemistry
University of Arizona
Tucson, AZ 85721

Dr. Howard E. Joham (Retired)
Professor and Head
Department of Plant Sciences
Texas A & M University
College Station, TX 77843

Dr. Lynn A. Jones
Director, Research & Education
National Cottonseed Products Assoc., Inc.
P.O. Box 12023
Memphis, TN 38112

Dr. Wayne R. Jordan
Professor
Texas Agricultural Experiment Station
Blackland Research Center
Temple, TX 76501
Director
Water Resources Institute
Texas A & M University
College Station, TX 77843

Dr. Russel J. Kohel
Geneticist
USDA, Agricultural Research Service
Cotton and Grain Crops Genetic Research
P.O. Drawer DN
College Station, TX 77840

Dr. K. Kosmidou-Dimitropoulou
Plant Physiologist
Hellenic Cotton Board
150 Syngrou Ave.
Athens (404). GREECE

Dr. Dan R. Krieg
Professor
Department of Plant & Soil Science
Texas Tech University
Lubbock, TX 79409

Dr. Donald T. Krizek
Plant Physiologist
USDA, Agricultural Research Service
Plant Stress Laboratory
Agricultural Research Center
Beltsville, MD 20705

Dr. Otto R. Kunze
Professor
Department of Agricultural Engineering
Texas A & M University
College Station, TX 77843

Dr. Harry R. Leffler
Plant Physiologist
USDA, Agricultural Research Service
Cotton Physiology & Genetics Research
Delta States Research Center
Stoneville, MS 38776

DeKalb-Pfizer Genetics
3100 Sycamore Rd.
DeKalb, IL 60115

Dr. Jack R. Mauney
Plant Physiologist
USDA, Agricultural Research Service
Western Cotton Research Laboratory
4135 E. Broadway Rd.
Phoenix, AZ 85040

Dr. Bobby L. McMichael
Plant Physiologist
USDA, Agricultural Research Service
Plant Stress & Water Conservation
Research
Southern Plains Cotton Research
Laboratory
Rt. #3
Lubbock, TX 79401

Dr. Jan A. Miernyk
Graduate Student
Department of Botany & Microbiology
Arizona State University
Tempe, AZ 85287

Chemist
USDA, Agricultural Research Service
Northern Regional Research Center
1815 N. University St.
Peoria, IL 61604

Dr. William H. Powell
Agronomist
National Cottonseed Products Assoc., Inc.
P.O. Box 12023
Memphis, TN 38112

3147 South Fairfield Drive
Tempe, AZ 85282

Dr. Jerry E. Quisenberry
Geneticist
USDA, Agricultural Research Service
Cropping Systems Research Laboratory
Rt. #3
Lubbock, TX 79401

Dr. John W. Radin
Plant Physiologist
USDA, Agricultural Research Service
Western Cotton Research Laboratory
4135 E. Broadway Rd.
Phoenix, AZ 85040

Dr. Harmon H. Ramey, Jr.
Geneticist
USDA, Agricultural Research Service
Cotton Quality Laboratories
University of Tennessee
Knoxville, TN 37996

Chief, Fiber Technology Branch
USDA, AMS, Cotton Division
4841 Summer Avenue
Memphis, TN 38112

Dr. Randy Rowland
Plant Physiologist
USDA, Agricultural Research Service
Plant Physiology Institute
Agricultural Research Center
Beltsville, MD 20705

Dr. A. Michael Schubert
Assistant Professor
Department of Plant Sciences
Texas A & M University
College Station, TX 77843

Associate Professor
Plant Disease Research Station
Texas A & M University
Yoakum, TX 77995

Dr. James McD. Stewart
Plant Physiologist
USDA, Agricultural Research Service
Department of Plant & Soil Science
University of Tennessee
Knoxville, TN 37996

Professor & Altheimer
Chair for Cotton Research
& Development
Department of Agronomy
University of Arkansas
Fayetteville, AR 72701

J.F.M. Sung
Research Associate
Department of Plant & Soil Science
Texas Tech University
Lubbock, TX 79409

Agronomy Department
Nat'l. Chung Hsing University
Taichung, TAIWAN
Republic of China

Dr. Robert O. Thomas
Plant Physiologist
USDA, Agricultural Research Service
Delta States Research Center
Stoneville, MS 38776

(Retired)

Dr. Richard N. Trelease
Professor
Department of Botany & Microbiology
Arizona State University
Tempe, AZ 85281

Dr. Gordon R. Tupper
Agricultural Engineer
Delta Branch Experiment Station
P.O. Box 96
Stoneville, MS 38776

Robert W. Wallace
Research Associate
Dept. of Biochemistry and Biophysics
Texas A & M University
College Station, TX 77843

Department of Pharmacology
University of Alabama
College Station
Birmingham, AL 35294

Dr. Donald F. Wanjura
Agricultural Engineer
USDA, Agricultural Research Service
Cropping Systems Research Laboratory
Rt. 3
Lubbock, TX 79401