

# Biotechnology in Agriculture and Forestry

Springer-Verlag Berlin Heidelberg GmbH

---

*Volumes already published*

- Volume 1: Trees I (1986)
- Volume 2: Crops I (1986)
- Volume 3: Potato (1987)
- Volume 4: Medicinal and Aromatic Plants I (1988)
- Volume 5: Trees II (1989)
- Volume 6: Crops II (1988)
- Volume 7: Medicinal and Aromatic Plants II (1989)
- Volume 8: Plant Protoplasts and Genetic Engineering I (1989)
- Volume 9: Plant Protoplasts and Genetic Engineering II (1989)
- Volume 10: Legumes and Oilseed Crops I (1990)
- Volume 11: Somaclonal Variation in Crop Improvement I (1990)
- Volume 12: Haploids in Crop Improvement I (1990)
- Volume 13: Wheat (1990)
- Volume 14: Rice (1991)
- Volume 15: Medicinal and Aromatic Plants III (1991)
- Volume 16: Trees III (1991)
- Volume 17: High-Tech and Micropropagation I (1991)
- Volume 18: High-Tech and Micropropagation II (1992)
- Volume 19: High-Tech and Micropropagation III (1992)
- Volume 20: High-Tech and Micropropagation IV (1992)
- Volume 21: Medicinal and Aromatic Plants IV (1993)
- Volume 22: Plant Protoplasts and Genetic Engineering III (1993)
- Volume 23: Plant Protoplasts and Genetic Engineering IV (1993)
- Volume 24: Medicinal and Aromatic Plants V (1993)
- Volume 25: Maize (1994)
- Volume 26: Medicinal and Aromatic Plants VI (1994)
- Volume 27: Somatic Hybridization in Crop Improvement I (1994)
- Volume 28: Medicinal and Aromatic Plants VII (1994)
- Volume 29: Plant Protoplasts and Genetic Engineering V (1994)
- Volume 30: Somatic Embryogenesis and Synthetic Seed I (1995)
- Volume 31: Somatic Embryogenesis and Synthetic Seed II (1995)
- Volume 32: Cryopreservation of Plant Germplasm I (1995)
- Volume 33: Medicinal and Aromatic Plants VIII (1995)
- Volume 34: Plant Protoplasts and Genetic Engineering VI (1995)
- Volume 35: Trees IV (1996)
- Volume 36: Somaclonal Variation in Crop Improvement II (1996)
- Volume 37: Medicinal and Aromatic Plants IX (1996)
- Volume 38: Plant Protoplasts and Genetic Engineering VII (1996)

*Volumes in preparation*

- Volume 39: High-Tech and Micropropagation V
- Volume 40: High-Tech and Micropropagation VI
- Volume 41: Medicinal and Aromatic Plants X

---

# Biotechnology in Agriculture and Forestry 37

---

## *Medicinal and Aromatic Plants IX*

Edited by Y.P.S. Bajaj

With 205 Figures, 11 in Colour and 69 Tables



Springer

Professor Dr. Y.P.S. BAJAJ  
A-137  
New Friends Colony  
New Delhi 110065, India

ISBN 978-3-642-08229-0

Library of Congress Cataloging-in-Publication Data. Medicinal and aromatic plants. (Biotechnology in agriculture and forestry; 4-). Includes bibliographies and index. 1. Medicinal plants – Biotechnology. 2. Aromatic plants – Biotechnology. 3. Plant cell culture. 4. Materia medica, Vegetable. I. Bajaj, Y.P.S., 1936–. II. Series. TP248.27.P55M43 1988 660'.62 88-3059.  
ISBN 978-3-642-08229-0 ISBN 978-3-662-08618-6 (eBook)  
DOI 10.1007/978-3-662-08618-6

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer-Verlag Berlin Heidelberg GmbH. Violations are liable for prosecution under the German Copyright Law.

© Springer-Verlag Berlin Heidelberg 1996

Originally published by Springer-Verlag Berlin Heidelberg New York in 1996  
Softcover reprint of the hardcover 1st edition 1996

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Cover design: Design & Production, Heidelberg

Typesetting: Thomson Press (India) Ltd., New Delhi

SPIN: 10471180

31/3137/SPS – 5 4 3 2 1 0 – Printed on acid-free paper

*Dedicated to  
Professor Dr G. Petri  
of the Semmelweis Medical University  
Budapest (Hungary) whose laboratory  
I had the privilege of visiting in 1981*

## Preface

This series of books on biotechnology of *Medicinal and Aromatic Plants* is being compiled to provide a survey of the literature focussing on recent information and the state of the art in tissue culture and the in vitro production of secondary metabolites. This book, *Medicinal and Aromatic Plants IX*, like the previous eight volumes published in 1988, 1989, 1991, 1993, 1994, and 1995, is unique in its approach. It comprises 24 chapters dealing with the distribution, importance, conventional propagation, micropropagation, tissue culture studies and the in vitro production of important medicinal and pharmaceutical compounds in various species of *Agave*, *Anthemis*, *Aralia*, *Blackstonia*, *Catha*, *Catharanthus*, *Cephalocereus*, *Clerodendron*, *Coronilla*, *Cyanara*, *Gloeophyllum*, *Liquidambar*, *Marchantia*, *Mentha*, *Onosma*, *Paeonia*, *Parthenium*, *Petunia*, *Phyllanthus*, *Populus*, *Portulaca*, *Sandersonia*, *Serratula*, *Scoparia*, and *Thapsia*. This book is tailored to the needs of advanced students, teachers, and research scientists in the field of pharmacy, plant tissue culture, phytochemistry, biomedical engineering, and plant biotechnology in general.

New Delhi, June 1996

Professor Y.P.S. BAJAJ  
Series Editor

# Contents

## I *Agave amaniensis* Trel & Nowell: In Vitro Culture and the Production of Phytosteroids

G. INDRAYANTO, W. UTAMI, and A. SYAHRANI  
(With 8 Figures)

1 General Account . . . . .	1
2 In Vitro Culture Studies . . . . .	5
3 Summary . . . . .	11
4 Protocol . . . . .	14
References . . . . .	14

## II *Anthemis nobilis* L. (Roman Chamomile): In Vitro Culture, Micropropagation, and the Production of Essential Oils

M.-L. FAUCONNIER, M. JAZIRI, J. HOMES, K. SHIMOMURA,  
and M. MARLIER (With 8 Figures)

1 General Account . . . . .	16
2 In Vitro Culture Studies . . . . .	24
3 Essential Oil Production by Normal and Transformed Cultures . . . . .	26
4 Improvement of Essential Oil Production by <i>A. nobilis</i> Tissue Culture . . . . .	32
5 Conclusions and Prospects . . . . .	33
6 Protocols . . . . .	34
References . . . . .	35

## III *Aralia cordata* Thunb.: In Vitro Culture and the Production of Anthocyanins

K. SAKAMOTO, Y. ASADA, and T. FURUYA (With 19 Figures)

1 General Account . . . . .	38
2 In Vitro Culture Studies . . . . .	40
3 Conclusions and Prospects . . . . .	59
4 Protocol . . . . .	60
References . . . . .	61

IV <i>Blackstonia perfoliata</i> (L.) Hudson (Yellow Wort): In Vitro Culture and the Production of Gentiopicroside and Other Secondary Metabolites L. SKRZYPCZAK, M. WESOŁOWSKA, B. THIEM, and J. BUDZIANOWSKI (With 7 Figures)	
1 General Account . . . . .	64
2 Secondary Metabolites . . . . .	65
3 Establishment of Tissue Cultures and Plant Regeneration . . . . .	67
4 Secondary Products in Tissue Culture . . . . .	70
5 Summary and Conclusions . . . . .	72
References . . . . .	73
V <i>Catha edulis</i> (Khat): In Vitro Culture and the Production of Cathinone and Other Secondary Metabolites H.M. ELHAG and J.S. MOSSA (With 6 Figures)	
1 General Account . . . . .	76
2 In Vitro Culture Studies . . . . .	80
3 Summary and Conclusions . . . . .	84
4 Protocol . . . . .	85
References . . . . .	85
VI <i>Catharanthus roseus</i> ( <i>Vinca rosea</i> ): In Vitro Production of Brassinosteroids A. SAKURAI and S. FUJIOKA (With 3 Figures)	
1 General Account . . . . .	87
2 In Vitro Culture Studies . . . . .	89
3 Conclusions and Prospects . . . . .	93
References . . . . .	94
VII <i>Cephalocereus senilis</i> (Old-Man-Cactus): In Vitro Culture and the Elicitation of Flavonoids P.W. PARÉ, Q. LIU, M.S. BONNESS, M. LIU, R.A. DIXON, and T.J. MABRY (With 6 Figures)	
1 General Account . . . . .	97
2 In Vitro Culture Studies . . . . .	99
3 Conclusion . . . . .	105
References . . . . .	106
VIII <i>Clerodendron trichotomum</i> Thunb.: Blue Pigment Production for Food Color T. ICHI, T. SHIMIZU, and K. YOSHIHIRA (With 12 Figures)	
1 General Account . . . . .	108
2 Blue Pigment Production by Callus . . . . .	111
3 Summary . . . . .	124
References . . . . .	125



**IX *Coronilla* Species: In Vitro Culture and the Production of Coumarin Compounds**

A. PIOVAN, R. FILIPPINI, G. INNOCENTI, R. CANIATO,  
and E.M. CAPPELLETTI (With 6 Figures)

1 General Account . . . . .	127
2 In Vitro Culture Studies . . . . .	130
3 Conclusion . . . . .	141
References . . . . .	141

**X *Gloeophyllum odoratum* (Brown Rot Fungus): In Vitro Culture, Growth, and Production of Volatiles, Sterols, and Triterpenes**

K. KAHLOS (With 11 Figures)

1 General Account . . . . .	144
2 Culture Studies and Production of Secondary Metabolites . . . . .	147
3 Conclusions and Future Prospects of <i>Gloeophyllum odoratum</i> . . . . .	164
4 Protocol . . . . .	163
References . . . . .	164

**XI *Liquidambar styraciflua* (Sweet Gum): In Vitro Culture and the Production of Tannins and Other Phenolic Compounds**

K. ISHIMARU (With 11 Figures)

1 General Account . . . . .	168
2 In Vitro Culture Studies . . . . .	169
3 Effects of Some Chemicals on Growth and Tannin Production of Callus Cultures . . . . .	177
4 Conclusions and Prospects . . . . .	183
5 Protocol . . . . .	183
References . . . . .	184

**XII *Marchantia polymorpha* (Liverwort): Culture and Production of Metabolites**

K.P. ADAM (With 5 Figures)

1 General Account . . . . .	186
2 Chemical Constituents . . . . .	186
3 In Vitro Culture Studies . . . . .	190
4 Conclusion . . . . .	198
5 Protocol for the Establishment of Aseptic Cultures and Cell Suspensions . . . . .	198
References . . . . .	199

**XIII *Mentha* Species (Mints): In Vitro Culture and Production of Lower Terpenoids and Pigments**

D.V. BANTHORPE (With 6 Figures)

1 General Account . . . . .	202
2 In Vitro Culture Studies . . . . .	210

3 Conclusions and Prospects . . . . .	219
4 Protocols . . . . .	220
References . . . . .	221

XIV *Onosma paniculatum*: In Vitro Culture and the Production of Purple-Red Pigment

W. NING and R.Q. CAO (With 17 Figures)

1 General Account . . . . .	226
2 In Vitro Culture Studies . . . . .	227
3 Conclusion . . . . .	239
References . . . . .	240

XV *Paeonia* Species: In Vitro Culture and the Production of Triterpenes

A. IKUTA (With 3 Figures)

1 General Account . . . . .	242
2 In Vitro Culture Studies . . . . .	246
3 Speculative Biogenesis of Triterpenes from Paeoniaceous Plant Callus Tissues . . . . .	251
4 Chemotaxonomic Studies . . . . .	253
5 Summary . . . . .	253
6 Protocol . . . . .	254
References . . . . .	254

XVI *Parthenium argentatum* Gray (Guayule):  
In Vitro Culture and the Production of Rubber  
and Other Secondary Metabolites

I.A. TRAUTMANN and H.S.C. SPIES (With 12 Figures)

1 General Account . . . . .	257
2 In Vitro Culture Studies . . . . .	261
3 Summary . . . . .	280
References . . . . .	281

XVII *Petunia hybrida*: In Vitro Culture and the Production of Anthocyanins and Other Secondary Metabolites

M.J.M. HAGENDOORN, L.H.W. VAN DER PLAS,  
and H.S. VAN WALRAVEN (With 10 Figures)

1 General Account . . . . .	284
2 In Vitro Culture Studies . . . . .	286
3 Secondary Metabolites in <i>Petunia</i> . . . . .	288
4 Induction of Secondary Metabolic Pathways by the Use of Biotic and Abiotic Elicitors . . . . .	290
5 Regulation of Anthocyanin and Lignin Synthesis in Cell Suspensions . . . . .	295

6 The Role of Cytoplasmic pH in Secondary Metabolite Production . . . . .	297
7 Summary . . . . .	300
References . . . . .	300

XVIII *Phyllanthus* Species: In Vitro Culture and the Production  
of Secondary Metabolites

D.W. UNANDER (With 2 Figures)

1 General Account . . . . .	304
2 In Vitro Culture Studies . . . . .	307
3 Summary . . . . .	315
References . . . . .	315

XIX *Populus* Species (Poplars): In Vitro Culture  
and the Production of Anthocyanins

Y.G. PARK, M.S. CHOI, and S.H. SON (With 10 Figures)

1 General Account . . . . .	319
2 In Vitro Approaches . . . . .	320
3 Conclusion . . . . .	331
References . . . . .	332

XX *Portulaca grandiflora* Hook. and *P. oleracea* L.:  
Formation of Betalains and Unsaturated Fatty Acids

H. BÖHM and L. BÖHM (With 11 Figures)

1 General Account . . . . .	335
2 In Vitro Systems . . . . .	340
3 Conclusion . . . . .	351
References . . . . .	351

XXI *Sandersonia aurantiaca* Hook. (Christmas Bells):  
Micropropagation and in Vitro Production of Colchicine

J.F. FINNIE and J. VAN STADEN (With 12 Figures)

1 General Account . . . . .	355
2 In Vitro Culture Studies . . . . .	360
3 Summary and Conclusions . . . . .	367
4 Protocols . . . . .	367
References . . . . .	368

XXII *Scoparia dulcis* L. (Sweet Broomweed):  
In Vitro Culture and the Production of Diterpenoids  
and Other Secondary Metabolites

T. HAYASHI (With 7 Figures)

1 General Account . . . . .	370
2 In Vitro Culture Studies . . . . .	373

3 Genetic Transformation of <i>S. dulcis</i> . . . . .	378
4 Conclusions and Prospects . . . . .	381
5 Protocol . . . . .	381
References . . . . .	382

XXIII *Serratula tinctoria* L. (Dyer's Savory):

In Vitro Culture and the Production of Ecdysteroids  
and Other Secondary Metabolites

M.-F. CORIO-COSTET, L. CHAPUIS, and J.-P. DELBECQUE

(With 10 Figures)

1 General Account . . . . .	384
2 In Vitro Culture Studies . . . . .	387
3 Conclusion . . . . .	398
4 Protocols . . . . .	399
References . . . . .	399

XXIV *Thapsia garganica* L.: In Vitro Culture,  
Somatic Embryogenesis, and the Production of Thapsigargins  
U.W. SMITT, A.K. JÄGER, and U. NYMAN (With 3 Figures)

1 General Account . . . . .	402
2 In Vitro Culture Studies . . . . .	405
3 Conclusion . . . . .	408
References . . . . .	409

Subject Index . . . . .	411
-------------------------	-----

## List of Contributors

ADAM, K.P., FR 12.3, Pharmakognosie und Analytische Phytochemie der Universität des Saarlandes, 66041 Saarbrücken, Germany

ASADA, Y., School of Pharmaceutical Sciences, Kitasato University, 5-9-1 Shirokane, Minato-ku, Tokyo 108, Japan

BANTHORPE, D.V., Department of Chemistry, University College London, 20 Gordon St., London WC1H OAJ, UK

BÖHM, H., Deutsches Institut für Ernährungsforschung, Arthur-Scheunert-Allee 114-116, 14558 Bergholz-Rehbrücke, Germany

BÖHM, L., Friedrich-Wilhelm-Murnau-Str. 20, 14480 Potsdam, Germany

BONNESS, M.S., Department of Botany, The University of Texas, Austin, Texas 78713, USA

BUDZIANOWSKI, J., Department of Pharmaceutical Botany, K. Marcinkowski University of Medical Sciences in Poznań, Wieniawskiego 1, 61-712 Poznań, Poland

CANIATO, R., Medicinal Plant Biotechnology Laboratory, Department of Biology, University of Padua, via Trieste 75, 35121 Padua, Italy

CAO, R.Q., Biology Department, Nanjing University, Nanjing 210093, P.R. China

CAPPELETTI, E.M., Medicinal Plant Biotechnology Laboratory, Department of Biology, University of Padua, via Trieste 75, 35121 Padua, Italy

CHAPUIS, L., INRA-Bordeaux, SRIV-Phytopharmacie, BP 81, 33883 Villenave d'Ornon, France

CHOI, M.S., Laboratory of Biotechnology, Forest Genetics Research Institute, Forestry Administration, P.O. Box 24, Suwon 441-350, Republic of Korea

CORIO-COSTET, M.-F., Institut National de Recherches Agronomiques, Centre de Recherches INRA-Bordeaux, Unité de Recherches Intégrées sur la Vigne, BP 81, 33883 Villenave d'Ornon, France

DELBECQUE, J.-P., Université de Bourgogne, Laboratoire de Développement et de Communication Chimique, Centre National de Recherches Scientifiques, CNRS-URA 674, 6 Bd Gabriel, 21000 Dijon, France

DIXON, R.A., Plant Biology Division, The Samuel Roberts Noble Foundations, P.O. Box 2180, Ardmore, Oklahoma 73402, USA

ELHAG, H.M., Department of Pharmacognosy, College of Pharmacy, King Saud University, P.O. Box 2457, Riyadh 11451, Saudi Arabia

FAUCONNIER, M.-L., Faculté des Sciences Agronomiques, UER Chimie Générale et Organique, Passage des Déportés 2, 5030 Gembloux, Belgium

FILIPPINI, R., Medicinal Plant Biotechnology Laboratory, Department of Biology, University of Padua, via Trieste 75, 35121 Padua, Italy

FINNIE, J.F., NU Research Unit for Plant Growth and Development, Department of Botany, University of Natal Pietermaritzburg, Private Bag X01, Scottsville, 3209, Republic of South Africa

FUJIOKA, S., Plant Growth Regulation Lab., The Institute of Physical and Chemical Research (RIKEN), 2-1 Hirosawa, Wako-shi, Saitama 35101, Japan

FURUYA, T., School of Pharmaceutical Sciences, Kitasato University, 5-9-1 Shirokane, Minato-ku, Tokyo 108, Japan

HAGENDOORN, M.J.M., Department of Plant Physiology, Agricultural University, Arboretumlaan 4, 6703 BD Wageningen, The Netherlands

HAYASHI, T., Faculty of Pharmaceutical Sciences, Toyama Medical and Pharmaceutical University, 2630 Sugitani, Toyama 930-01, Japan

HOMES, J., Laboratory of Plant Morphology, Université Libre de Bruxelles, Chaussée de Wavre 1850, 1160 Brussels, Belgium

ICHI, T., San-Ei Gen F.F.I., Inc. (formerly, SAN-EI Chemical Industries, Ltd.), 1-1-11 Sanwacho, Toyonaka, Osaka 561, Japan

IKUTA, A., Research Institute for Science, Science University of Tokyo, 2669 Yamazaki, Noda City, Chiba 278, Japan

INDRAYANTO, G., Laboratory of Pharmaceutical Biotechnology,  
Faculty of Pharmacy, Airlangga University, Jl. Dharmawangsa dalam,  
Surabaya 60286, Indonesia

INNOCENTI, G., Department of Pharmaceutical Sciences,  
University of Padua, via Marzolo 5, 35123 Padua, Italy

ISHIMARU, K., Department of Applied Biological Sciences,  
Faculty of Agriculture, Saga University, 1 Honjo, Saga 840, Japan

JÄGER, A.K., Department of Botany, University of Natal, P.O. Box 375,  
Pietermaritzburg 3200, Republic of South Africa

JAZIRI, M., Laboratory of Plant Morphology, Université Libre  
de Bruxelles, Chaussée de Wavre 1850, 1160 Brussels, Belgium

KAHLOS, K., Pharmacognosy Division, Department of Pharmacy,  
Biocenter 2, P.O. Box 56 (Viikinkaari 5), University of Helsinki,  
00014 Helsinki, Finland

LIU, M., Department of Botany, The University of Texas, Austin,  
Texas 78713, USA

LIU, Q., Department of Botany, The University of Texas, Austin,  
Texas 78713, USA

MABRY, T.J., Department of Botany, The University of Texas, Austin,  
Texas 78713, USA

MARLIER, M., Faculté des Sciences Agronomiques,  
UER Chimie Générale et Organique, Passage des Déportés 2,  
5030 Gembloux, Belgium

MOSSA, J.S., Department of Pharmacognosy College of Pharmacy,  
King Saud University, P.O. Box 2457, Riyadh 11451, Saudi Arabia

NING, W., Biology Department, Nanjing University, Nanjing 210093,  
P.R. China

NYMAN, U., Department of Pharmacognosy, Royal Danish School  
of Pharmacy, Universitetsparken 2, 2100 Copenhagen, Denmark

PARÉ, P.W., Department of Botany, The University of Texas, Austin,  
Texas 78713, USA (Present address: Insect Attractants, Behavior,  
and Basic Biology Research Laboratory, United States Department  
of Agriculture, Agriculture Research Service, 1700 S.W. 23rd Drive,  
Gainesville, Florida 32604, USA)

PARK, Y.G., Laboratory of Forest Genetics, Department of Forestry, Kyungpook National University, Taegu 702-701, Republic of Korea

PIOVAN, A., Department of Pharmaceutical Sciences, University of Padua, via Marzolo 5, 35131 Padua, Italy

SAKAMOTO, K., Tonen Corporation, Division of Immuno-Engineering, Corporate Research and Development Laboratory, 1-3-1 Nishi-tsurugaoka, Ohi-machi, Iruma-gun, Saitama 356, Japan

SAKURAI, A., Plant Growth Regulation Lab., The Institute of Physical and Chemical Research (RIKEN), 2-1 Hirosawa, Wako-shi, Saitama 351-01, Japan

SHIMIZU, T., San-Ei Gen F.F.I., Inc. (formerly, SAN-EI Chemical Industries, Ltd.), 1-1-11 Sanwacho, Toyonaka, Osaka 561, Japan

SHIMOMURA, K., Tsukuba Medicinal Plant Research Station, National Institute of Health Sciences, 1 Hachimandai, Tsukuba, Ibaraki 305, Japan

SKRZYPCZAK, L., Department of Pharmaceutical Botany, K. Marcinkowski University of Medical Sciences in Poznań, Wieniawskiego 1, 61-712 Poznań, Poland

SMITT, U.W., Department of Pharmacognosy, Royal Danish School of Pharmacy, Universitetsparken 2, 2100 Copenhagen, Denmark

SON, S.H., Laboratory of Biotechnology, Forest Genetics Research Institute, Forestry Administration, P.O. Box 24, Suwon 441-350, Republic of Korea

SPIES, H.S.C., Department of Chemistry, University of Stellenbosch, Stellenbosch, 7600, South Africa

SYAHRANI, A., Laboratory of Pharmaceutical Biotechnology, Faculty of Pharmacy, Airlangga University, Jl. Dharmawangsa dalam, Surabaya 60286, Indonesia

THIEM, B., Department of Pharmaceutical Botany, K. Marcinkowski University of Medical Sciences in Poznań, Wieniawskiego 1, 61-712 Poznań, Poland

TRAUTMANN, I.A., Nietvoorbij Institute for Viticulture and Oenology, Private Bag X5026, Stellenbosch, 7599, South Africa



UNANDER, D.W., Department of Biology, Eastern College,  
10 Fairview Drive, St. Davids, Pennsylvania 19087-3696, USA

UTAMI, W., Laboratory of Pharmaceutical Biotechnology,  
Faculty of Pharmacy, Airlangga University, Jl. Dharmawangsa dalam,  
Surabaya 60286, Indonesia

VAN DER PLAS, L.H.W., Department of Plant Physiology, Agricultural  
University, Arboretumlaan 4, 6703 BD Wageningen, The Netherlands

VAN STADEN, J., NU Research Unit for Plant Growth and Development,  
Department of Botany, University of Natal Pietermaritzburg,  
Private Bag X01, Scottsville, 3209, Republic of South Africa

VAN WALRAVEN, H.S., Department of Physiology and Biochemistry  
of Plants, IMBW, Vrije Universiteit, De Boelelaan 1087,  
1081 HV Amsterdam, The Netherlands

WESOŁOWSKA, M., Department of Pharmaceutical Botany,  
K. Marcinkowski University of Medical Sciences in Poznań,  
Wieniawskiego 1, 61-712 Poznań, Poland

YOSHIHIRA, K., Graduate School of Integrated Science and Art,  
University of Toa, 2-1 Ichinomiya-Gakuencho, Shimonoseki, 751, Japan