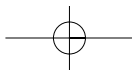
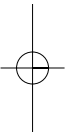
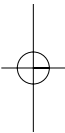
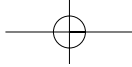


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HARTMANN AND KESTER'S PLANT PROPAGATION PRINCIPLES AND PRACTICES



HARTMANN AND KESTER'S PLANT PROPAGATION PRINCIPLES AND PRACTICES

EIGHTH EDITION

Hudson T. Hartmann, PhD
University of California, Davis

Dale E. Kester, PhD
University of California, Davis

Fred T. Davies, Jr., PhD
Texas A&M University College Station

Robert L. Geneve, PhD
University of Kentucky, Lexington

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Dedications

7 July 2009



The eighth edition of *Plant Propagation* is dedicated to Dr. Dale Emmert Kester, Professor Emeritus for the University of California, Davis. Dale passed away on November 21, 2003.

His lifelong interest in horticulture led Dale to enroll as a horticulture student at Iowa State University in Ames, Iowa in 1941. His college career was interrupted in 1943 when Dale joined the war effort as a US Air Force P-51 Mustang pilot. As a World War II pilot, he escorted bombers on 28 missions over Italy and Central Europe. Dale met his future wife, Daphne Dougherty, while he was stationed in Baton Rouge, Louisiana. Daphne was a USO dancer at the time. Following the war, he returned to Iowa State University and completed his horticulture degree in 1947.

Dale was the first PhD graduate from the University of California, Davis Pomology Department following the war. His dissertation concerned embryo culture of peaches. In 1951, he was offered an Assistant Professor position in the Department of Pomology at UC Davis where his work was to focus on almond production and breeding. This was the position he would hold until his retirement 40 years later in 1991. He taught undergraduate plant propagation and pomology

courses. Early in his career, he partnered with Dr. Hudson Hartmann to publish the first edition of “*Plant Propagation—Principles and Practices*” in 1959.

Along with Hudson Hartmann and others, Dale was a founding member of the Western Region of the International Plant Propagators’ Society. He served that organization as Vice-President, program chair in 1996 and President in 1997. Dale received the Curtis J. Alley Award in 1999 for his lifetime service to the International Plant Propagators’ Society. In 2002, shortly before his death, he received the society’s highest award, the International Award of Honor. With this award, he was recognized for “his long-standing reputation as a dedicated teacher of students interested in plant propagation, his service to the International Plant Propagators’ Society and especially, for his seminal textbook on plant propagation used the world over.”

Dale was a longtime member of the American Society for Horticultural Science and was recognized as a Fellow in 1977. He served as the first chair of the Propagation Working Group and received the Stark Award in 1980. In 1998, he was the Spenser Ambrose Beach Lecturer at Iowa State University. He published over 120 research papers in journals and conference proceedings. His research efforts in almond led to numerous root stock introductions, as well as the cause for noninfectious bud failure in almond.

Dale Kester was one of the most internationally recognized horticulturists of his generation, but remained a very unpretentious man. He was easy-going, good humored and appeared more impressed with his colleagues’ achievements than his own. Dale was a mentor, role model, and a friend. He will be greatly missed by the horticultural community.

The seventh edition of *Plant Propagation* was dedicated to Dr. Hudson T. Hartmann. Dr. Hartmann died March 2, 1994 just as plans for the sixth edition were getting underway. He is remembered as a dedicated, hard-working, conscientious scientist, teacher, and human being. He conceived of the writing of this text about 1955 and asked the second author, Dr. Dale E. Kester, to join him. Dr. Hartmann taught *Plant Propagation* at the University of California at Davis from 1945 to his retirement in 1980. His research in propagation involved early studies on hormones, mist propagation, and other aspects of cutting propagation

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particularly as they applied to fruit trees. He was also a specialist in olive research and development, attaining a worldwide reputation for this crop.

One of his primary accomplishments was his activity with the International Plant Propagation Society. He became a member in 1953 and then was instrumental in initiating the Western Region of the Society in 1960. He served as Western Region Editor for the Society from 1960 to 1993, serving also as International Editor from 1970 until 1991. During his career he published many scientific papers and popular articles. As well as the present text, he was senior author of *Plant Science: Growth, Development and Utilization of Cultivated Plants*, first edition (1981), second edition (1988) published by Prentice Hall.

Dr. Hartmann was a member of the American Society for Horticultural Science, becoming a Fellow in 1974. As an undergraduate he was a member of

Gamma Sigma Delta and Alpha Zeta. He received many awards, including the Charles G. Woodbury Award (1960), Joseph H. Gourley Award (1962), and Stark Brothers Award (1964) from ASHS. The American Association of Nurserymen awarded him its Norman J. Coleman Award (1970), The California Association of Nurserymen presented him with its Research award (1977), and Pi Alpha Xi made him an honorary member (1981). The Western Region IPPS awarded Dr. Hartmann its Merit award (1979), Honorary Membership (1983), and established the Hudson T. Hartmann Western Region Research Grant in his honor. The International IPPS Board of Directors awarded him the International Award of Honor in 1990.

Dr. Hartmann was a close personal friend, a collaborator who made working together a pleasure, and a respected peer whose guidance and insight are missed.

brief contents

Preface xii
 About the Authors xiv
 Acknowledgements xv

part one

General Aspects of Propagation

- 1 How Plant Propagation Evolved in Human Society 2
- 2 Biology of Plant Propagation 14
- 3 The Propagation Environment 49

part two

Seed Propagation

- 4 Seed Development 110
- 5 Principles and Practices of Seed Selection 140
- 6 Techniques of Seed Production and Handling 162
- 7 Principles of Propagation from Seeds 200
- 8 Techniques of Propagation by Seed 250

part three

Vegetative Propagation

- 9 Principles of Propagation by Cuttings 280
- 10 Techniques of Propagation by Cuttings 344
- 11 Principles of Grafting and Budding 415
- 12 Techniques of Grafting 464
- 13 Techniques of Budding 512
- 14 Layering and Its Natural Modifications 537
- 15 Propagation by Specialized Stems and Roots 561
- 16 Principles and Practices of Clonal Selection 594

part four

Cell and Tissue Culture Propagation

- 17 Principles of Tissue Culture and Micropropagation 644
- 18 Techniques for Micropropagation 699

part five

Propagation of Selected Plant Species

- 19 Propagation Methods and Rootstocks for Fruit and Nut Species 728
- 20 Propagation of Ornamental Trees, Shrubs, and Woody Vines 774
- 21 Propagation of Selected Annuals and Herbaceous Perennials Used as Ornamentals 840

Appendix 000
 Glossary 000
 Index 000



contents

Preface xii
 About the Authors xiv
 Acknowledgements xv

part one

General Aspects of Propagation 1

1

How Plant Propagation Evolved in Human Society 2

Introduction 2

Learning Objectives 2

Stages of Agricultural Development 3

Organization of Human Societies 4

Exploration, Science, and Learning 5

The Development of Nurseries 8

The Modern Plant Propagation Industry 12

Discussion Items 12

References 12

2

Biology of Plant Propagation 14

Introduction 14

Learning Objectives 14

Biological Life Cycles in Plants 14

Taxonomy 18

Legal Protection of Cultivars 21

Genetic Basis for Plant Propagation 21

Genetic Inheritance 27

Gene Structure and Activity 30

Plant Hormones and Plant Development 38

Discussion Items 45

References 45

3

The Propagation Environment 49

Introduction 49

Learning Objectives 49

Environmental Factors Affecting Propagation 50

Physical Structures for Managing the Propagation Environment 54

Containers for Propagating and Growing Young Liner Plants 70

Management of Media and Nutrition in Propagation and Liner Production 77

Management of Microclimatic Conditions in Propagation and Liner Production 85

Biotic Factors—Pathogen and Pest Management in Plant Propagation 90

Post-Propagation Care of Liners 100

Discussion Items 102

References 103

part two

Seed Propagation 109

4

Seed Development 110

Introduction 110

Learning Objectives 110

Reproductive Life Cycles of Vascular Plants 110

Characteristics of a Seed 112

Reproductive Parts of the Flower 117

Relationship Between Flower and Seed Parts 118

Stages of Seed Development 122

Unusual Types of Seed Development 130

Plant Hormones and Seed Development 133

Ripening and Dissemination 136

Discussion Items 137

References 137



5

Principles and Practices of Seed Selection 140**Introduction 140****Learning Objectives 140****Breeding Systems 140****Categories of Seed-Propagated Cultivars and Species 147****Control of Genetic Variability During Seed Production 150****Seed Production Systems 153***Discussion Items 159**References 159*

6

Techniques of Seed Production and Handling 162**Introduction 162****Learning Objectives 162****Sources For Seeds 162****Harvesting and Processing Seeds 166****Seed Testing 175****Seed Treatments to Improve Germination 184****Seed Storage 189***Discussion Items 195**References 195*

7

Principles of Propagation from Seeds 200**Introduction 200****Learning Objectives 200****The Germination Process 200****Dormancy: Regulation of Germination 218****Kinds of Primary Seed Dormancy 220****Secondary Dormancy 235****Dormancy Control by Plant Hormones 236***Discussion Items 240**References 240*

8

Techniques of Propagation by Seed 250**Introduction 250****Learning Objectives 250****Seedling Production Systems 250***Discussion Items 276**References 276***part three****Vegetative Propagation 279**

9

Principles of Propagation by Cuttings 280**Introduction 280****Learning Objectives 280****Descriptive Observations of Adventitious Root and Bud (and Shoot) Formation 281****Correlative Effects: How Hormonal Control Affects Adventitious Root and Bud (and Shoot) Formation 293****The Biochemical Basis for Adventitious Root Formation 299****Molecular/Biotechnological Advances in Asexual Propagation 304****Management and Manipulation of Adventitious Root and Shoot Formation 305****Management of Stock Plants to Maximize Cutting Propagation 307****Treatment of Cuttings 318****Environmental Manipulation of Cuttings 323***Discussion Items 331**References 332*

10

Techniques of Propagation by Cuttings 344**Introduction 344****Learning Objectives 344****Types of Cuttings 344****Sources of Cutting Material 363****Rooting Media 367****Wounding 373****Treating Cuttings with Auxins 373****Preventative Disease Control 381****Environmental Conditions for Rooting Leafy Cuttings 383**



Preparing the Propagation Bed, Bench, Rooting Flats, and Containers, and Inserting the Cuttings 393

Preventing Operation Problems with Mist and Fog Propagation Systems 395

Management Practices 396

Care of Cuttings During Rooting 401

Hardening-Off and Post-Propagation Care 403

Handling Field-Propagated Plants 406

Container-Grown Plants and Alternative Field Production Systems 409

Discussion Items 409

References 409

11

Principles of Grafting and Budding 415

Introduction 415

Learning Objectives 415

The History of Grafting 415

Terminology 417

Seedling and Clonal Rootstock Systems 419

Reasons for Grafting and Budding 419

Natural Grafting 424

Formation of the Graft Union 425

Graft Union Formation in T- and Chip Budding 432

Factors Influencing Graft Union Success 433

Genetic Limits of Grafting 439

Graft Incompatibility 441

Scion-Rootstock (Shoot-Root) Relationships 450

Discussion Items 457

References 457

12

Techniques of Grafting 464

Introduction 464

Learning Objectives 464

Requirements for Successful Grafting 464

Types of Grafts 465

Production Processes of Graftage 491

Aftercare of Grafted Plants 502

Field, Bench, and Miscellaneous Grafting Systems 504

Discussion Items 509

References 509

13

Techniques of Budding 512

Introduction 512

Learning Objectives 512

Importance and Utilization of Budding 512

Rootstocks for Budding 513

Time of Budding—Summer, Spring, or June 513

Types of Budding 519

Top-Budding (Topworking) 532

Double-Working by Budding 533

Microbudding 534

Discussion Items 535

References 536

14

Layering and Its Natural Modifications 537

Introduction 537

Learning Objectives 537

Reasons for Layering Success 537

Management of Plants During Layering 539

Procedures in Layering 539

Plant Modifications Resulting in Natural Layering 551

Discussion Items 558

References 558

15

Propagation by Specialized Stems and Roots 561

Introduction 561

Learning Objectives 561

Bulbs 563

Corms 577

Tubers 579

Tuberous Roots and Stems 581

Rhizomes 584

Pseudobulbs 587

Discussion Items 590

References 590



* 16

Principles and Practices of Clonal Selection 594

Introduction 594

Learning Objectives 594

History 594

Using Clones as Cultivars 595

Origin of Clones as Cultivars 597

Phenotypic Variations Within Clones 601

Patterns of Genetic Chimeras Within Clones 603

Management of Phase Variation During Vegetative Propagation 613

Pathogens and Plant Propagation 619

Selection and Management of Propagation Sources 623

Propagation Sources and Their Management 630

Discussion Items 635

References 636

part four

Cell and Tissue Culture Propagation 643

* 17

Principles of Tissue Culture and Micropropagation 644

Introduction 644

Learning Objectives 644

A Brief History of Tissue Culture and Micropropagation 644

Types of Tissue Culture Systems 649

Control of the Tissue Culture Environment (119, 209, 229) 679

Special Problems Encountered by *In Vitro* Culture 681

Variation in Micropropagated Plants 684

Discussion Items 687

References 687

* 18

Techniques for Micropropagation 699

Introduction 699

Learning Objectives 699

Uses for Micropropagation 699

Disadvantages of Micropropagation 701

General Laboratory Facilities and Procedures 702

Micropropagation Procedures 712

Stage I—Establishment 713

Stage II—Shoot Multiplication 716

Stage III—Root Formation 717

Stage IV—Acclimatization to Greenhouse Conditions 718

Discussion Items 724

References 724

part five

Propagation of Selected Plant Species 727

* 19

Propagation Methods and Rootstocks for Fruit and Nut Species 728

Introduction 728

References 766

* 20

Propagation of Ornamental Trees, Shrubs, and Woody Vines 774

Introduction 774

References 825

* 21

Propagation of Selected Annuals and Herbaceous Perennials Used as Ornamentals 840

Introduction 840

References 869

Subject Index 000

Plant Index, Scientific Names 000

Plant Index, Common Names 000

Preface

The eighth edition of *Plant Propagation: Principles and Practices* continues the legacy of updating the ever-changing principles and practices associated with plant propagation, but it is also the first edition with expanded color figures throughout the text. This is an exciting prospect that the co-authors hope will enhance student learning. Some 90% or more of the images and illustrations are either new or enhanced.

The eighth edition is published a half-century after the initial printing of *Plant Propagation: Principles and Practices* in 1959, but still continues the tradition of presenting paired chapters where the principles underlying the science of propagation alternate with the technical practices and skills utilized for commercial plant propagation. As with previous editions, the amount of material between editions has increased at an incredible rate and many aspects of growth and development have expanded beyond the wildest forecasts in 1959. We have tried to integrate the most current commercial techniques and understanding of the biology of propagation into current chapters. We have substantially updated the references and sections on “Getting More in Depth on the Subject” to help the reader delve deeper into these subjects than the general scope of this textbook.

As in previous editions, the book is organized into four basic parts. The initial three chapters are general chapters meant to support general aspects of propagation including a historical perspective, basic plant biology concepts and the impact and control of the environment as it affects propagation and nursery practices. Chapter 2 has been significantly revised to reflect the significant progress in plant hormone biology and the molecular advances in plant growth and development. We hope that it serves as background support for understanding the concepts described in the Principles chapters, and provides a foundation for students to pursue these fascinating subjects in the literature. Chapter 3 continues the integration of concepts and application to control the propagation environment, which is of major importance in commercial propagation. The latest engineering, computerization, and mechanization systems for propagation are included. The next two sections describe seed and vegetative propagation, respectively. Each revised section provides a chapter on the concepts behind genetic selection for either sexual or clonal plants, and then specific chapters for the principles and practices. The final section is an updated compilation of propagation techniques for specific crops.

New with this edition is the inclusion of study questions at the end of each chapter to compliment the keywords provided in the page margins, and web-based student resources available through www.pearsonhighered.com/hartmann (PH update this - UPDATED). There is also an instructors' resource website at www.pearsonhighered.com/hartmann (PH update this - UPDATED). Propagation instructors are encouraged to contact their local Prentice-Hall representative for a complimentary copy of the textbook.

A substantial increase in the number of figures was used to support the text for the eighth edition. The majority of these images have been taken by the co-authors while visiting commercial producers and research labs throughout the world. This opportunity was only possible because of the generosity of companies and individuals associated with those organizations. These groups are too numerous to acknowledge here, but the authors would like to express our sincere appreciation for the access granted to us that has made it possible to illustrate commercial plant propagation techniques to students. Additional images were taken while using the library resources



of the Lloyd Library in Cincinnati, and the rare book collections at the Missouri Botanical Garden and the University of Kentucky. We would also like to express our appreciation to those colleagues who have generously supplied images to enhance this and previous editions.

Mention or photographs of any products or techniques are for information purposes only, and are not intended as endorsements; neither is criticism implied for products not mentioned. Always follow instructions on product labels, and be aware that regulations may vary by country, state, and region. In any commercial propagation system it is important to conduct small trials before propagating on a large scale. Any propagation techniques and references listed are to serve as a guide. Propagators must develop their own procedures and

chemical treatments that work best for their particular propagation system.

In preparing the eighth edition of this book, we have depended upon the assistance of authorities in the various fields of propagation and related subjects. We thank them for their critical evaluation and suggestions. We also thank our wives, Maritza Davies and Pat Geneve, and families for their support, encouragement, and patience during the writing and production of this edition. We thank Mike Geneve for preparing selected illustrations used in the text.

Finally we acknowledge the skill and professionalism of the Prentice-Hall and associated editors who made this production possible including: Stephanie Kelly, William Lawrensen, Alicia Ritchey, Laura Weaver, Lara Dimmick, and Alex Wolf.

About the Authors



Fred T. Davies, Jr., Professor of Horticultural Sciences, and Molecular & Environmental Plant Sciences, and TAES Research Faculty Fellow, Texas A&M University, has taught courses in plant propagation and nursery production and management since 1979. He has co-authored over 150 research and technical publications. He was a J. S. Guggenheim Fellow (1999), and a Fulbright Senior Fellow to Mexico (1993) and Peru (1999). He is a Fellow of the American Society for Horticultural Sciences (ASHS) (2003) and the International Plant Propagators' Society (IPPS). He received the Distinguished Achievement Award for Nursery Crops from the ASHS (1989), L.M. Ware Distinguished Research Award—

ASHS—SR (1995), and S. B. Meadows Award of Merit—IPPS (1994). He is a recipient of the Association of Former Students Distinguished Achievement Award for Teaching—TAMU (1997), Chancellor of Agriculture's Award in Excellence in Undergraduate Teaching—TAMU (1998), L.M. Ware Distinguished Teaching Award, ASHS—SR (1998), and L.C. Chadwick Educator's Award, American Nursery and Landscape Association (1999). He was the International Division Vice-President—ASHS. He was President, and is currently Editor, of the IPPS—SR. He is President-Elect of the ASHS.

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Robert L. Geneve is a Professor in the Department of Horticulture at the University of Kentucky. He teaches courses in plant propagation and seed biology. He has co-authored over 100 scientific and technical articles in seed biology, cutting propagation, and tissue culture. He is also the co-editor of the book *Biotechnology of Ornamental Plants* and author of *A Book of Blue Flowers*. He has served as a Vice-President, program chair and President for the International Plant Propagators' Society—Eastern Region. He has served as the Editor for the international horticulture journal, *Scientia Horticulturae* from 2001 to 2008 and is currently on the editorial boards of the Propagation of Ornamental Plants and the Journal of Seed

Technology. He is a recipient of the University of Kentucky, George E. Mitchell Jr. Award for Outstanding Faculty Service to Graduate Students (2006), and is a Fellow the American Society for Horticultural Science (2005), and the International Plant Propagators' Society—Eastern Region (2003).

Fred T. Davies, Jr.
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Horticulture
Tarrant County College
Fort Worth, TX

Todd P. West, PhD, *Assistant Professor*

Horticulture
West Virginia University
Morgantown, WV

Sandra B. Wilson, *Associate Professor*

Environmental Horticulture
University of Florida
Fort Pierce, FL

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