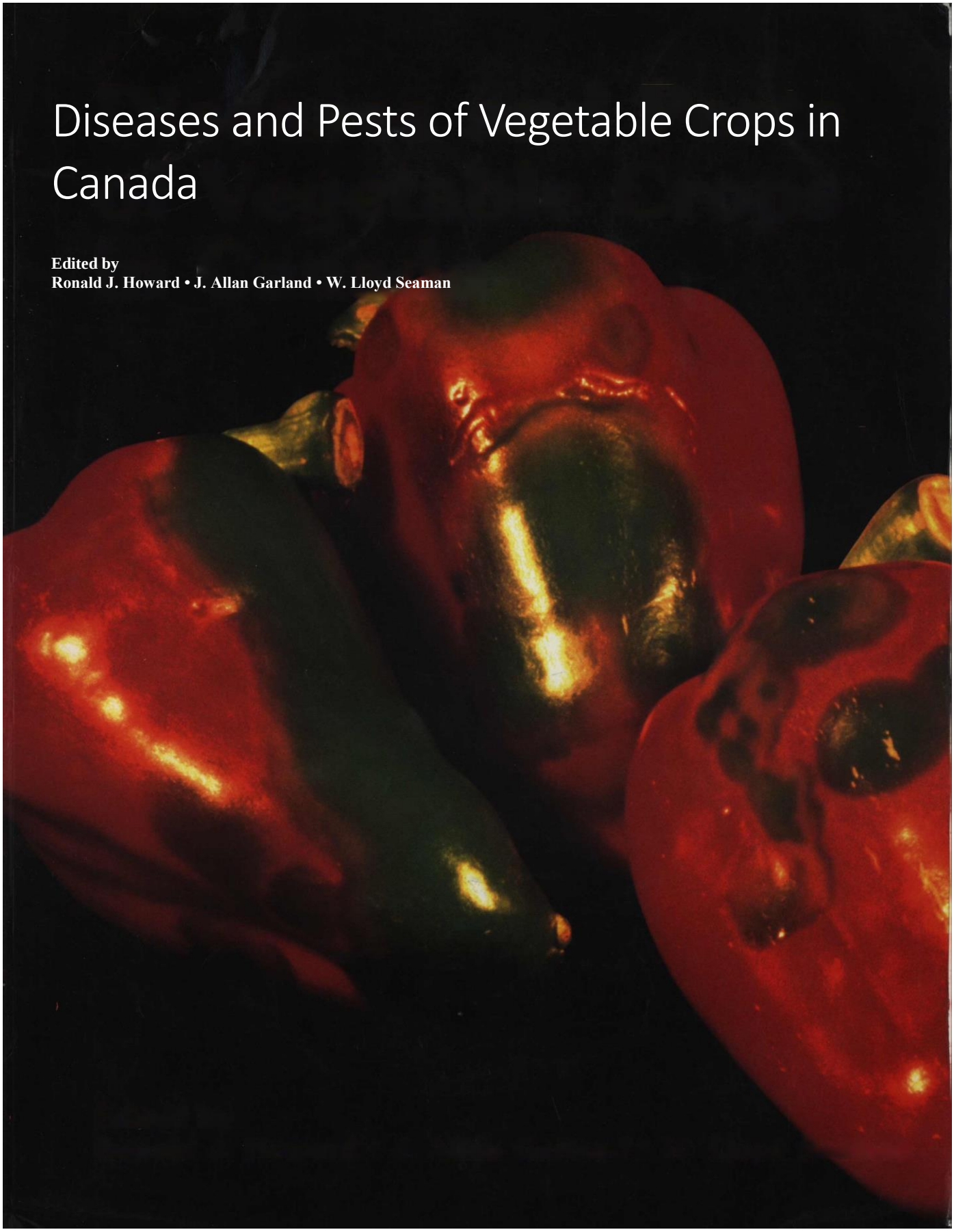
Diseases and Pests of Vegetable Crops in Canada

Edited by
Ronald J. Howard • J. Allan Garland • W. Lloyd Seaman



To the amateur biologists and professional plant pathologists and entomologists
whose studies and publications on vegetable diseases and pests have provided the foundation for this book.

In the 19th century, information on identifying and controlling diseases and pests was provided largely by self-taught naturalists, often clergy, through local agricultural societies and colleges and through reports published by government boards of agriculture. The Entomological Society of Canada (founded in 1863, incorporated in 1871 as the Entomological Society of Ontario, and re-established in 1951) frequently included information on economic entomology in its reports. Regional colleges of agriculture (the first founded in 1859 at Sainte-Anne-de-la-Pocatière) provided instruction in pest management, and *Le Naturaliste canadien,* founded in 1868, included articles on diseases and pests. Expert advice was provided by universities, beginning in 1874 with the Ontario Agricultural College, which produced a series of bulletins from 1886. Research and extension on a national scale began in 1886 with the formation of the Experimental Farms of the Dominion Department of Agriculture, with William Saunders as director and James Fletcher as entomologist and botanist. Fletcher and his successors, botanist H.T. Güssow and entomologist C.G. Hewitt, established laboratories of plant pathology and entomology across Canada; the department also introduced several series of bulletins and other publications, including *Canadian Plant Disease Survey* (1920) and the *Canadian Insect Pest Review* (1923). The Quebec Society for the Protection of Plants, founded in 1908 by naturalists and biologists interested in plant diseases and insect and weed pests, published annual reports in English and in French that were widely distributed in Quebec and elsewhere. In 1918 Canadian plant pathologists met to form the Canadian Division of the American Phytopathological Society, which in 1929 became the Canadian Phytopathological Society. The following list of publications is representative of advisory contributions of that period on diseases and pests of vegetable crops.

1868 **Bustin,** W. The potato disease. *J. Agric. Nova Scotia* 1:314-315.

1869 **Provancher, L.** Les pommes de terre et leur maladie; L'anthomye de l'ognon. *Nat. Can. (Que.)* 1:37-44; 155-157.

1872 **Beadle, D.W.** *Canadian Fruit, Flower, and Kitchen Garden.* James Campbell & Son, Toronto. 391 pp.

1891 **Fletcher, J.** Recommendations for the prevention of damage by some common insects of the farm, the orchard and the garden. Dorn. Can. Dep. Agric. Exp. Farms Bull. 11.

1891 **Fyles, T.W.** Kitchen-garden pests and how to deal with them. Pages 44-50 *in* 21st Annu. Rep. Entomol. Soc. Ont., 1891.

1892 **Shaw, T.,** and **C.A. Zavitz.** Weeds and modes of destroying them. Ont. Agric. Coll. Bull. 85.

1893 **Panton, J.H.** Remedies for common plant and insect foes. Ont. Agric. Coll. Bull. 87.

1895 **Craig,** J., and J. **Fletcher.** 1. Spraying for the prevention of fungous diseases; 2. Injurious insects; 3. Potato diseases [potato blights, potato scab]; 4. Black knot of the plum and cherry. Dorn. Can. Dep. Agric. Exp. Farms Bull. 23.

1904 **Harrison,** F.C., and **B. Barlow.** Some bacterial diseases of plants prevalent in Ontario. Ont. Agric. Coll. Bull. 136.

1905 **Fletcher, J.** Insects injurious to grain, fodder crops, root crops and vegetables. Dorn. Can. Dep. Agric. Exp. Farms Bull. 52.

1906 **Lochhead, W.,** and **T.D. Jarvis.** The common fungus and insect pests of growing vegetable crops. Ont. Agric. Coll. Bull. 150.

1907 **Harcourt, R.,** and **H.L. Fulmer.** Insecticides and fungicides. Ont. Agric. Coll. Bull. 154.

1909 **Bethune,** C.J.S. Insects affecting vegetables; and **Eastham,** J.W., and J.E. **Howitt.** Fungus diseases affecting vegetables. Ont. Agric. Coll. Bull. 171.

1909 **Giissow, H.T.** A serious potato disease occurring in Newfoundland. Dorn. Can. Dep. Agric. Exp. Farms, Div. Bot. Bull. 63.

1909 **Swaine,** J.M. Injurious insects of the Montreal area in 1908. Pages 17-23 in 1st Annu Rep. Que. Soc. Prot. Plants.

1912 **Hewitt, C.G.** Legislation in Canada to prevent the introduction and spread of insects, pests and diseases destructive to vegetation, with regulations regarding the importation of vegetation into Canada. Dorn. Can. Dep. Agric. Exp. Farms Div. Entomol. Bull., 2nd Ser. 11.

1913 **Gorham, R.P.** Insecticides and fungicides for orchards and garden crops. N.B. Dep. Agric. Bull. 2.

1914 **Fraser, W.P.** Storage rots of potatoes and other vegetables. Pages **50-51** in 6th Annu Rep. Que. Soc. Prot. Plants.

1914 **Eastham,** J.W. Powdery scab of potatoes. Dorn. Can. Dep. Agric. Exp. Farms Div. Bot. Farmers' Circ. 5.

1916 **Eastham,** J.W., and **M.H. Ruhmann.** Diseases and pests of cultivated plants; and **Hoy, B.** Sprays and spraying. B.C. Dep. Agric. Bull. 68.

1916 **Murphy, P.A.** The black leg disease of potatoes. Dorn. Can. Dep. Agric. Exp. Farms Div. Bot. Cire. 11.

1917 **Gibson, A.** Common garden insects and their control. Can. Dep. Agric. Entomol. Br. Circ. 9.

1917 **Jackson,** V.W. Potato diseases in Manitoba. Man. Agric. Coll. Ext. Bull. 14 (Part II).

1918 **Howitt, J.E.,** and **D.H. Jones.** The more important fungus and bacterial diseases of vegetables in Ontario. Ont. Agric. Coll. Bull. 258.

1918 **Maheux,** G. The protection of plants. Que. Dep. Agric. Bull. 42.

1918 **McCubbin, W.A.** The diseases of tomatoes. Dorn. Can. Dep. Agric. Exp. Farms Div. Bot. Bull., 2nd Ser. 35.

1920 **Dickson, B.T.** Diseases of the potato. Pages 67-103 *in* 14th Annu. Rep. Que. Soc. Prot. Plants.

1921 **Cutler, G.H.,** and **G.B. Sanford.** Potato diseases. Univ. Alberta Coll. Agric. Field Husb. Circ. 7.

1922 **Caesar, L.** The cabbage maggot. Ont. Agric. Coll. Bull. 289.

1922 **Gibson, A.,** and **W.A. Ross.** Insects affecting greenhouse plants. Dorn. Can. Dep. Agric. Bull., N.S. 7.

1923 **Treherne, R.C.** Root maggots and their control. Dorn. Can. Dep. Agric. Pamphlet, N.S. 32.

1924 **Vanterpool, T.C.** The stripe or streak disease of tomatoes in Quebec. Pages 116-123 *in* 16th Annu. Rep. Que. Soc. Prot. Plants.

1926 **Racicot, H.N.** A spotting and shrinking of potatoes in storage. Pages 55-56 *in* 18th Annu. Rep. Que. Soc. Prot. Plants.

1927 **Gingras, P.** La pyrale du maïs. *Rev. Inst. Agric. Oka* 1:228-230.

1928 **Baribeau, B.** Inspection et certification de la pomme de terre. *Rev. Inst. Agric. Oka* 2:2-7.

1929 **Howitt, J.E., D.R. Sands** and **D.H. Jones.** Fungus and bacterial diseases of vegetables. Ont. Agric. Coll. Bull. 345.

1929 **Hurst, R.R.** Studies in potato diseases. 1. Late blight and rot of potatoes caused by the fungus *Phytophthora infestans* (Mont.) de Bary. Dom. Can. Dep. Agric. Bull., N.S. 119.

1932 **Dustan, A.G.** Vegetable insects and their control. Dom. Can. Dep. Agric. Bull., N.S. 161.

Recognition also is extended to **J.C. Walker** for *Diseases of Vegetable Crops* (1952) and to **C. Chupp** and **A.F. Sherf** for *Vegetable Diseases and their Control* (1960), classic textbooks on vegetable diseases in North America; and to **I.L. Conners** for *An Annotated Index of Plant Diseases in Canada* (1967).

Diseases and Pests of Vegetable Crops in Canada

An Illustrated Compendium

Edited by Ronald J. Howard, J. Allan Garland and W. Lloyd Seaman

The Canadian Phytopathological Society

Entomological Society of Canada

Aussi disponible en français sous le titre

Maladies et ravageurs des cultures légumières au Canada

ISBN 0-9691627-4-X (relié), ISBN 0-9691627-5-8 (broché)

Canadian Cataloguing in Publication Data
Main entry under title:
Diseases and pests of vegetable crops in Canada: an illustrated compendium
Co-published by: Entomological Society of Canada.
Includes bibliographical references and index.
ISBN 0-9691627-3-1 (pbk.)-
ISBN 0-9691627-2-3 (bound)
1. Vegetables—Diseases and pests—Canada—Identification. 2. Vegetables—Diseases and pests—Control—Canada. 3. Vegetables—Diseases and pests— Canada—Pictorial works. I. Howard, R. J. (Ronald James), 1947-. II. Garland, J. A. (John Allan), 1942-. III. Seaman, W. L. (William Lloyd), 1934-. IV. Canadian Phytopathological Society. V. Entomological Society of Canada (1951-).

SB608.V4D48 1994 632'.0971 C94-900090-6

Front cover: Pepper fruits infected by tomato spotted wilt virus; photo by Leslie MacDonald.
Back cover: Striped cucumber beetle; photo by Lloyd Harris.
Design: Lloyd Seaman
Cover: Paul Mason
Color separations: Hadwen Imaging Technologies, Ottawa
Printing: M.O.M. Printing Ltd., Ottawa
Paper: Multifect Coated Gloss, 50/10 recycled, pH neutral

ISBN 0-9691627-2-3 (hard cover)
ISBN 0-9691627-3-1 (soft cover)

Printed in Canada

Contents

Foreword

This compendium is intended for producers, extension personnel, students, diagnosticians and others interested in the diseases and pests of vegetable crops grown in Canada. It is patterned after *Diseases of Field Crops in Canada*, a companion volume published by the Canadian Phytopathological Society in 1984 and revised in 1988. *Diseases and Pests of Vegetable Crops in Canada* represents the combined efforts of plant pathologists, entomologists and vegetable specialists employed in or recently retired from careers in research, extension, teaching and regulation with provincial and federal governments, universities and other agencies.

This book was seven years in preparation and it is the product of an entirely voluntary effort. The presidents of the CPS and ESC, on behalf of the members they represent, extend thanks and congratulations to the editors, to the many contributors of text and illustrations, to the numerous reviewers of the manuscript, and to all others who assisted in making this publication a reality. We hope that it fulfills a need for current information on vegetable crop protection and that it will encourage further collaboration between the two sponsoring societies and foster closer cooperation in research and extension work between their members and the vegetable industry in Canada.

The Canadian Phytopathological Society

Presidents 1986-1994

J.W. Martens

R. Hall

L.N. Chiykowski

V.J. Higgins

C. Hiruki

H. Harding

M. Caron

R.A.A. Morrall

CPS Steering Committee

R.J. Howard, Chair

W.R. Jarvis, Past-chair

R.F. Cerkauskas

L.V. Edgington

P.D. Hildebrand

M.R. McDonald

D.J. Ormrod

G.B. Ouellette

H.W. Platt

C. Richard

W.L. Seaman

L.M. Tartier

Entomological Society of Canada

Presidents 1986-1994

G.G.E. Scudder

E.C. Becker

D.C. Eidt

J.N. McNeil

J.E. Laing

R.A. Ring

P.W. Riegert

G.H. Gerber

ESC Steering Committee

J.A. Garland, Chair

G. Boivin

R.P. Jaques

L.S. Thompson

W.J. Tumock

R.S. Vernon

Acknowledgments

The Canadian Phytopathological Society and the Entomological Society of Canada express gratitude to the many individuals who helped in the production of this publication.

The editors thank Bill Jarvis, Agriculture Canada, Harrow, for originally chairing the CPS Steering Committee and for helpful advice throughout the project; Karen Chapman, Alberta Special Crops and Horticultural Research Center, Brooks, for secretarial assistance throughout the preparation of this book; Claire Lamoureux, Agriculture Canada, Ottawa, for the use of word-processing facilities; Karen Burns, Plant Research Centre, Agriculture Canada, Ottawa, for word processing; Constance Bowerman, Ottawa, for assistance with photo editing; Judy McCarthy and Jane Buckley, Agriculture Canada, Ottawa, for advice on layout and typography; Paul Mason, Chelsea, Quebec, for cover design; Ralph Estey, McGill University, for advice on the history of plant pathology; staff of the Crop Protection and Print Media Branches of Alberta Agriculture during the early stages of marketing and promotion of the book; and Howard Harding, Past President of CPS, for coordinating the budgeting and translation, ensuring liaison between the societies, and providing support and encouragement in bringing the project to completion. Special thanks are extended to Claude Richard, who directed translation of this book into French, for his effective collaboration in harmonizing the sequence of chapters in the English and French editions, and in achieving consistency and accuracy throughout the text.

A joint CPS/ESC Marketing Committee, initially chaired by Ieuan Evans (CPS), was co-chaired by Marilyn Dykstra (CPS) and Lloyd Dosdall (ESC) from 1991 to 1992, and since then by Marilyn Dykstra (CPS) and John Laing and Joe Shorthouse (ESC).

Institutions that made photographic material available for use in this book include the APS Press, St. Paul, Minnesota, USA (APS); Cornell University Press, Ithaca, New York, USA; Academic Press, Inc., Orlando, Florida, USA; the Alberta Special Crops and Horticultural Research Center (ASCHRC), Brooks, Alberta; the British Columbia Ministry of Agriculture, Fisheries and Food (BCMAFF), Surrey, British Columbia; the British Ministry of Agriculture, Fisheries and Food (BMAFF), United Kingdom; the Ontario Ministry of Agriculture and Food (OMAF), Guelph, Ontario; the Department of Environmental Biology, University of Guelph, Guelph, Ontario; le Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Service de phytotechnie (MAPAQ), Sainte- Foy, Québec; the Department of Plant Pathology, University of Wisconsin, Madison, Wisconsin, USA; IPM Education and Publications, University of California, Davis, California, USA; and the Communications Branch, Food Production and Inspection Branch, and Research Branch, Agriculture Canada, Ottawa, Ontario.

Individuals who authored or reviewed text or who provided photographs or other illustrations are credited below:

G.S. Abawi Department of Plant Pathology, Cornell University, Geneva, New York, USA 14456

W.R. Allen Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0

R.V. Anderson Agriculture Canada, Centre for Land and Biological Resources Research, Ottawa, Ontario KlA 0C6 (retired)

T.R. Anderson Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0

T.G. Atkinson Agriculture Canada, Research Station, 195 Dafoe Road, Winnipeg, Manitoba R3T 2M9 (retired)

E.Banks Ontario Ministry of Agriculture and Food, Muck Research Station, RR 1, Kettleby, Ontario L0G 1J0

S.J. Barkley Alberta Agriculture, Food and Rural Development, Alberta Special Crops and Horticultural Research Center, SS 4, Brooks, Alberta T1R 1E6

F.Bauduin 3313 Place Radisson, Sainte-Foy, Québec G1X 2K2

C.Beaulieu Département de Biologie, Université de Sherbrooke, Sherbrooke, Québec J1K 2R1

J.M. Beausoleil Gouvernement du Québec, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Service de phytotechnie, C.P. 480, 3300, rue Sicotte, Saint-Hyacinthe, Québec J2S 7B8

E.C. Becker Agriculture Canada, Centre for Land and Biological Resources Research, Ottawa, Ontario K1A 0C6 (retired)

D.L. Benoit Agriculture Canada, Station de recherches, 430, boul. Gouin, Saint-Jean-sur- Richelieu, Québec J3B 3E6

L.S. Bérard Agriculture Canada, Station de recherches, 430, boul. Gouin, Saint-Jean-sur- Richelieu, Québec J3B 3E6

G.C. Bergstrom Department of Plant Pathology, Cornell University, Ithaca, New York, USA 14853-5908

G.Boiteau Agriculture Canada, Research Station, P.O. Box 20280, Fredericton, New Brunswick E3B 4Z7

G. Boivin Agriculture Canada, Station de recherches, 430, boul. Gouin, Saint-Jean-sur- Richelieu, Québec J3B 3E6

A.T. Bolton Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6 (retired)

W.G. Bonn Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0

G.K. Bracken Agriculture Canada, Research Station, 195 Dafoe Road, Winnipeg, Manitoba R3T 2M9 (retired)

W.T. Bradnock Agriculture Canada, Animal and Plant Health, Plant Protection, Ottawa, Ontario KlA 0C6

R.A. Brammall Ontario Ministry of Agriculture and Food, Horticultural Experiment Station, P.O. Box 587, Simcoe, Ontario N3Y 4N5

A.B. Broadbent Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0

B.Brolley Ontario Ministry of Agriculture and Food, Centralia College of Agricultural Technology, Centralia, Ontario N0M 1Y0

A.J. Buonassisi British Columbia Ministry of Agriculture, Fisheries and Food, 17720-57th Avenue, Surrey, British Columbia V3S 4P9

W.P. Campbell Agriculture Canada, Animal and Plant Health, Plant Protection, Ottawa, Ontario K1A 0C6 (retired)

O. Carisse Agriculture Canada, Station de recherches, 430, boul. Gouin, Saint-Jean-sur-Richelieu, Québec J3B 3E6

R.F. Cerkauskas Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0

K.F. Chang Alberta Agriculture, Food and Rural Development, Alberta Tree Nursery and Horticulture Centre, RR 6, Edmonton, Alberta T5B 4K3

J.Chaput Ontario Ministry of Agriculture and Food, Muck Research Station, RR 1, Kettleby, Ontario L0G 1J0

H.H. Cheng Agriculture Canada, Research Station, P.O. Box 186, Delhi, Ontario N4B 2W9 (deceased)

L.N. Chiykowski Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6 (retired)

D.R. Christenson Department of Crop and Soil Sciences, Michigan State University, East Lansing, Michigan, USA 48824

R.M. Clear Grain Research Laboratory, Canadian Grain Commission, Winnipeg, Manitoba R3C 3G8

C.Cloutier Département de Biologie, Université Laval, Québec, Québec G1K 7P4

R.J. Copeman Department of Plant Science, University of British Columbia, Vancouver, British Columbia V6T 1Z4

M.P. Corlett Agriculture Canada, Centre for Land and Biological Resources Research, Biosystematics Research, Ottawa, Ontario K1A 0C6

R.A. Costello British Columbia Ministry of Agriculture, Fisheries and Food, 17720-57th Avenue, Surrey, British Columbia V3S 4P9

R.Crête Agriculture Canada, Station de recherches, 430, boul. Gouin, Saint-Jean-sur- Richelieu, Québec J3B 3E6 (retired)

L.M. Crozier Nova Scotia Department of Agriculture and Marketing, P.O. Box 550, Truro, Nova Scotia B2N 5E3

S.**H. DeBoer** Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2

T.L. DeHaan Agriculture Canada, Seed Potato Certification Laboratory, P.O. Box 1240, Charlottetown, Prince Edward Island C1A 7M8

R.W. Delbridge Nova Scotia Department of Agriculture and Marketing, Plant Industry Branch, Kentville Agricultural Centre, Kentville, Nova Scotia B4N 1J5

P.L. Dixon Agriculture Canada, Research Station, P.O. Box 7098, St. John's, Newfoundland A1E 3Y3

M.G. Dolinski Alberta Agriculture, Food and Rural Development, Soil and Crop Management Branch, 6909-116th Street, Edmonton, Alberta T6H 4P2

E.Drijfhout Institute for Horticultural Plant Breeding, Wageningen, The Netherlands

B.Drouin Gouvernement du Québec, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Service de phytotechnie, 2700, rue Einstein, Sainte-Foy, Québec G1P 3W8

B.A. Ebsary Agriculture Canada, Animal and Plant Health, Central Plant Health Laboratory, 3851 Fallowfield Road, Nepean, Ontario K2H 8P9

L.V. Edgington Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1 (deceased)

D.P. Elliott Applied Bio-nomics Ltd., P.O. Box 2637, Sidney, British Columbia V8L 4C1

C.R. Ellis Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

P.J. Ellis Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2

R. Esau Alberta Agriculture, Food and Rural Development, Alberta Special Crops and Horticultural Research Center, SS 4, Brooks, Alberta T1R 1E6

I.R. Evans Alberta Agriculture, Food and Rural Development, Soil and Crop Management Branch, 6909-1 16th Street, Edmonton, Alberta T6H 4P2

J.C. Fisher Ontario Ministry of Agriculture and Food, Plant Industry Branch, Harrow, Ontario N0R 2P0

A.R. Forbes Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2 (retired)

F.Fournier Groupe Biocontrôle, 430, boul. Gouin, Saint-Jean-sur-Richelieu, Québec J3B 3E6

S.Freyman Agriculture Canada, Research Station, P.O. Box 1000, Agassiz, British Columbia V0M 1A0

J.A. Frowd Agriculture Canada, Policy Branch, Ottawa, Ontario K1A 0C6

J.A. Garland c/o Entomological Society of Canada, 393 Winston Avenue, Ottawa, Ontario K2A 1Y8

L.F. Gates Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0 (retired)

M.M. Gaye British Columbia Ministry of Agriculture, Fisheries and Food, Cloverdale Soil Conservation Group, 17720-57th Avenue, Surrey, British Columbia V3S 4P9

H.S. Gerber British Columbia Ministry of Agriculture, Fisheries and Food, 17720-57th Avenue, Surrey, British Columbia V3S 4P9

L.A. Gilkeson British Columbia Environment, Lands and Parks, Pesticide Management Branch, 737 Courtney Street, Victoria, British Columbia V8V 1X5

D.R. Gillespie Agriculture Canada, Research Station, P.O. Box 1000, Agassiz, British Columbia V0M 1A0

D. Gindrat Station fédérale de recherches agronomiques de Changins, Route de Duillier, C.P. 254, CH-1260 Nyon, Switzerland

P.H. Goodwin Department of Environmental Biology, University of Guelph, Guelph, Ontario NIG 2W1

J.C. Guppy Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6 (retired)

D.J. Hagedorn Department of Plant Pathology, University of Wisconsin, Madison, Wisconsin, USA 53706 (retired)

R. Hall Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

A.S. Hamill Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0

K.G.A. Hamilton Agriculture Canada, Land and Biological Resources Research Centre, Biosystematics Research, Ottawa, Ontario K1A 0C6

M.C. Hampson Agriculture Canada, Research Station, P.O. Box 7098, St. John's, Newfoundland A1E 3Y3

D.G. Harcourt Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6 (retired)

L.Harris Saskatchewan Agriculture and Food, Soils and Crops Branch, 133-3085 Albert Street, Regina, Saskatchewan S4S 0B1

M.J. Herbut Alberta Environment, Alberta Environmental Centre, Postal Bag 4000, Vegreville, Alberta T9C 1T4

P.D. Hildebrand Agriculture Canada, Research Station, Kentville Agricultural Centre, Kentville, Nova Scotia B4N 1J5

C.Hiruki Department of Plant Science, University of Alberta, Edmonton, Alberta T6G 2P5

J.D. Holley Alberta Agriculture, Food and Rural Development, Alberta Special Crops and Horticultural Research Center, SS 4, Brooks, Alberta T1R 1E6

N.J. Holliday Department of Entomology, University of Manitoba, Winnipeg, Manitoba R3T 2N2

A.A. Hopper 3399 Paul Anka Drive, Unit 6, Ottawa, Ontario K1V 9R8

R.J. Howard Alberta Agriculture, Food and Rural Development, Alberta Special Crops and Horticultural Research Center, SS 4, Brooks, Alberta T1R 1E6

M. Hudon Agriculture Canada, Station de recherches, 430, boul. Gouin, Saint-Jean-sur- Richelieu, Québec J3B 3E6 (retired)

C.L. Hunter Ontario Ministry of Agriculture and Food, Agriculture and Food Laboratory Services Branch, 259 Grange Road, P.O. Box 1030, Guelph, Ontario N1H 6N1

S.F. Hwang Alberta Environment, Alberta Environmental Centre, Postal Bag 4000, Vegreville, Alberta T9C 1T4

J.A. Ivany Agriculture Canada, Research Station, P.O. Box 1210, Charlottetown, Prince Edward Island C1A 7M8

M.K. James British Columbia Ministry of Agriculture, Fisheries and Food, 17720-57th Avenue, Surrey, British Columbia V3S 4P9

R.P. Jaques Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0 (retired; Honorary Research Associate)

W.R. Jarvis Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0

D.A. Johnson Washington State University, IAREC, Rt. 2, P.O. Box 2953-A, Prosser, Washington, USA 99350

J.W. Jones Alberta Agriculture, Food and Rural Development, Soil and Crop Management Branch, Alberta Special Crops and Horticultural Research Center, SS 4, Brooks, Alberta T1R 1E6

G.J.R. Judd Agriculture Canada, Research Station, Summerland, British Columbia V0H 1Z0

F. Kaethler Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0

D.A. Kaminski Saskatchewan Agriculture and Food, Soils and Crops Branch, 133-3085 Albert Street, Regina, Saskatchewan S4S 0B1

L.M. Kawchuk Agriculture Canada, Research Station, P.O. Box 3000-Main, Lethbridge, Alberta T1J 4B1

W.E. Kayler Government of Newfoundland and Labrador, Department of Forestry and Agriculture, P.O. Box 640, Bishop's Falls, Newfoundland A0H 1C0

J.S. Kelleher Agriculture Canada, Centre for Land and Biological Resources Research, Biosystematics Research, Ottawa, Ontario K1A 0C6 (retired)

W.G. Kemp Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0 (retired)

E.A. Kerr Stokes Seeds Ltd., P.O. Box 10, St. Catharines, Ontario L2R 6R6

P.G. Kevan Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

F.A. Kiehn Agriculture Canada, Research Station, P.O. Box 3001, Morden, Manitoba R0G 1J0

J. Kimpinski Agriculture Canada, Research Station, P.O. Box 1210, Charlottetown, Prince Edward Island C1A 7M8

A.J. Kolach Manitoba Department of Agriculture, Soils and Crops Branch, P.O. Box 2000, Carman, Manitoba R0G 0J0

H.S. Krehm Agriculture Canada, Research Program Service, Ottawa, Ontario K1A 0C6 (retired)

A.C. Kushalappa Department of Plant Science, Macdonald College of McGill University, 21 111 Lakeshore Road, Sainte-Anne-de-Bellevue, Québec H9X 1C0

M.L. Lacey Department of Botany and Plant Pathology, Michigan State University, East Lansing, Michigan, USA 48824

J.E. Laing Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

R.J. Lamb Agriculture Canada, Research Station, 195 Dafoe Road, Winnipeg, Manitoba R3T 2M9

D.A. Lee Agricultural Consulting Research and Development, P.O. Box 158, Halkirk, Alberta T0C 1M0

J.R. Letal Alberta Agriculture, Food and Rural Development, Alberta Tree Nursery and Horticulture Centre, RR 6, Edmonton, Alberta T5B 4K3

K.P. Lim Forestry Canada, Newfoundland and Labrador Region, P.O. Box 6028, St. John's, Newfoundland A1C 5X8

A. Liptay Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0

C.C. Loan Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6 (retired)

F.J. Louws Department of Botany and Plant Pathology, Michigan State University, East Lansing, Michigan, USA 48824-1312

D.L. Lowery Ontario Ministry of Agriculture and Food, Plant Industry Branch, Harrow, Ontario N0R 2P0

R.N. Lucy Professional Ecological Services Ltd., 98B Burnside Road, Victoria, British Columbia V9A 1B5

K.Lynch New Brunswick Department of Agriculture, Plant Industry Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1

H.Lyon Department of Plant Pathology, Cornell University, Ithaca, New York, USA 14853

L.S. MacDonald British Columbia Ministry of Agriculture, Fisheries and Food, 17720-57th Avenue, Surrey, British Columbia V3S 4P9

J.R. Mackenzie Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2

I.A. MacLatchy Agriculture Canada, Animal and Plant Health, Pest Risk Assessment Unit, 3851 Fallowfield Road, Nepean, Ontario K2H 8P9

S.A. Marshall Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

P.M.D. Martin Agriculture Canada, Centre for Land and Biological Resources Research, Biosystematics Research, Ottawa, Ontario K1A 0C6

A.R. Maurer Agriculture Canada, Research Station, P.O. Box 1000, Agassiz, British Columbia V0M 1A0

D.C. Maurice Alberta Agriculture, Food and Rural Development, Soil and Crop Management Branch, 6909-116th Street, Edmonton, Alberta T6H 4P2

B.E. Mauza Western Greenhouse Growers' Cooperative Association, P.O. Box 1236, Station 'A', Surrey, British Columbia V3S 2B3

J.G. McDonald Agriculture Canada, Animal and Plant Health, Central Plant Health Laboratory, 3851 Fallowfield Road, Nepean, Ontario K2H 8P9

M.R. McDonald Ontario Ministry of Agriculture and Food, Muck Research Station, RR 1, Kettleby, Ontario L0G 1J0

F.L. McEwen Ontario College of Agriculture, University of Guelph, 103 Johnston Hall, Guelph, Ontario N1G 2W1 (retired)

C.D. McKeen Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0 (retired)

A.R. McKenzie Agriculture Canada, Animal and Plant Health, Central Plant Health Laboratory, 3851 Fallowfield Road, Nepean, Ontario K2H 8P9

D.G.R. McLeod Agriculture Canada, Research Centre, University Sub P.O., London, Ontario N6A 5B7

J.N. McNeil Département de Biologie, Université Laval, Sainte-Foy, Québec G1K 7P4

F. Meloche Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6

J.G. Menzies Agriculture Canada, Research Station, P.O. Box 1000, Agassiz, British Columbia V0M 1A0

J.D. Miller Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6

M. Mohyuddin Alberta Agriculture, Food and Rural Development, Alberta Tree Nursery and Horticulture Centre, RR 6, Edmonton, Alberta T5B 4K3

R.A.A. Morrall Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0

R.F. Morris Agriculture Canada, Research Station, P.O. Box 7098, St. John's, Newfoundland A1E 3Y3 (retired; Honorary Research Associate)

L.North Leaver Mushrooms, RR 2, Ellsworth Estates, Centreville, Nova Scotia B0P 1J0

V.W. Nuttall Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0 (deceased)

W.J. Odermatt British Columbia Ministry of Agriculture, Fisheries and Food, 17720-57th Avenue, Surrey, British Columbia V3S 4P9

T.H.A. Olthof Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0

D.J. Ormrod British Columbia Ministry of Agriculture, Fisheries and Food, 17720-57th Avenue, Surrey, British Columbia V3S 4P9

J. O'Sullivan Ontario Ministry of Agriculture and Food, Horticultural Experiment Station, Box 587, Simcoe, Ontario N3Y 4N5

B.Otrysko Gouvernement du Québec, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Station de recherche Les Buissons, C.P. 455, RR 1, Les Buissons, Québec G0H 1H0

M.Parr Gouvernement du Québec, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Service de phytotechnie, C.P. 480, 3300, rue Sicotte, Saint-Hyacinthe, Québec J2S 7B8

M. Parrot 236, boul. Valcartier, Loretteville, Québec G2A 2M7

Z.A. Patrick Department of Botany, University of Toronto, 25 Willcocks Street, Ontario M5S 3B2 (retired; Emeritus Professor)

T.C. Paulitz Department of Plant Science, Macdonald College of McGill University, 21 111 Lakeshore Road, Sainte-Anne-de-Bellevue, Québec H9X 1C0

Y.Pelletier Agriculture Canada, Research Station, P.O. Box 20280, Fredericton, New Brunswick E3B 4Z7

H.S. Pepin Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2 (retired)

S.Perley New Brunswick Department of Agriculture, Plant Industry, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1

P. Perrin Agriculture Canada, Research Branch, Ottawa, Ontario KlA 0C6

C.C.Peters Saskatchewan Agriculture and Food, 133-3085 Albert Street, Regina, Saskatchewan S4S 0B1

J.F. Peterson Department of Plant Science, Macdonald College of McGill University, 21 111 Lakeshore Road, Sainte-Anne-de-Bellevue, Québec H9X 1C0 (retired)

H.G. Philip British Columbia Ministry of Agriculture, Fisheries and Food, 1873 Spall Road, Kelowna, British Columbia V1Y 4R2

R.E. Pitblado Ontario Ministry of Agriculture and Food, Ridgetown College of Agricultural Technology, Ridgetown, Ontario N0P 2C0

R.G. Platford Manitoba Agriculture, Plant Pathology Laboratory, 201-545 University Crescent, Winnipeg, Manitoba R3T 5S6

H.W. Platt Agriculture Canada, Research Station, P.O. Box 1210, Charlottetown, Prince Edward Island C1A 7M8

J.W. Potter Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station. Ontario L0R 2E0

R.K. Prange Agriculture Canada, Research Station, Kentville Agricultural Centre, Kentville, Nova Scotia B4N 1J5

K.G. Proudfoot Agriculture Canada, Research Station, P.O. Box 7098, St. John's, Newfoundland A1E 3Y3 (retired)

R. Provvidenti Department of Plant Pathology, Cornell University, Geneva, New York, USA 14456

A.M. Pucat Agriculture Canada, Animal and Plant Health, Pest Risk Assessment Unit, 3851 Fallowfield Road, Nepean, Ontario K2H 8P9

Z.K. Punja Pest Management Centre, Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6

P.R. Ragan Alberta Agriculture, Food and Rural Development, Alberta Special Crops and Horticultural Research Center, SS 4, Brooks, Alberta T1R 1E6

J.E. Rahe Simon Fraser University, Department of Biological Sciences, Burnaby, British Columbia V5A 1S6

D.C. Read Agriculture Canada, Research Station, P.O. Box 1210, Charlottetown, Prince Edward Island C1A 7M8 (retired)

R.D. Reeleder Agriculture Canada, Research Station, P.O. Box 186, Delhi, Ontario N4B 2W9

L.Reid Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6

A.A. Reyes Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0

C.Richard Agriculture Canada, Station de recherches, 2560, boul. Hochelaga, Sainte- Foy, Québec G1V 2J3

D.L. Rinker Ontario Ministry of Agriculture and Food, Horticultural Research Institute, 4890 Victoria Avenue North, Vineland Station, Ontario L0R 2E0

C. Ritchot Gouvernement du Québec, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Service de recherche en phytotechnie, C.P. 480, 3300, rue Sicotte, Saint- Hyacinthe, Québec J2S 7B8 (retired)

W.E. Sackston Department of Plant Science, Macdonald College of McGill University, 21 111 Lakeshore Road, Sainte-Anne-de- Bellevue, Québec H9X 1C0 (retired; Emeritus Professor)

A.W. Saettler Department of Botany and Plant Pathology, Michigan State University, East Lansing, Michigan, USA 48824-1312 (deceased)

P. Sauriol Gouvernement du Québec, Ministère de l'Agriculture, de Pêcheries et de l'Alimentation, Bureau de renseignements agricoles, C.P. 367, 118, rue Lemieux, Saint- Rémi, Québec J0L 2L0

A.Schaafsma Ontario Ministry of Agriculture and Food, Ridgetown College of Agricultural Technology, Ridgetown, Ontario N0P 2C0

H.F. Schwartz Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, Colorado, USA 80523

W.L. Seaman Agriculture Canada, Plant Research Centre, Ottawa, Ontario K1A 0C6

M.K. Sears Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

V.I. Shattuck Department of Horticultural Science, University of Guelph, Guelph, Ontario N1G 2W1

B.R. Shaw Alberta Agriculture, Food & Rural Development, Field Services Division, Agriculture Centre, Postal Bag 3014, Lethbridge, Alberta T1J 4C7

J.W. Sheppard Agriculture Canada, Food Production and Inspection, Central Seed Laboratory, Ottawa, Ontario K1A 0C6

J.L. Shipp Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0

M.C. Shurtleff Department of Plant Pathology, University of Illinois, 1102 South Goodwin Avenue, Urbana, Illinois, USA 61801

R.P. Singh Agriculture Canada, Research Station, P.O. Box 20280, Fredericton, New Brunswick E3B 4Z7

C.B. Skotland Washington State University, IAREC, Rt. 2, P.O. Box 2953-A, Prosser, Washington, USA 99350 (retired)

J.J. Soroka Agriculture Canada, Research Station, 107 Science Place, Saskatoon, Saskatchewan S7N 0X2

R. Stace-Smith Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2 (retired)

M.F. Stapleton Newfoundland and Labrador Department of Forestry and Agriculture, P.O. Box 8700, St. John's, Newfoundland A1B 4J6

J.R. Stavely USDA, Department of Microbiology and Plant Pathology, Beltsville, Maryland, USA 20705

M.Y. Steiner Alberta Environment, Alberta Environmental Centre, Postal Bag 4000, Vegreville, Alberta T9C 1T4

C.T. Stephens Department of Botany and Plant Pathology, Michigan State University, East Lansing, Michigan, USA 48824

A.B. Stevenson Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0

J.G. Stewart Agriculture Canada, Research Station, P.O. Box 1210, Charlottetown, Prince Edward Island C1A 7M8

L.W. Stobbs Agriculture Canada, Research Station, P.O. Box 6000, Vineland Station, Ontario L0R 2E0

J.C. Sutton Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

M. E. Sweeney British Columbia Ministry of Agriculture, Fisheries and Food, 205-33780 Laurel Street, Abbotsford, British Columbia V2S 1X4

L.M. Tartier Gouvernement du Québec, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Service de phytotechnie, C.P. 480, 3300, rue Sicotte, Saint-Hyacinthe, Québec J2S 7B8

A.J. Tellier Alberta Agriculture, Food and Rural Development, Alberta Special Crops and Horticultural Research Center, SS 4, Brooks, Alberta T1R 1E6

D.Thomas Integrated Crop Management Inc., P.O. Box 164, Okanagan Centre, British Columbia V0H 1P0

C.N. Thompson Nova Scotia Department of Agriculture and Marketing, Kentville Agricultural Centre, Kentville, Nova Scotia B4N 1J5

L.S. Thompson Agriculture Canada, Research Station, P.O. Box 1210, Charlottetown, Prince Edward Island C1A 7M8 (retired)

B.Toms Nova Scotia Department of Agriculture and Marketing, Plant Industry Branch, P.O. Box 550, Truro, Nova Scotia B2N 5E3

J.C. Tu Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0

W.J. Turnock Agriculture Canada, Research Station, 195 Dafoe Road, Winnipeg, Manitoba R3T 2M9 (retired)

J. Uyenaka Ontario Ministry of Agriculture and Food, RR 1, Ancaster, Ontario L3Y 3K9

M.Valk Ontario Ministry of Agriculture and Food, Muck Research Station, RR 1, Kettleby, Ontario L0G 1J0 (retired)

T.C. Vanterpool Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0 (deceased)

R.S. Vernon Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2

V.R. Vickery Lyman Entomological Museum and Research Laboratory, Macdonald College of McGill University, 21111 Lakeshore Road, Sainte-Anne-de-Bellevue, Québec H9X 1C0 (retired; Honorary Curator)

V.R. Vockeroth Agriculture Canada, Centre for Land and Biological Resources Research, Biosystematics Research, Ottawa, Ontario KlA 0C6 (retired)

P. von Aderkas Department of Biology, University of Victoria, Victoria, British Columbia V8W 2Y2

T.C. Vrain Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2

H.L. Warren Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, Virgina, USA 24061

M.C. Watson Ontario Ministry of Agriculture and Food, Research Station, P.O. Box 186, Delhi, Ontario N4B 2W9

R.J. West Forestry Canada, Newfoundland and Labrador Region, P.O. Box 6028, St. John's, Newfoundland A1C 5X8

G.H. Whitfield Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0

A.T.S. Wilkinson Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2 (retired)

S.L. Wood Agriculture Canada, Food Production and Inspection, Plant Health Laboratory, P.O. Box 9472, Station B, St. John's, Newfoundland A1A 2Y4

N.S. Wright Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2 (retired)

P.J. Wuest Department of Plant Pathology, 210 Buckhout Laboratory, The Pennsylvania State University, University Park, Pennsylvania, USA 16802

R.T. Wukasch Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

B.F. Zilkey Agriculture Canada, Research Station, P.O. Box 186, Delhi, Ontario N4B 2W9

R.C. Zimmer Agriculture Canada, Research Station, P.O. Box 3001, Morden, Manitoba R0G 1J0 (retired)

T.A. Ziffer Department of Plant Pathology, Cornell University, Ithaca, New York, USA 14853-5908

Photo credits

Photographs and line drawings were kindly provided by many of the individuals identified in the preceding section. In the following list of credits, the photographer or artist has been identified wherever possible. However, the original source of many transparencies is unknown, in which case credit is attributed to the individual or institution from which the illustration was obtained.

Abawi, G.S.: 15B.4

Academic Press (G.N. Agrios): 5.7T1, 15B.7T1, 15B.9T1, 16.2T1, 16.5T1, 16.11T1,

Agriculture Canada: 3.7b, 3.7r, 3.11e, 5.14a, 5.17a, 5.17b, 5.17c, 6.25a, 6.25b, 7.22a, 7.22b, 8.40a, 8.40c, 8.40d, 8.41d, 8.41e, 8.41f, 8.41g, 8.47a, 8.47b, 8.47c, 12.13a, 12.13b, 12.13d, 12.16f, 12.16g, 12.16h, 12.22a, 16.40a, 16.40b, 16.41a, 16.41b, 16.42b, 16.42c, 16.49a, 16.49c, 16.49d, 18.37b, 18.37c, 18.42f, 18.42g

Agriculture Canada (B.W. Lukey): 3.7c, 3.11d, 4.10a, 4.10b, 4.10c, 7.21a, 9.22c, 11.27a, 11.27b, 11.27c, 12.17e, 14.7, 18.42a

Agriculture Canada (L. St-Jean): 5.15, 5.16, 5.17d, 13.25, 15A.15, 15B. 19b

Alberta Agriculture, Food and Rural Development: 2.3m

Alberta Special Crops and Horticultural Research Center: 3.12, 3.13, 4.2a, 4.8, 4.10d, 5.1, 6.2, 6.6b, 6.6c, 6.9a, 6.9d, 6.14, 6.15a, 6.15b, 6.17b, 6.18, 6.25c, 7.7c, 7.7e, 7.7f, 7.7g, 8.4c, 8.9, 8.13a, 8.21c, 8.23d, 8.28b, 8.41b, 8.41c, 9.1a, 9.1b, 9.7, 9.14a, 9.14c, 9.18a, 9.18c, 10.9a, 10.9c, 10.10c, 10.11a, 10.11b, 11.1a, 11.9f, 11.17b, 11.19c, 11.23b, 12.2a, 12.7b, 12.9a, 12.9b, 12.9c, 12.9d, 13.12d, 15A.la, 15A.lb, 15A.2g, 15A.3a, 15A.3b, 15A.3c, 15A.3d, 15A.3e, 15A.3f, 15A.4a, 15A.4c, 15A.9e, 15B.la, 15B.lb, 15B.ld, 15B.lg, 15B.li, 15B.3b, 15B.5a, 15B.5c, 15B.9a, 15B.11, 15B.12c, 15B.13a, 15B.13b, 15B.13d, 15B.13e, 15B.18, 16.Id, 16.2b, 16.3a, 16.4b, 16.5b, 16.5c (shallow scab), 16.8a, 16.8b, 16.11a, 16.12b, 16.15b, 16.17a, 16.17c, 16.18b, 16.18c, 16.20b, 16.22, 16.23, 16.24, 16.25a, 16.25b, 16.27a, 16.28a, 16.29a, 16.31, 16.34a, 16.34d, 16.34h, 16.34m, 16.34n, 16.43, 16.48a, 17.2a, 17.2b, 18.3a, 18.4a, 18.14c, 18.26a, 18.26b, 18.26c, 18.26d, 18.42h, 21.5a, 21.5b, 22.1, 22.7b, 22.7d, 22.9b, 22.10a, 22.10b, 22.10c, 22.10d, 22.11a, 22.11b, 22.11c, 22.11d, 22.12a, 22.12b, 22.15b, 22.15c, 22.15d, 22.17a, 22.17b, 22.18c, 22.20b, 22.24a, 22.25a, 22.26a, 22.26b, 22.26c, 22.26d, 22.26g, 22.28, 22.30a, 22.30b, 22.30c, 22.31a, 22.31b, 22.31c, 22.32a, 22.34a, 22.34b, 22.35a, 22.35b, 22.36b, 22.36c, 22.36d, 23.6a, 23.6b, 23.9, 23.10, 23.14, 23.16, 24.1, 24.12a, 24.14c, 25.1, 25.4a, 25.4b, 25.4c, 25.6a, 25.6b, 25.7, 25.9a, 25.10a, 25.11b, 25.11c, 25.12a, 25.12b, 25.12c, 25.16a, 25.19a, 25.19b, 25.21a, 25.21b, 25.21e, 25.23, 25.24a, 25.25a, 25.25e, 25.27a, 25.27g, 25.28c, 25.28b, 27.1a, 27.1b, 27.2 Allen, W.R.: 9.17a, 18.18a, 23.15, 24.8b, 25.22b, 25.22d

American Phytopathological Society: 5.6T1, 15A.10, 15A.2T1, 15B.7, 25.9b

Banks, E.: 13.12b, 13.12c, 13.12e

Hildebrand, P.D.: 8.3a, 8.3b, 8.8b, 8.10b, 8.10c, 8.10e, 8.13b, 8.13d, 8.13e, 8.14, 8.18, 8.22b, 13.5b

Hoes, J.A.: 21.2

Holliday, N.J.: 16.45a, 16.45c

Hopper, A.A.: 4.10e

Howard, R.J.: 6.1a, 6.1b, 6.5a, 6.5b, 6.17a, 6.17c, 6.19a, 6.19b, 6.20, 8.23c, 8.44d, 15A.3b, 15A.11a, 15A.11b, 15A.11c

Hudon, M.: 12.3a, 12.4, 12.13c, 12.14,12.16a, 12.16b, 12.16c, 12.22b

Hunter, C.L.: 20.4a

Hussey, N.W.: 22.36T1

Jaques, R.P.: 3.7w, 3.7x, 3.7y, 3.7z, 8.40b, 8.40e, 8.40f, 8.45b

Jarvis, W.R.: 7.6a, 9.2a, 9.2b, 11.9c, 11.9e, 11.16, 13.7b, 18.15a, 18.15b, 18.15c, 18.15d, 18.15e, 22.4a, 22.4b, 22.7c, 22.8a, 22.8b, 22.11e, 22.14a, 22.14b, 22.16, 22.18a, 22.18d, 22.19, 22.20a, 22.30d, 24.9,

25.3, 25.10b, 25.13a, 25.13b, 25.15, 25.21c, 25.25b, 25.25c, 25.25d, 25.26

Johnson, D.A.: 10.2, 10.7a, 10.7b, 10.9d

Judd, G.J.R.: 18.38a, 18.38b, 18.38c, 18.38d, 18.38e, 18.38f, 18.38g

Kaethler, F.: 7.21b, 7.21d

Kaminski, D.A.: 15A.2e

Kemp, W.G.: 8.5a, 10.15b, 13.13, 25.21d

Kiehn, F.A.: 21.1a, 21.1b

Kushalappa, A.C.: 6.9c

Lacey, M.L.: 4.6b

Laing, D.R.: 12.15b, 12.15c, 22.32c

Lamb, R.J.: 15A.14

Lemieux, C.: 2.3i, 2.3j, 2.3k

Letal, J.R.: 16.11c

Lim, K.P.: 16.49T2

Liptay, A.: 27.2T1

Louws, F.J.: 4.2b, 4.2d, 4.2e, 4.6T1, 8.11b, 18.14a

Lowery, D.T.: 8.12

Lyon, H.: 16.3b, 16.35, 16.36

MacDonald, L.S.: 7.1b, 7.6b, 7.12b, 8.1b, 10.5, 10.6b, 10.10b, 11.19b, 13.9a, 16.34f, 18.22b, 20.6, 20.9b, 22.24b, 22.25b, 24.2c, 24.5a, 24.5b, 24.8a, 24.8c, 25.5, 25.18a, 25.18b, 25.22a, 25.22c

Mauza, B.E.: 22.9a, 22.18b, 22.22, 25.8

McDonald, M.R.: 5.8a, 5.8b, 6.3, 6.8, 6.9b, 6.16, 7.3a, 7.8a, 7.8b, 11.7c, 11.8a, 13.8a, 13.8b, 13.11a, 13.15a, 13.15b, 13.15c, 13.17,13.19,13.20,13.21,18.1b

McKeen, C.D.: 9.3a, 9.3c, 9.6a, 9.6b, 11.5, 12.2b, 16.34e, 16.34i, 18.18d, 18.18e, 22.13,25.21c

Menzies, J.G.: 22.7a, 22.15T1, 25.10c, 25.10d

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (B. Drouin): 3.7a, 3.7e, 3.7f, 3.7g, 3.7i, 3.7k, 3.7n, 3.7p, 3.7v, 4.9, 5.17e, 7.21e, 8.39b, 8.42a, 8.42b, 8.42c, 8.42d, 8.42e, 8.42f, 8.45c, 8.45d, 8.45e, 8.45f, 10.15a, 11.23a, 12.12a, 12.12b, 12.12c, 12.15a, 12.17a, 12.17b, 12.17c, 12.21b, 13.7d, 13.10, 13.11c, 13.16, 13.26b, 13.26c, 13.26d, 15A.6,16.50,18.18c, 18.35c, 18.35d, 18.35e, 18.35f, 18.35g, 18.42b, 18.42c, 18.42d, 18.42e

Mohyuddin, M.: 22.26f

Morrall, R.A.A.: 11.9a, 15A.4b, 15A.5a, 15A.7, 18.8f, 18.8g, 22.15a, 25.1 la

Introduction

Diseases and Pests of Vegetable Crops in Canada is a practical guide to the diagnosis and management of the more important diseases and pests of vegetable crops grown in Canada. Pest management recommendations emphasize sustainable approaches to crop protection.

Part 1 Chapter 1 provides an overview of vegetable crops and their commercial importance in Canada. Chapter 2 includes a discussion of the effects of diseases and pests on vegetable production and a description of the major groups of causal agents and physiological factors that limit crop productivity or affect the quality of produce. Chapter 3 provides an outline of management strategies that will prevent crop losses or limit damage from diseases and pests to an acceptable level. This chapter also includes information on recommended cultural control practices, the availability of resistant cultivars, and the current status of monitoring techniques, biological controls, including parasites and predators, and the role of chemicals in management strategies. A special section on management by exclusion deals with pathogens and pests that are subject to import restrictions or quarantine regulations limiting or prohibiting the movement of seeds, plants and soil into or within Canada. Other major sections in Chapter 3 include discussions on the management of weeds and of nematode pests, and a special section on problems likely to be encountered in the home vegetable garden, where pest problems and management strategies often differ from those found in commercial production.

Parts 2 to 5 provide detailed descriptions of the most important diseases and pests that affect specific vegetable crops. For convenience, crops are grouped according to the method of production and are listed alphabetically within each group. The sequence of chapters and illustrations is the same in both the English and French editions of the book. This harmonization was achieved by the use of some unusual crop headings, such as Maize (sweet corn) [Mai's sucré] and Pea and bean [Pois et haricot]. Part 2, chapters 4 to 18, deals with disease and pest problems of the major field-grown vegetable crops. Part 3, chapters 19 to 21, includes plant species that are native to North America. The fiddlehead, or ostrich fern, is not cultivated in the normal sense; rather, it is collected from natural sites in eastern Canada. The Jerusalem artichoke, which is considered a weedy plant in some areas, is grown commercially on a very small scale as a vegetable and for other uses. Ginseng, although field-grown, is protected by lathing. Part 4, chapters 22 to 25, describes the disease and pest problems of the major greenhouse vegetable crops, including cucumber, lettuce, pepper and tomato. Vegetables grown in the greenhouse share many of the same disease and pest problems that are encountered on their counterparts in the field, but there also are important differences in epidemiology and management; in some cases, the reader will be referred to one or another section of the book for further information or for color illustrations. Part 5, chapters 26 and 27, deals with other protected crops, namely, the button mushroom and vegetable sprouts.

Disease and pest descriptions To aid in finding descriptions of diseases and pests and their color illustrations, which are grouped near the end of the book, the major text entries are numbered sequentially by chapter and section; the color illustrations appear in the same order and have the same number as the corresponding text. Halftones and line drawings in the text also are identified by section number and the letter T. For example, 4.6 is the section describing rust of asparagus and is also the figure number of the corresponding illustrations *(4.6a,b)* and text figure *(4.6T1).* Tables also are identified by the corresponding section number. The running head for a left-hand page includes the crop name and section number of the first entry beginning on that page; the running head for a right-hand page contains the section number of the last entry on that page.

The presentation of diseases and pests for each crop follows the same general order, beginning with diseases of bacterial, fungal, viral or physiological origin, followed by problems caused by nematodes, insects, other arthropods, and molluscs. Within these sections, diseases and pests are listed alphabetically by the most widely used common name. Included for some diseases and pests are alternative, often regional, names or names that are associated with distinctive symptoms, such as root rot, seedling blight or damping-off, all of which describe phases of the same disease.

The common name of a disease or pest is followed by the italicized scientific name or names of the causal organism and the name, usually abbreviated, of the taxonomic specialist who described the organism. Many fungi have distinct asexual (anamorph) and sexual (teleomorph) states, and each has a different scientific name. To add to the possible confusion, scientific names change from time to time as the result of research; therefore, synonyms or earlier names of organisms may be included for continuity and reference to earlier literature. Scientific names will be of interest chiefly to specialists but are essential in clearly identifying diseases and pests, which is a prerequisite to prescribing effective management practices.

The description of each disease or pest begins with an introduction to its importance and distribution in Canada, followed by a discussion of symptoms or damage that will assist in the diagnosis of the problem in the field or greenhouse. Sections headed Causal agent or Identification include detailed descriptions of causal organisms, including microscopic features and measurements of reproductive organs, or information on specialized media on which these organisms can be grown in the laboratory for identification. Because this type of information is of interest mainly to diagnosticians and other specialists, these sections are set in smaller type. Other sections describe the disease cycle or the life history of the pest, the epidemiology of the disease, or factors influencing epidemics and fluctuations in pest populations.

The Management section includes currently recommended strategies for limiting economic pest damage to vegetable crops; these include monitoring, cultural practices, resistant cultivars, biological control and chemical control. In this publication,

pesticides and resistant cultivars usually are discussed only in general terms because specific recommendations should be based on local conditions and current information.

Many descriptions include selected references to scientific articles and books containing more detailed information on diagnosis, epidemiology or management that will be of special interest to disease and pest specialists. Guides to further reading are found in additional references at the end of the crop chapters and in the Bibliography.

Each disease or pest description is followed by the name of the contributing author(s). In many cases, the original description has been modified following review and editing.

Color photographs For many users of the book, the color illustrations will provide the initial clues to diagnosing a problem. Illustrations include symptoms of most of the major infectious diseases and disorders described in the text, as well as many of the arthropod (insects and mites), nematode and mollusc pests of each of the crops. To aid in searching for the appropriate descriptive text for a disease or pest, the color illustrations are arranged by crop in the same sequence as in the text chapters, and the figure number for each illustration is the same as the section number of the corresponding text. Multiple illustrations of a disease or pest are identified by letters appended to the number; for example, the figure numbers of the two illustrations of downy mildew of beet are *5.4a* and *5.4b.*

Sources of information In addition to the references specific to pest sections and crop chapters, a list of general references for further reading is included in the Bibliography. Most of the technical terms used in the text are explained in the Glossary.

Advice Vegetable growers are encouraged to consult qualified extension specialists or crop consultants for advice on management strategies appropriate to a given crop and location. In most areas of Canada, expert advice is available at provincial diagnostic clinics and extension offices, at Agriculture Canada research stations, and at some universities and privately operated pest clinics. A guide to the location of such clinics or sources of advice may be found in the Appendix.

Collecting and submitting specimens for diagnosis For many diseases and pests, accurate diagnosis or identification will require microscopic examination of affected tissues for signs of a causal agent. In some cases, the isolation and characterization of a pathogen requires specialized techniques or resources found in diagnostic laboratories.

Plants or pests collected for diagnosis must be as complete and as fresh as possible. It is best to collect several specimens that show the various stages of a problem. Where possible, whole plants should be submitted. To keep root systems intact, plants should be dug rather than pulled from the soil. Soil samples should be submitted along with plants if a soil-borne insect or nematode problem is suspected. To avoid deterioration during shipment, foliage should be free of soil and excessive moisture. It is also important that plants not be mailed in plastic bags as this will hasten spoilage. Intact plants often may be shipped successfully in a cardboard container if a small amount of moist soil is retained around the roots and the root ball is enclosed in plastic wrap or a snuggly fitted plastic bag tied off around the stem to prevent soil from escaping.

Hard-shelled insects should be placed in cotton wool or another soft material, placed in a sturdy vial, then securely packed in a cardboard mailing container. Dead insects are very fragile and shatter easily, making identification almost impossible. Mites and insects, especially caterpillars and grubs, should be collected live because they often must be reared through to the adult stage before an accurate identification can be made. Such specimens should be provided with adequate food, usually host material, to minimize mortality during shipment.

As much information as possible should be provided with specimens to aid the specialist in making an accurate diagnosis and in recommending appropriate control measures. This should include such details as host and cultivar names, habitat, cropping practices, type and extent of damage, and recent history of weather conditions and crop rotation.

Inquiries about this book General inquiries or comments about *Diseases and Pests of Vegetable Crops in Canada* should be addressed to the editors. We would appreciate receiving constructive criticism of the contents and would welcome new or additional information and photographs that could be used to improve a subsequent edition.

This book is also available in French under the title *Maladies et Ravageurs des Cultures Légumières au Canada.*

Ronald J. Howard J. Allan Garland W. Lloyd Seaman