

Economic Botany

Written primarily to cater to the needs of senior undergraduate and graduate students of botany, horticulture, food and nutrition, forestry, plant breeding, environment science, ethnobotanical studies and biotechnology, this book has use-value for a wide range of people stretching from an anthropologist to a lay-person interested in information about the natural sources of antioxidants and phytonutrients. It provides an up-to-date account of important crops grown worldwide, with insights into the history of plant exploration, plant migration, domestication and distribution, and crop improvement efforts.

The text begins with an enquiry into the origin and diversification of cultivated plants, followed by a discussion on tropical, subtropical and temperate crops that are sources of food, beverages, spices, medicines, plant insecticides, timber plants and essential oil-yielding plants. The genetic and evolutionary aspects of different plants and their health benefits are highlighted. It also covers topics dealing with biodiversity conservation, petro-crops, ethnobotanical studies and commercially important plants. The significance of major plant species under each category is described in detail. This book, on plant resource utilisation, is illustrated with numerous well-labelled diagrams and pictures.

S. L. Kochhar taught courses in economic botany and plant physiology at Khalsa College, a constituent college of the University of Delhi, for more than four decades (1965–2007). His areas of interest include botany, crop science, tropical crops and plant physiology.

Economic Botany

A Comprehensive Study

5th edition

S. L. Kochhar



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press & Assessment
978-1-107-11294-0 — Economic Botany 5th Edition
S. L. Kochhar
Frontmatter
[More Information](#)



Shaftesbury Road, Cambridge CB2 8EA, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

We share the University's mission to contribute to society through the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781107112940

© S. L. Kochhar 2016

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press & Assessment.

First published 2016

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging-in-Publication data

Names: Kochhar, S. L., author.

Title: Economic botany : a comprehensive study / Suraj Lal Kochhar.

Description: Fifth edition. | New York : Cambridge University Press, 2016. |

Includes bibliographical references and index.

Identifiers: LCCN 2016012281 | ISBN 9781107112940 (hardback : alk. paper)

Subjects: LCSH: Botany, Economic. | Plants, Useful. | Crop improvement.

Classification: LCC SB107 .K64 2016 | DDC 581.6/3--dc23 LC record available at <https://lcn.loc.gov/2016012281>

ISBN 978-1-107-11294-0 Hardback

Cambridge University Press & Assessment has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Cambridge University Press & Assessment
978-1-107-11294-0 — Economic Botany 5th Edition
S. L. Kochhar
Frontmatter
[More Information](#)

*With much love and affection to my granddaughter Myra
and grandsons Anish and Sarthak*

Contents

<i>Foreword</i>	<i>xv</i>
<i>Preface</i>	<i>xvii</i>
<i>Acknowledgements</i>	<i>xix</i>
1. Introduction	1
• Energy-giving Foods and Flavourings	2
• Plants and Home	3
• Plant Fibres and Fabrics	3
• Plants and Health	3
• Plants as Colouring Materials	3
• Plants and Beauty	4
• Plants and Atmosphere	4
• Plants and Perfume	4
• Miscellaneous Products	5
• Origin of Cultivated Plants	7
• The Work of Vavilov	11
• The Future Role of Plants in Relation to Mankind	17
2. Fibres and Fibre Yielding Plants	20
• Classification of Fibres	21
• Cotton	23
• Flax	34
• Hemp	37
• Jute	40
• Sann or Sunn Hemp	46
• Ramie, Rhea or China grass	47
• Abacá, Manila Hemp	50
• Sisal	53
• Coconut	57
• Kapok	60

3. Cereal Crops	64
• Wheat	67
Breeding of wheat	78
• Rice	85
Breeding of rice	98
• Wild Rice	100
• Maize or Corn	101
Breeding of Maize (Hybrid Maize)	114
• Sorghum (Guinea Corn)	118
• Barley	122
• Oats	124
• Rye	126
• Millets	128
• Man-made New Cereals	130
• Pseudocereals	131
Grain Amaranth	131
Buckwheat	133
Quinoa	134
Chia	136
Eel-grass or Sea-grass	138
• Grasses as a Source of Fodder	138
4. Sugars, Starches and Cellulose Products	141
• Sugars	141
• Sugarcane	143
Breeding of sugarcane	152
• Starches	154
• Cellulose Derived Products	155
5. Legumes or Pulses	167
• Pigeon Pea, Red Gram or Congo Pea	171
• Chickpea, Gram, Bengal Gram, Garbanzos	173
• Cluster Bean, Guar	175
• Grass Pea, Chickling Vetch or Pea, Lathyrus Pea	176
• Lentil	178
• Beans – Dry and Green	180
• Pea	187
• Cowpeas or Lubia	190
• Winged Bean, Princess Bean, Goa Bean, Asparagus Pea, Manila Bean	191
• Fodder Legumes	193
• Green Manure Crops	195
6. Vegetable Oils and Fats	196
• Classification of Vegetable Oils	198
• Location of Oils	199
• Methods of Obtaining Oils	199
• Keeping Quality of Oilseeds and Vegetable Oils and Fats	200

• Groundnut, Peanut or Monkey-nut	202
• Rape Seeds, Mustard Seeds and Relatives	205
• Coconut	208
• Oil Palm, African Oil Palm	212
• Common Olive	217
• Castor	220
• Cottonseed	222
• Sesame, Gingelly or Beniseed	224
• Tung and Relatives	227
• Soya Bean	228
• Linseed	231
• Canola	233
7. Fruits and Nuts	237
• Classification of Fruits	241
• Citrus	245
• Apple	252
• Mango	254
• Banana	258
• Pineapple	263
• Date Palm	266
• Grapevine	270
• Papaya, Pawpaw	274
• Avocado or Alligator Pear or Aguacate	277
• Nuts	280
Cashew	281
Chestnuts	284
Hazelnut and Filberts	285
Walnut	287
Pistachio Nut	289
Almond	291
Macadamia Nut or Queensland Nut	292
Brazil Nut or Para Nut	293
8. Vegetables	297
• Domestication of Vegetable Crops	298
• Root Crops	300
Potato, Irish Potato	302
Sweet Potato	309
Cassava	311
Yams	314
Taro and Relatives	316
Onion	319
Garlic, Ajo	322
Beetroot	324
Turnips	326
Rutabaga, Swede	328

x *Contents*

Carrot	329
Radish	331
• Herbage or Leafy Vegetables	332
Celery	334
Asparagus	335
Cabbage, Cauliflower and Relatives	337
Lettuce	343
Rhubarb	345
Spinach	346
Malabar Spinach, Indian Spinach, Ceylon Spinach or Malabar Nightshade	347
Kang Kong, Swamp Cabbage, Water Spinach	348
Edible Amaranth	349
• Fruit and Seed Vegetables	350
Chillies, Sweet or Bell Pepper	356
Tomato	359
Brinjal, Eggplant, Aubergine, Melongene	362
Okra, Lady's Finger, Gumbo	363
9. Spices, Condiments and Other Flavourings	365
• The Quest for Spices	365
• The Introduction of Spice Crops	366
• Production	367
• Ginger	368
• Turmeric	371
• Cinnamon	374
• Clove	376
• Saffron	378
• Allspice, Pimento or Jamaican Pepper	380
• Black Pepper	381
• Cardamom, Lesser Cardamom	384
• Nutmeg	387
• Chillies or Red Pepper	391
• Vanilla	393
• The Apiaceous or Umbelliferous Spices	396
Fennel	396
Coriander or Cilantro	398
Caraway Seed	400
Cumin	401
10. Fumitory and Masticatory Materials	402
• Tobacco	404
• Kola or Cola	415
• Areca or Betel Nut Palm	416
• Coca or Cocaine Plant	418
• Indian Hemp	420

11. Beverages	425
• Alcoholic Beverages	425
Wines	426
Beers	428
Distilled Beverages	430
Liqueurs	431
• Non-Alcoholic Beverages	432
Tea	432
Coffee	440
Cocoa	448
12. Wood and its Uses	457
• Gross Anatomical Characteristics	460
• Properties of Wood	464
• From Logs to Timber	472
• Wood as Fuel	474
• Construction Materials	477
• Wood Containers	481
• Chemically Derived Products	482
• Mechanically Reduced Products	487
• Hardwood Dimension Products	488
• Miscellaneous Wood Products	489
• Some Important Commercial Woods	493
• Ceylon Ebony	494
• Sal	496
• Spanish, Cuban or West Indian Mahogany	496
• Moulmein Teak, Rangoon or Burma Teak	498
• Cedar	499
• Pines	502
• Bamboo: the 'Green Gold' of India	505
13. Vegetable Tannins and Dyestuffs	508
• Vegetable tannins	508
Black Wattle	511
Red Mangrove	513
Sicilian Sumac	514
Canaigre	515
Quebracho	516
Chebolic Myrobalan	516
• Vegetable Dyestuffs	518
Annatto	520
Safflower	521
Cochineal	523
Logwood or Campeachy Wood	524
Indigo	525
Woad	527

xii *Contents*

Henna	528
Other Dyes	529
14. Rubber	530
• History of Rubber	531
• Para Rubber Tree	534
• Substitutes for Para Rubber	540
• Balatas	540
15. Medicinal Plants	543
• Belladonna, Deadly Nightshade	545
• Fever Bark Tree or Quinine Tree	547
• Foxglove	549
• Ephedrine	551
• Opium Poppy, White Poppy	552
• Rauwolfia	555
• Nux Vomica	556
• Ergot	557
• Madagascar Periwinkle	559
• Medicinal Yams	560
• Antibiotics	561
16. Insecticides and Herbicides	567
• Pyrethrum	569
• Rotenone	571
• Herbicides	572
17. Essential Oil Yielding Plants	576
• Extraction Methods	578
• Citrus or Agrumen Oil	585
• Jasmine	591
• Lavender	592
• German or Hungarian Chamomile	594
• Pandang, Screwpine or Keora	595
• Geranium	596
• Patchouli	598
• Damask Rose, Otto of Rose or Attar of Rose	599
• Khas-Khas, Khus-Khus or Vetiver	601
• Violet	603
• Flavouring Oils	604
• Mints	607
• Natural Camphor	609
• Blue Gum	611
• Sandalwood	613
18. Plant Diversity and its Conservation	615
• Threats to Biodiversity	615
• Concepts of Biodiversity	616

	<i>Contents</i>	<i>xiii</i>
• Objectives of Biological Resources Conservation		616
• Vastness of Indian Region		616
• Richness of Indian Flora		617
• Strategies for Genetic Resource Conservation		617
• Scientific Aspects of Conservation		619
• Conservation Methodologies		620
• Spheres of Responsibility		625
19. Petrocrops: Our Future Fuels		627
• Traditional or Conventional Energy Crops		627
• Hydrocarbon-yielding Plants		628
• Guayule		629
• Euphorbias		629
• Rubber Bush		637
• Copaiba		638
• Petroleum Nut Tree		638
• Botryococcus		639
• Non-edible Oils as Biofuels		639
• Physic Nut or Purging Nut		641
• Jojoba or Goat Nut		642
20. Ethnobotany: An Integrated Approach		644
• Ethnobotanical Research in India		647
• Traditional Knowledge Base		649
<i>References</i>		651
<i>Index</i>		657

Foreword

Professor S. L. Kochhar is one of the most distinguished authorities in the field of economic botany in the world. He has not only been a great teacher but also an eminent author of many books in the area of botany. The present book is the 5th edition of his earlier book “Economic Botany in the Tropics” which was first published in 1981. During the last 35 years he has published several other books introducing both students and the public to the beauty and utility of many of our flowering plants.

The present book deals, in a comprehensive way, with a variety of crops including cereals, grain legumes, fruits, vegetables, oil seeds and root and tuber crops. It also deals with many interesting issues like the origin of maize and the health risks associated with tobacco. In particular, the author has dealt in an authoritative manner with issues relating to transgenic crops. As far as I know, there is no other book which covers with such great scientific authority and clarity the range of topics dealt with by Professor Kochhar. This is a gift, in particular, to the student of botany as well as to all interested in economic botany.

Professor Kochhar’s dedication to the science of economic botany and to spreading a love of plants is practically unmatched. This, latest, book is the outcome of his dedication to the cause of spreading scientific literacy in the area of economic botany. I hope the book will be widely read and used not only by university students and teachers but by all interested in the world of botany. We should always recall that we live on this planet as guests of green plants, sunlight and farmers. This book as well as the earlier books of Professor Kochhar will help to strengthen our bonds with nature.

M. S. Swaminathan

Preface

Economic Botany in the Tropics was first published in 1981, and its fourth edition appeared in 2011, and in between the book has been reprinted several times. It is a matter of great privilege and honour that its new edition is being published by Cambridge University Press, under the new title 'Economic Botany: A Comprehensive Study' 5th edition. During the course of revision I have been influenced by review inputs from subject experts, across the world, as well as from advice offered to me by the editorial staff of the Cambridge University Press, India. It gives me pleasure in presenting to the readers an expanded and updated edition and I hope it will prove to be even more useful than the previous ones.

Salient features of this edition are as follows:

The production data for different crops is given for the year 2012–13, alongside top ten producers of cereals, grain legumes, fruits, vegetables, oil crops and root and tuber crops. The role of essential fatty acids (EFAs), such as linoleic and linolenic acids in human nutrition has been emphasised. These fatty acids if not supplemented in the diet can lead to many functional disorders.

Another significant feature is the inclusion of well-known 'natural sources' of antioxidants and phytonutrients, which, if made a part of our diet, can prevent cardiovascular, cancerous and neurodegenerative disorders, etc. The health benefits of many of our food plants have been given special coverage, along with a listing of the physiological basis of the chemical constituents present in them. Besides these, I have included discussions on 'the catastrophic sexual transmutation theory' of the origin of maize; 'pseudocereals' such as grain amaranth, quinoa, buckwheat, chia seeds and eel-grass; forage grasses of different regions (in Chapter 3); sugarcane propagation and its breeding strategies, and other sweetening plant materials (in Chapter 4); winged bean and fodder legumes as well as green manures (in Chapter 5); canola oilseed crop (in Chapter 6); kinnow mandarin, Brazil nut and many other sources of exotic fruits (in Chapter 7); True Potato Seed (TPS) Technology and select varieties of potato, turnip and pea (in Chapter 8); the risks associated with the use of Smokeless Tobacco, *bidi* and E-cigarettes (in Chapter 10); wines, beers, distilled spirits and liqueurs (in Chapter 11); and medicinal yams and Madagascar periwinkle (in chapter 15). The inclusion of the write-up on 'Terminator Gene Technology' will be of great value to students and scholars in various fields.

The earlier less-focused photographs have been substituted with high-quality images. Many line diagrams have been recast and have been made more informative in content.

xviii *Preface*

The online resource material includes topics such as green revolution – an overview; transgenic crops – objectives, achievements and concerns; plant biotechnology and sustainable agriculture; plant diversity and its conservation (including the work of N.I. Vavilov); plant introduction activities; and several appendices dealing with horticulture, forestry, archaeology as well as food and nutrition.

University and college students preparing for their degrees and diplomas in botany, agriculture, and horticulture as well as those engaged in studies of forestry, food science and nutrition, ethnobotany, archaeology, plant breeding and biotechnology or indeed anyone with a concern for our natural resources, will hopefully find this book useful. For a commoner, it can serve as a customized window to the fascinating world of useful plants as the book also emphasises the health benefits of some common food plants which should be made a part of one's regular diet. The book does not sermonise; it instead seeks to explain the necessity of and the rationale behind the usage of such plants. The information presented in this book is not intended to provide medical advice or treatment: do check with your physician/dietitian.

Acknowledgements

There are several people whom I want to warmly thank. I wish to express my utmost gratitude to Professor M. S. Swaminathan FRS, Founder Chairman and Chief Mentor, UNESCO Chair in Ecotechnology, M. S. Swaminathan Research Foundation, Chennai (India), not only for his kindness in writing the Foreword to the 5th edition but also for his great encouragement and continued interest in this project.

I could not have compiled a textbook of this magnitude without the willing cooperation of all the people and organisations who kindly sent or arranged pictures, and even accorded permission to use their illustrative material: Professor Scott A. Mori, Emeritus Curator, NYBG, Bronx, USA; Dr Robert Stewart Zeigler, Director General, IRRI, Manila, Philippines; Dr Claude M. Fauquet, Director, GCP 21, CIAT, Cali, Colombia; Dr Gudev S. Khush FRS, Adjunct Professor, University of California, Davis, CA, USA; Professor Elena Conti, Director, Institute of Systematic Botany and Botanical Garden, University of Zurich, Switzerland; Professor Igor G. Loskutov, N.I.Vavilov Institute of Plant Industry, St. Petersburg, Russia; Professor Dan Perlman, Department of Biology, Brandeis University, Waltham, MA (USA); Professor Steve Busby, School of Biosciences, University of Birmingham, Great Britain; Professor German Bollero, Department of Crop Sciences, University of Illinois at Urbana-Champaign, USA; Dr Theodore Hymowitz, Professor Emeritus, University of Illinois, Urbana-Champaign, USA; Dr Gene Hettel, Executive Director, Asia Research Foundation, IRRI, Philippines; Professor Sara Maldonado, Faculty of Exact, Physical and Natural Sciences, University of Buenos Aires, Argentina; Dr Enrique A. Martinez, Northern Catholic University at Coquimbo, CEAZA, La Serena, Chile; Professor H.H. Iltis, University of Wisconsin, USA; Mr. Dilip Tambyrajah, Secretary, International Natural Fiber Organisation, the Netherlands; Dr Valerie Cawoy, Universite Catholique de Louvain, Belgium; Dr Anupam Varma, Adjunct Professor and INSA Honorary Scientist, IARI, New Delhi; Dr Anil Kumar Singh (Ex Chief Scientist) CSIR-CIMAP, Lucknow, India; Professor H.Y. Mohan Ram, INSA Srinivasa Ramanujan Research Professor, New Delhi; Professor Satish C Maheshwari, Honorary Scientist INSA and Visiting Professor, CCT, University of Rajasthan, Jaipur; Dr Rameshwar Singh, Project Director, DKMA, ICAR, New Delhi; Directorate of Extension, Ministry of Agriculture, Govt. of India; Dr James Jacob, Director, RRII, Kottayam, Kerala; Dr B.S. Sreeramu, University of Agricultural Sciences, Bangalore; The Wealth of India, NISCAIR-CSIR, New Delhi; Dr Priya Ranjan, Director IC and Training, Ministry of Rural Development, Govt. of India; Dr Gurcharan Singh, Former Associate Professor, SGTB Khalsa College, University of Delhi; Dr Godofredo U.

xx *Acknowledgements*

Stuart MD, Stuartxchange. com, Philippine Medicinal Plants; Dr Ruth Baker Grimes, California, USA; Mr. Carl Davies, Photographer, CSIRO, Australia; Dr Brian J. Weir, Office of the Gene Technology Regulator, Canberra, Australia; Mr. Andrew Grygus, Automation Access, La Crescenta, CA, USA; U S Canola Com; Canola Council of Canada; USDA-Agricultural Research Service, Beltsville, Maryland; FAO of the United Nations (Photo Library); California Agriculture-Regents of the University of California; Dr Madhu Aneja, Cook College, Rutgers University, New Jersey, USA; and Dr Foong Swee Yeok, School of Biological Sciences, Penang, Malaysia; Dr. V. Selvam, Director, Coastal System Research, MSSRF, Annamalai Nagar, Tamil Nadu, India; Drs S. Gopala Krishnan and Navinder Saini, Senior Scientists (Rice and Cotton Breeding respectively), Division of Genetics, IARI, New Delhi; Dr Ranbir Singh, Ex. Principal Scientist, NBPGR, Pusa Campus, New Delhi, India; Dr. Sanjeet Kumar, Senior Research Fellow, Regional Plant Resource Center, Bhubaneswar, Odisha, India.

For pictures originating from more than one sources, the author expresses his deep appreciation to: International Natural Fiber Organization, the Netherlands and The Fiber Industry Development Authority, Philippines (for abaca) and The Institute of Bast Fiber Crops (IBFC) Changsha, Hunan Province-Chinese Academy of Agricultural Sciences and International Natural Fiber Organization, the Netherlands (for ramie)

I am grateful to Professor Ashwani Pareek of School of Life Sciences, Jawaharlal Nehru University, New Delhi for contributing a write-up on 'Terminator Gene Technology', appearing in the Chapter on 'Transgenic Crops: Objectives, achievements and concerns'. I do hope this information will be quite useful to students, scholars and teachers alike.

I am indebted above all to my wife Urmil for her understanding and continuous encouragement without which the revised version of this book would not have materialized. She has been a source of strength to my family and me. It was very thoughtful of my children to have gifted me a laptop and an iPad so that I could easily handle web communications and effectively make use of web resources. I wish to express my deep gratitude to my children Monica, Shalloo and Saurabh, whose knowledge in computer application was very helpful in preparing Excel sheets for illustrative material, consolidating permissions-clearance and reorganising the textual material in its final format.

Sincere thanks are also due to my other family members Puneet and Monica, Atul and Shalloo, Saurabh and Namita for their deep interest, support and genuine concern about the Cambridge edition. A special word of appreciation goes to my beloved grandchildren Sarthak, Anish and Myra for their excitement and wait over the years to see the book in print.

I would also like to express my sincere thanks to my former colleagues at Khalsa College, University of Delhi, especially Dr G. N. Dixit, Dr Sukhbir Kaur Gujral and Dr Vivek Chopra for their help in providing information relating to this edition. Special thanks are due to Dr Jaswinder Singh, Principal of Khalsa College for his interest in my research and for providing me ready use of the library facilities. In addition, I am thankful to Neeraj and Reema Gulati for preparing high-resolution images of the illustrative material used in the book.

I wish to express my deep gratitude to the editorial and production staff of the Cambridge University Press, India for the courtesy, co-operation and technical guidance to details, and for their sincere and meticulous efforts in bringing out this edition well in time and in the best possible shape.

Data on world production of various crops was obtained principally from FAO Stats by the Food and Agriculture Organisation of the United Nations, Rome, Italy. While every effort has been made to acknowledge the sources of information and any other copyrighted material, omissions may have been made inadvertently. If these are brought to the author's or publisher's attention, appropriate acknowledgements will be made in future editions.