Agriculture Canada

# RESEARCH BRANCH REPORT

1982

# RAPPORT DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE



Canada

# Research Branch Report

1982

# Rapport de la Direction générale de la recherche

RESEARCH BRANCH
DIRECTION GÉNÉRALE DE LA RECHERCHE

AGRICULTURE CANADA

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Dr. E. J. LeRoux

Dr. J. W. Morrison

Dr. R. L. Halstead

Dr. E. E. Lister

Mr. J.-J. Jasmin

Dr. J. J. Cartier

Dr. J. E. Andrews

Dr. T. H. Anstey

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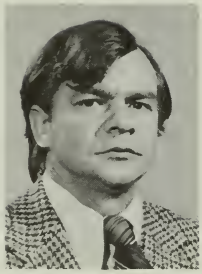
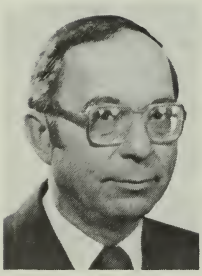


Dr. R. Bouchard



Dr. W. J. Saidak

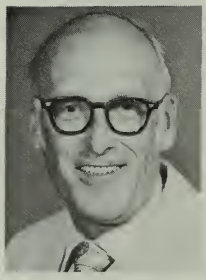
Dr. R. R. Riel

Dr. W. Baier

Dr. C. J. Bishop

Mr. R. M. Prentice

Mr. J. Nowland



Dr. J. R. Aitken

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***Directeur général***

R. L. Halstead, B.S.A., Ph.D.

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| | |
|---|---|
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| Crops/*Cultures* | W. J. Saidak, B.S.A., M.S., Ph.D. |
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| Protection/*Protection* | R. M. Prentice, B.Sc., M.Sc. |
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|---|---|
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| Crops/*Cultures* | L. Dessureaux, B.A., B.Sc., M.S., Ph.D. |
| Crops/*Cultures* | J. Mulders, Ing.B.S.A. |
| Production/*Production* | B. R. Baum, M.Sc., Ph.D. |
| Program Analysis/*Analyse du programme* | S. Thomson, B.Sc., Ph.D., M.A. |
| Protection/*Protection* | C. Madhosingh, D.I.C.T.A., B.S.A., M.S.A., Ph.D. |

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*Détaché de la Direction générale des finances et de l'administration.*

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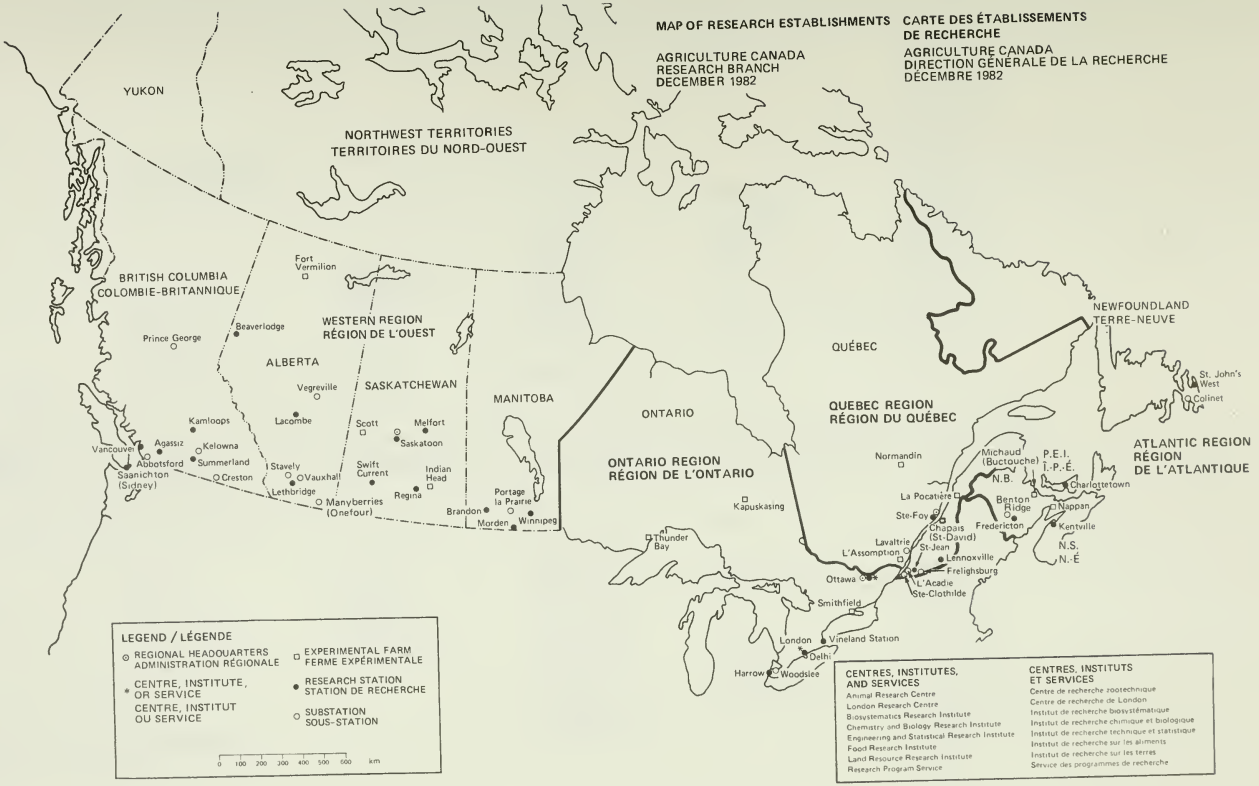
***Planification financière***
A. L. Dignard
*Seconded from Finance and Administration Branch*
*Détaché de la Direction générale des finances et de l'administration.*

**Financial analysis**
***Analyse financière***
Vacant

**Financial planning and analysis (Institutes and Ontario)**
***Planification et analyse financières (Instituts et Ontario)***
J. B. Moran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RESEARCH BRANCH
DECEMBER 1982
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DIRECTION GÉNÉRALE DE LA RECHERCHE
DÉCEMBRE 1982
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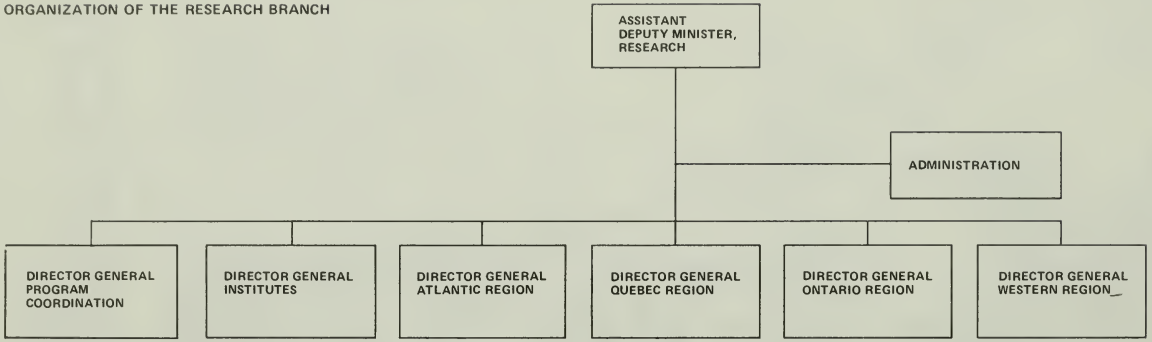
TERRITOIRES DU NORD-OUEST
BRITISH COLUMBIA
COLOMBIE-BRITANNIQUE
WESTERN REGION
RÉGION DE L'OUEST
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
ONTARIO REGION
RÉGION DE L'ONTARIO
QUÉBEC
QUEBEC REGION
RÉGION DU QUÉBEC
NEWFOUNDLAND
TERRE-NEUVE
ATLANTIC REGION
RÉGION DE L'ATLANTIQUE
Fort Vermilion
Beaverlodge
Prince George
Vegreville
Lacombe
Scott
Saskatoon
Melfort
Kamloops
Agassiz
Kelowna
Vancouver
Abbotsford
Summerland
Saanichton (Sidney)
Creston
Stavely
Vauxhall
Lethbridge
Swift Current
Indian Head
Regina
Manyberries (Onefour)
Brandon
Portage la Prairie
Morden
Winnipeg
Thunder Bay
Kapuskasing
Ottawa
Smithfield
London
Vineland Station
Delhi
Harrow
Woodslee
Normandin
Michaud (Buctouche)
N.B.
P.E.I. I.-P.-É.
Charlottetown
La Pocatière
Benton Ridge
Nappan
Ste-Foy
Chapais (St-David)
Fredericton
Kentville
N.S. N.-É.
Lavaltrie
L'Assomption
St-Jean
Lennoxville
Frelighsburg
L'Acadie
Ste-Clothilde
St. John's West
Colinet
LEGEND / LÉGENDE
REGIONAL HEADQUARTERS ADMINISTRATION RÉGIONALE
CENTRE, INSTITUTE, OR SERVICE
CENTRE, INSTITUT OU SERVICE
EXPERIMENTAL FARM FERME EXPÉRIMENTALE
RESEARCH STATION STATION DE RECHERCHE
SUBSTATION SOUS-STATION
0 100 200 300 400 500 600 km
CENTRES, INSTITUTES, AND SERVICES
Animal Research Centre
London Research Centre
Biosystematics Research Institute
Chemistry and Biology Research Institute
Engineering and Statistical Research Institute
Food Research Institute
Land Resource Research Institute
Research Program Service
CENTRES, INSTITUTS ET SERVICES
Centre de recherche zootechnique
Centre de recherche de London
Institut de recherche biosystématique
Institut de recherche chimique et biologique
Institut de recherche technique et statistique
Institut de recherche sur les aliments
Institut de recherche sur les terres
Service des programmes de recherche

## ORGANIZATION OF THE RESEARCH BRANCH




**Research Coordinators**

**Analysts**

**Advisers**

**Research Institutes**

Biosystematics
Chemistry and Biology
Engineering and Statistical
Food
Land Resource

Research Program Service

**Research Stations**

St. John's West, Nfld.
Colinet, Nfld.
Charlottetown, P.E.I.
Kentville, N.S.
Nappan, N.S.
Fredericton, N.B.
Benton Ridge, N.B.
Senator Hervé J. Michaud (Buctouche), N.B.

**Research Stations**

Lennoxville, Que.
Sainte-Foy, Que.
La Pocatière, Que.
Normandin, Que.
Chapais (Saint-David), Que.
Saint-Jean, Que.
Frelighsburg, Que.
L'Acadie, Que.
L'Assomption, Que.
Lavaltrie, Que.
Sainte-Clothilde, Que.

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London, Ont.

**Research Stations**

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Harrow, Ont.
Woodslee, Ont.
Ottawa, Ont.
Kapuskasing, Ont.
Thunder Bay, Ont.
Vineland Station, Ont.
Smithfield, Ont.

**Research Stations**

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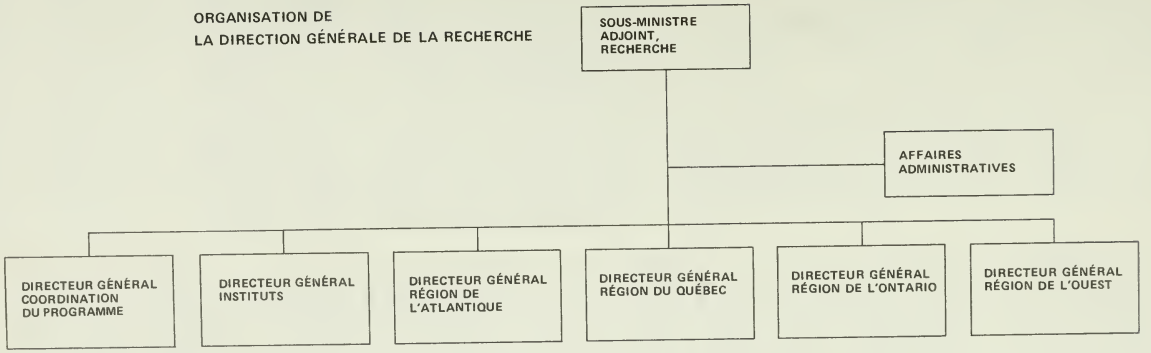
Morden, Man.
Portage la Prairie, Man.
Winnipeg, Man.
Melfort, Sask.
Regina, Sask.
Indian Head, Sask.
Saskatoon, Sask.
Scott, Sask.
Swift Current, Sask.
Beaverlodge, Alta.
Fort Vermilion, Alta.
Lacombe, Alta
Végreville, Alta.
Lethbridge, Alta.
Onefour (Manyberries), Alta.
Stavely, Alta.
Vauxhall, Alta.
Agassiz, B.C.
Abbotsford, B.C.
Kamloops, B.C.
Prince George, B.C.
Saanichton Research and Plant Quarantine Station, B.C.
Summerland, B.C.
Creston, B.C.
Kelowna, B.C.
Vancouver, B.C.

December 1982

## ORGANISATION DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE




**Coordonnateurs de la recherche**

**Analystes**

**Conseillers**

**Instituts de recherches**

Aliments
Biosystématique
Chimie et biologie
Technique et statistique
Terres

Service des programmes de recherche

**Stations de recherche**

Saint-Jean (T.-N.)
  Colinet (T.-N.)
Charlottetown (Î.-P.-É.)
Kentville (N.-É.)
  Nappan (N.-É.)
Fredericton (N.-B.)
  Benton Ridge (N.-B.)
  Senateur Hervé J. Michaud (Buctouche), N.-B.

**Stations de recherche**

Lennoxville (Québec)
Sainte-Foy (Québec)
  La Pocatière (Québec)
  Normandin (Québec)
  Chapais (Saint-David) (Québec)
Saint-Jean (Québec)
  Frelighsburg (Québec)
  L'Acadie (Québec)
  L'Assomption (Québec)
  Lavaltrie (Québec)
  Sainte-Clothilde (Québec)

**Centres de recherche**

London (Ont.)
Zootechnie (Ottawa)(Ont.)

**Stations de recherche**

Delhi (Ont.)
Harrow (Ont.)
  Woodslee (Ont.)
Ottawa (Ont.)
  Kapuskasing (Ont.)
  Thunder Bay (Ont.)
Vineland Station (Ont.)
  Smithfield (Ont.)

**Stations de recherche**

Brandon (Man.)
Morden (Man.)
  Portage-la-Prairie (Man.)
Winnipeg (Man.)
Melfort (Sask.)
Regina (Sask.)
  Indian Head (Sask.)
Saskatoon (Sask.)
  Scott (Sask.)
Swift Current (Sask.)
Beaverlodge (Alb.)
  Fort Vermilion (Alb.)
Lacombe (Alb.)
  Végreville (Alb.)
Lethbridge (Alb.)
  Onefour (Manyberries) (Alb.)
  Stavely (Alb.)
  Vauxhall (Alb.)
Agassiz (C.-B.)
  Abbotsford (C.-B.)
Kamloops (C.-B.)
  Prince George (C.-B.)
Station de recherche et de quarantaine des plantes de Saanichton (Sidney) (C.-B.)
Summerland (C.-B.)
  Creston (C.-B.)
  Kelowna (C.-B.)
Vancouver (C.-B.)

décembre 1982

# FOREWORD

During 1982, the regions and institutes of the Branch effectively contributed to scientific and technical knowledge pertinent to the agricultural industry through their basic and mission-oriented research activities. Results were reported in some 1300 scientific and 900 miscellaneous papers. This information was transferred to producers and food processors by personnel of the research establishments of the Branch through provincial extension services, publications, seminars, committees, and direct contacts with farmers. Specific accomplishments this year included the production of 106 soil survey maps in cooperation with the provinces, the development of 41 varieties for licensing or release, and the publication of a world-leading textbook on canola. These visible achievements, many of which are the result of several years of research, have had a direct impact on agricultural production efficiency.

In 1982, the Research Branch had a budget of $177 million and a staff of 3647, of which 907 were professionals. The Branch also administered a $9.2 million contract program, directed primarily to the high-priority items of energy, food processing, and mechanization. The contract program for energy, at $6 million, was the largest one, after having received an increase of $2 million during the year.

Our programs are developed in response to the needs of the agri-food industry, as determined by consultation at several levels. The Agri-Food Strategy and the Deputy Minister's Priority Memorandum are the primary documents in which Branch programs are broadly defined. Annual work plans and long-term plans then form the basis for operational control, allocation of financial resources, human resources planning, and management commitments.

The development of new technology through research is essential for the success of the Agri-Food Strategy in the 1980s and 1990s. The increased production needed to meet the challenges of this Strategy can only be achieved if emphasis is given to both mission-oriented and basic research.

To ensure this success, focus is being given to the following mission-oriented programs: research in food processing; research in utilization, productivity, and quality of the land resource base; expanded research in crop and animal production, focusing on the application of new techniques for increasing the productive efficiency of Canadian farms.

To support mission-oriented programs, a continuing effort will be exerted in such high-priority basic areas as biotechnology. Biotechnological research includes assessing the use of biological control in integrated pest management, developing cereal varieties with nitrogen-fixing ability to reduce the requirements for nitrogen fertilizers, and assessing the use of bacteria in food processing. New techniques derived from biotechnological research will significantly improve the efficiency of crop production, in that these methods are energy-saving, economical, and environmentally clean.

The Branch liaised with and supported other branches of the Department in areas such as policy review; strategic planning, including the development of a new program activity structure; the western railway transportation initiatives; and programs dealing with regulation of such items as Casabello grapes, blue mold in tobacco, potato ring rot, and mycotoxins. Activities of the development committees and liaison committees of Agriculture Canada have resulted in defining federal agricultural development strategies in the provinces concerned. Extensive interdepartmental discussions have led to the development of national strategies or policy papers in the following areas: biotechnology, in collaboration with the National Research Council of Canada; crop information systems, with Energy, Mines, and Resources Canada and the Atmospheric Environment Service of Environment Canada; land resources, with Energy, Mines, and Resources Canada and Environment Canada; and pesticides and mycotoxins, with Health and Welfare Canada.

International research and development activities of the Branch increased significantly. Staff members contributed to the departmental and governmental international activities under five memorandums of understanding, eight science and technology agreements, and seven other agreements. The Branch has assumed responsibility for the management of six research and development projects funded by the Canadian International Development Agency. After the first session of the Mixed Canada–USSR Commission on Agricultural Cooperation, the Minister of Agriculture for the USSR, with Mr. Whelan, visited several research establishments. The Assistant Deputy Minister, Research, for Agriculture Canada led an interbranch delegation to Romania for the first meeting of the Canada–Romania Joint Committee on Agricultural Cooperation. This meeting resulted in subsequent Canadian missions to Romania in 1982 on horticulture and marketing.

E. J. LeRoux

# AVANT-PROPOS

Au cours de 1982, les régions et les instituts de la Direction générale ont contribué efficacement à accroître les connaissances scientifiques et techniques relatives au secteur agricole dans le cadre de programmes de recherches fondamentales et thématiques. Les résultats ont paru dans quelque 1300 publications scientifiques et 900 documents divers. Le personnel des établissements de recherche de la Direction générale a transmis ces connaissances aux producteurs et aux transformateurs des aliments par l'entremise des services provinciaux de vulgarisation, de publications, de conférences, de comités et en communiquant directement avec les agriculteurs. Parmi les réalisations particulières de cette année, on peut citer la production de 106 cartes pédologiques en coopération avec les provinces, la création de 41 variétés destinées à l'homologation ou à la diffusion et la publication d'un manuel de premier plan sur le colza canola. Ces réalisations concrètes, dont plusieurs sont le fruit de nombreuses années de recherche, ont eu des répercussions directes sur l'efficacité de la production agricole.

En 1982, la Direction générale de la recherche disposait d'un budget de 177 millions de dollars et d'un personnel de 3647 employés, dont 907 professionnels. La Direction générale a aussi administré un programme contractuel de 9,2 millions de dollars consacré aux questions hautement prioritaires de l'énergie, de la transformation des aliments et de l'automatisation. Le programme contractuel sur l'énergie, le plus important, a utilisé 6 millions de dollars y inclus les 2 millions de dollars qu'on lui a alloués au cours de l'année.

Nos programmes sont conçus pour répondre aux besoins du secteur agro-alimentaire tels que déterminés après consultation à plusieurs niveaux. La Stratégie agro-alimentaire et la Note de service du Sous-ministre sur les priorités constituent les principaux documents dans lesquels sont définis grosso modo les programmes de la Direction générale. Les plans de travail annuels et les plans à long terme constituent la base du contrôle opérationnel, de l'allocation des ressources financières, de la planification des ressources humaines et des engagements administratifs.

Le développement d'une nouvelle technologie par la recherche est essentiel au succès de la Stratégie agro-alimentaire dans les années 80 et 90. Le raffermissement de la production nécessaire pour relever le défi de cette stratégie ne peut être atteint que par des recherches fondamentales et thématiques.

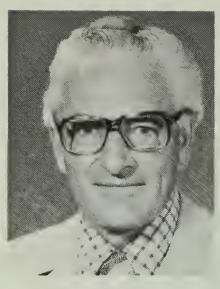
Pour atteindre ces objectifs, on a mis l'accent sur les programmes de recherches thématiques suivants: transformation des aliments; utilisation, productivité et qualité des ressources des terres; accroissement de l'efficacité de la production animale et végétale à la ferme, grâce à l'application de nouvelles techniques.

Pour appuyer les programmes de recherches thématiques, des efforts soutenus porteront sur des secteurs fondamentaux hautement prioritaires comme la biotechnologie. Les recherches en biotechnologie comprennent l'évaluation de l'utilisation de la lutte biologique intégrée contre les ravageurs, la création de variétés de céréales capables de fixer l'azote pour réduire les besoins en engrais azotés et l'évaluation de l'utilisation de bactéries pour la transformation des aliments. De nouvelles techniques dérivées de la recherche en biotechnologie amélioreront de façon significative l'efficacité des productions végétales, car ces méthodes sont économiques en terme d'énergie et non polluantes.

La Direction générale a collaboré et appuyé d'autres directions générales du Ministère dans des domaines comme la révision des politiques; la planification stratégique y compris la création de nouvelles structures d'activités des programmes; les activités relatives au transport ferroviaire dans l'Ouest; les programmes de réglementation de certains produits comme les raisins Casabello, la moisissure bleue du tabac, la flétrissure bactérienne de la pomme de terre et les mycotoxines. Les activités des comités de développement et des comités de liaison d'Agriculture Canada ont permis de définir les stratégies fédérales de développement agricole dans les provinces concernées. Des discussions interministérielles exhaustives ont conduit à la création de stratégies nationales ou à la rédaction de documents sur les politiques dans les secteurs suivants: biotechnologie, en collaboration avec le Conseil national de recherches du Canada; les systèmes d'information sur les cultures, avec Énergie, Mines et Ressources Canada et le Service de l'environnement atmosphérique d'Environnement Canada; les ressources des terres, avec les deux mêmes ministères; les pesticides et les mycotoxines, avec Santé et Bien-être social Canada. Les activités internationales de développement et de recherche de la Direction générale ont augmenté de façon significative. Les membres du personnel ont contribué aux activités internationales du Ministère et du gouvernement dans le cadre de cinq protocoles d'entente, de huit accords scientifiques et technologiques, et de sept autres ententes. La Direction générale a assumé la responsabilité de la gestion de six projets de recherche et de développement financés par l'Agence canadienne de développement international. Après la première session de la Commission mixte Canada-U.R.S.S. sur la coopération en agriculture, le ministre de l'Agriculture de l'U.R.S.S. a visité plusieurs établissements de recherche en compagnie de M. Whelan. Le sous-ministre adjoint à la Recherche pour Agriculture Canada a dirigé une délégation inter-directions générales en Roumanie pour la première réunion du Comité conjoint Canada-Roumanie sur la coopération en agriculture. Cette rencontre a donné lieu, en 1982, à d'autres visites de Canadiens en Roumanie portant sur l'horticulture et la commercialisation.

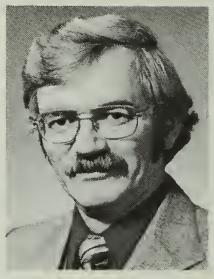
E.J. LeRoux

# INSTITUTES DIRECTORATE
# DIRECTION DES INSTITUTS



Dr. J. W. Morrison

Mrs. E. Larmond



Mr. D. G. Proctor

## EXECUTIVE OF THE INSTITUTES DIRECTORATE
## *L'EXÉCUTIF DE LA DIRECTION DES INSTITUTS*

**Director General**
***Directeur général***
J. W. Morrison, B.Sc., M.Sc., Ph.D.

**Program Specialist**
***Spécialiste en programmes***
E. Larmond, B.Sc.

**Acting Chief, Administration**
***Chef intérimaire, administration***
D. G. Proctor

# PREFACE

The Institutes Directorate, located at the Central Experimental Farm in Ottawa, consists of Biosystematics Research Institute, Chemistry and Biology Research Institute, Engineering and Statistical Research Institute, Food Research Institute, Land Resource Research Institute, and Research Program Service. By long-standing tradition, the institutes in Ottawa have combined active research on national programs with service to regional stations or to the public in specialized areas of their research. In 1982 the institutes' programs were conducted by a staff of 593 with a budget of $27.4 million.

A primary responsibility of the Biosystematics Research Institute is to conduct research on the biosystematics of insects, vascular plants, and fungi of importance to Canada and Canadian agriculture. An essential function of the Institute is to ensure adequate maintenance, planned growth, and effective utilization of the collections in its care. An identification service is a direct extension of the Institute's programs.

The Chemistry and Biology Research Institute carries out research in specialized areas such as nitrogen fixation, mycotoxins, environmental quality, plant pathology, stress physiology, soil management, and conservation. It also provides analytical chemistry and electron microscopy services to other Branch establishments.

The Engineering and Statistical Research Institute provides the Research Branch with a center of expertise where engineers and statisticians carry out research and analyses to improve the agriculture and food production system and to support research by other disciplines. Energy concerns are addressed through a combination of in-house and contract research under the auspices of the national energy program.

The Food Research Institute conducts multidisciplinary basic and applied research in three program areas in response to nationally recognized concerns and priorities: food processing technology, food ingredient and new product development, and food safety and nutrition.

The major function of the Land Resource Research Institute is to provide national leadership in preparing an inventory of Canada's land resources and in developing systems for interpreting land information for agriculture and other uses. National programs supported by research are maintained on soil mapping, soil classification, land evaluation, and crop–weather systems.

Research Program Service provides a variety of specialized services on a national basis to Research Branch establishments and in support of Canadian agricultural research at the university, provincial, and federal levels.

Dr. Robert Trottier, Director of Research Program Service, began a secondment to the Department of External Affairs. He is serving as scientific attaché in Brussels. Dr. J.C. St-Pierre is replacing him at Research Program Service.

Further information about our programs may be obtained by writing to the Research establishments concerned or by addressing inquiries to Institutes, Research Branch, Agriculture Canada, Room 2077, K. W. Neatby Building, Ottawa, Ont. K1A 0C6.

J. W. Morrison

# PRÉFACE

La Direction des instituts, située à la Ferme expérimentale centrale à Ottawa, comprend l'Institut de recherche biosystématique, l'Institut de recherche chimique et biologique, l'Institut de recherche technique et de statistique, l'Institut de recherche sur les aliments, l'Institut de recherche sur les terres et le Service aux programmes de recherche. Depuis toujours, les instituts ont assuré la recherche active dans le cadre de programmes nationaux et les services spécialisés aux stations régionales ou au public. En 1982, l'exécution des programmes des instituts a été effectuée par un personnel de 593 membres qui disposait d'un budget de 27,4 millions de dollars.

La responsabilité première de l'Institut de recherche biosystématique réside dans les travaux sur la biosystématique des principaux insectes, des plantes vasculaires et des champignons d'importance au Canada et pour l'agriculture canadienne. L'une des fonctions essentielles de l'Institut est d'assurer la cueillette planifiée de spécimens ainsi que l'entretien et l'usage efficace des collections dont il a la garde. Un service d'identification a été mis sur pied en prolongement des programmes.

L'Institut de recherche chimique et biologique s'oriente vers des domaines spécialisés comme la fixation de l'azote, les mycotoxines, la qualité de l'environnement, la phytopathologie, la physiologie du stress ainsi que la gestion et la conservation du sol. L'Institut fournit également des services de chimie analytique et de microscopie électronique aux autres établissements de la Direction générale.

L'Institut de recherche technique et de statistique met à la disposition de la Direction générale de la recherche un centre d'expertise où les ingénieurs et les statisticiens effectuent des travaux et des analyses pour améliorer le système agro-alimentaire et appuyer la recherche dans d'autres disciplines. Les questions sur l'énergie font l'objet de recherches internes et contractuelles dans le cadre du Programme national sur l'énergie.

L'Institut de recherche sur les aliments s'occupe de recherche pluridisciplinaire fondamentale et appliquée dans le cadre de trois programmes qui répondent aux préoccupations et aux priorités relevées à l'échelle nationale: la technologie de la transformation des aliments; les composantes alimentaires et le développement de nouveaux produits; l'innocuité des aliments et la nutrition.

L'Institut de recherche sur les terres joue un rôle de coordination à l'échelle nationale par la préparation d'un inventaire des ressources des terres au Canada et par la mise au point de systèmes d'interprétation de l'information sur les terres pour l'agriculture et d'autres secteurs. Les programmes nationaux de recherche portent sur le traçage de cartes pédologiques, la classification des sols, l'évaluation des terres et les systèmes agrométéorologiques.

Le Service aux programmes de recherche offre à tous les établissements de la Direction générale de la recherche une vaste gamme de services spécialisés et appuie la recherche sur l'agriculture canadienne à l'échelle universitaire, provinciale et nationale.

Robert Trottier, directeur du Service aux programmes de recherche, a été détaché au ministère des Affaires extérieures et travaille à titre d'attaché scientifique à Bruxelles. J.C. St-Pierre le remplace actuellement.

Pour de plus amples renseignements sur nos programmes, écrire aux établissements de recherche concernés ou s'adresser à la Direction des instituts, la Direction générale de la recherche, Agriculture Canada, pièce 2077, immeuble K.W. Neatby, Ottawa (Ont.), K1A 0C6.

J.W. Morrison

# Biosystematics Research Institute
# Ottawa, Ontario

## PROFESSIONAL STAFF

| | |
|---|---|
| G. A. Mulligan, B.Sc. | Director |
| I. M. Smith, B.Sc., Ph.D. | Assistant Director |
| E. Gavora,[1] I.N.G., B.L.S. | Librarian, Botany |
| R. A. Sharrett,[1] B.A., M.L.S. | Librarian, Entomology |
| J. E. H. Martin | Manager, National Identification Service, Zoology; Unit Curator of Miscellaneous Insect Orders |
| P. M. LeClair | Manager, National Identification Service, Botany |
| A. Giroux | Administrative Officer |

### Coleoptera, Lepidoptera, and Trichoptera

| | |
|---|---|
| J. M. Campbell, B.Sc., M.S., Ph.D. | Head of Section; Staphylinidae (rove beetles) |
| S. A. Allyson, B.Sc., M.Sc. | Lepidopterous larvae (caterpillars) |
| Y. Bousquet, B.Sc., M.Sc. | Colydiidae, Elateridae (click beetles and wireworms, and other stored-products beetles) |
| D. E. Bright, B.Sc., M.Sc., Ph.D. | Scolytidae (bark beetles), Curculionidae (weevils) |
| P. T. Dang,[2] B.Sc., M.S., Ph.D. | Microlepidoptera of forest importance (spruce budworm) |
| J. D. Lafontaine, B.A., Ph.D. | Noctuidae (cutworm moths); Unit Curator of Lepidoptera–Trichoptera |
| J. F. Landry, M.Sc. | Microlepidoptera of agricultural importance |
| L. LeSage, B.Sc., M.S., Ph.D. | Chrysomelidae (leaf beetles) |
| A. Mutuura, B.Sc., Ph.D. | Tortricidae (leafroller moths) |
| F. Schmid, Lic. ès Sc. Nat., D. ès Sc. Nat. | Trichoptera (caddisflies) |
| A. Smetana,[2] M.U.Dr., Cand. Sc. Biol. | Aquatic beetles, Staphylinidae (rove beetles); Unit Curator of Coleoptera |

## Diptera and Hemiptera

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|---|---|
| K. G. A. Hamilton, B.S.A., M.Sc., Ph.D. | Head of Section; Unit Curator of Hemiptera; Cicadellidae (leafhoppers), Cercopidae (spittlebugs) |
| A. Borkent, B.Sc., Ph.D. | Cecidomyiidae (gall midges), Ceratopogonidae (biting midges) |
| L. A. Kelton, B.S.A., M.Sc., Ph.D. | Miridae (plant bugs), Anthocoridae (flower bugs) |
| J. F. McAlpine, B.S.A., M.Sc., Ph.D. | Lonchaeidae (lance flies), Chamaemyiidae (silver flies) |
| R. V. Peterson, B.Sc., M.S., Ph.D. | Simuliidae (black flies), Nycteribiidae and Streblidae (bat flies) |
| H. J. Teskey, B.Sc., M.S.A., Ph.D. | Tabanidae (horse flies and deer flies), dipterous larvae; Unit Curator of Diptera |
| J. R. Vockeroth, B.A., M.A., D.Phil. | Syrphidae (flower flies), Scatophagidae (dung flies) |
| D. M. Wood, B.A., M.A., Ph.D. | Tachinidae (parasitic tachinid flies), Culicidae (mosquitoes) |

## Hymenoptera and Acari

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|---|---|
| E. E. Lindquist, B.Sc., M.Sc., Ph.D. | Head of Section; Acari (mites and ticks) |
| J. R. Barron, B.Sc., M.Sc., Ph.D. | Ichneumonidae (ichneumon wasps) |
| V. M. Behan-Pelletier, B.Sc., M.Sc., Ph.D. | Oribatei (oribatid mites); Unit Curator of Arachnida |
| G. A. P. Gibson, B.Sc., M.Sc. | Chalcidoidea (chalcid wasps) |
| H. Goulet, B.A., B.Sc., M.Sc., Ph.D. | Symphta (sawflies) |
| L. Masner, B.Sc., M.Sc., Ph.D. | Proctotrupoidea (proctotrupid wasps), Sphecoidea (digger wasps), Evanioidea (ensign wasps); Unit Curator of Hymenoptera |
| W. R. M. Mason, B.Sc., Ph.D. | Braconidae (braconid wasps) |
| M. J. Sharkey, B.Sc., M.Sc. | Braconidae (braconid wasps) |
| I. M. Smith, B.Sc., Ph.D. | Eriophyoidea (rust and gall mites), Hydrachnida (water mites) |
| C. M. Yoshimoto,[2] B.A., M.Sc., Ph.D. | Chalcidoidea (chalcid wasps), Cynipoidea (gall wasps) |

## Mycology: Plant Disease and Biodegrading Fungi

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|---|---|
| R. A. Shoemaker, B.S.A., M.S.A., Ph.D. | Head of Section; Ascocarpic parasites of cereals |
| D. J. S. Barr, B.Sc., M.Sc., Ph.D. | Zoosporic parasites of vegetable crops |
| J. D. Bissett, B.Sc., Ph.D. | Conidial parasites of forage crops |

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| M. P. Corlett, B.A., M.A., Ph.D. | Ascocarpic parasites of fruit crops |
| Y. Dalpé, B.Sc., M.Sc., D.Sc. | Mycorrhizae |
| J. H. Ginns, B.Sc., M.Sc., Ph.D. | Curator of National Collection of Fungus Cultures; Basidiocarpic tree wood rots |
| S. J. Hughes, B.Sc., M.Sc., D.Sc., F.L.S., F.R.S.C. | Conidial molds of wood and insects |
| G. A. Neish, B.Sc., Ph.D. | Mycotoxin fungi |
| J. A. Parmelee, B.Sc., M.A., Ph.D. | Curator of National Mycological Herbarium; Obligate parasites of plants (rusts, smuts, mildews) |
| S. A. Redhead, B.Sc., M.Sc., Ph.D. | Mushrooms |

## Nematodes and Arthropods

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|---|---|
| C. D. Dondale, B.Sc., M.Sc., Ph.D. | Head of Section; Araneae (spiders), Opiliones (harvestmen) |
| R. V. Anderson, B.A., M.S., Ph.D. | Unit Curator of Nematodes; Hoplolaimidae (spiral nematodes), Tylenchorhynchidae (stylet nematodes), Aphelenchoidea (foliar nematodes) |
| B. A. Ebsary, B.Sc., M.Sc., Ph.D. | Criconematidae (ring nematodes), Paratylenchidae (pin nematodes), Hemicycliophoridae (sheath nematodes) |
| B. N. A. Hudson, B.Sc., Ph.D. | Chemical taxonomy of insects polymorphic enzymes |
| R. Matsuda, B.A., Ph.D., D.Sc. | Comparative morphology |
| D. R. Oliver, B.A., M.A., Ph.D. | Chironomidae (nonbiting midges) |

## Vascular Plants

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|---|---|
| B. R. Baum, M.Sc., Ph.D. | Head of Section; Cultivated crops, *Hordeum* |
| S. G. Aiken, B.Sc., M.Sc., M.S., Ph.D. | Grass flora of Canada |
| G. Baillargeon, B.S.A., M.Sc. | Cultivated crops, *Brassica* |
| I. J. Bassett, B.A. | Hay-fever plants, palynology, weeds |
| P. M. Catling, B.Sc., Ph.D. | Sedges, aquatic plants |
| W. J. Cody, B.A. | Curator of Herbarium; Canadian flora, ferns |
| G. A. Mulligan, B.Sc. | Weeds, Cruciferae |
| E. Small, B.A., B.Sc., M.Sc., Ph.D. | Cultivated crops, *Medicago* |
| A. E. Stahevitch, B.Sc., M.Sc., Ph.D. | Weed taxonomy |
| S. I. Warwick, B.Sc., Ph.D. | Weeds, genecology |

## Honorary Research Associates

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|---|---|
| J. W. Arnold, B.A., M.Sc., Ph.D. | Insect hemocytology (blood cells) |

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| E. C. Becker, B.Sc., M.Sc., Ph.D. | Elateridae (click beetles, wireworms) |
| J. A. Downes, B.Sc. | Ceratopogonidae (biting midges) |
| G. P. Holland, B.A., M.A., D.Sc., F.R.S.C. | Siphonaptera (fleas) |
| R. Macrae, B.A., M.Sc., Ph.D. | Basidiocarpic wood rots, polypores |
| W. C. McGuffin, B.A., M.A., Ph.D. | Geometridae (geometer moths, loopers) |
| D. B. O. Savile, B.S.A., M.Sc., Ph.D., D.Sc., F.R.S.C. | Plant rusts |
| G. E. Shewell, B.Sc., M.Sc. | Lauxaniidae (lauxaniid flies), Calliphoridae (blow flies) |
| A. Wilkes, B.S.A., M.Sc., Ph.D. | Insect genetics |

## Departure

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| E. S. Eveleigh, B.Sc., M.Sc., Ph.D. | Dorylaimida (dagger nematodes), acarine systems (mites) |

[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]Seconded from Environment Canada.

## INTRODUCTION

The Biosystematics Research Institute maintains and develops the major National research collections of insects, arachnids, nematodes, vascular plants, and fungi; conducts research on all aspects of the biosystematics of these organisms of importance to Canadians; prepares and transfers interpretive material to workers in related fields; and provides the National Identification Service utilized by clients throughout Canada.

The program of the Institute emphasizes collection development and taxonomic study of organisms of special interest to Canadians and the production of identification guides and inventories of organisms having economic or environmental impact. These activities steadily improve the effectiveness of the National Identification Service, and the policies and procedures of this Service are reviewed regularly to ensure that the needs of clients are met efficiently.

Reprints of research publications are available from the authors. Correspondence on other matters should be addressed to the Director, Biosystematics Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

G. A. Mulligan
Director

## COLLECTION DEVELOPMENT

The holdings of the Canadian National Collection of Insects, Arachnids, and Nematodes increased by 190 000 specimens during 1982, and the classified holdings increased by 144 600 specimens. Major contributions were made by 20 officers of the Institute collecting throughout Canada and eastern and western United States. Two entomologists collected in the Yukon Territory, making substantial collections in glacial refugial areas. Purchases of material of exceptional scientific interest amounted to 87 500 specimens. Growth of the Collection mainly involved acquisition of specimens required for current research activities of Institute scientists, but new acquisitions also increased representations of other groups of importance to Canadians. Requests for loaning of material from other scientists throughout the world amounted to 214 loans of 90 000 specimens. Many scientists and students from various parts of the world visited the Canadian National Collection to study and curate specific groups. Noteworthy of these were 11 people, supported by the CanaColl Foundation grants, who curated some 57 550 specimens of specific groups of Hymenoptera, Coleoptera, Diptera, and Hemiptera. Eight of these scientists came from the United States and one each from China, Germany, and Sweden.

The holdings of the Vascular Plant Herbarium now stand at 732 599 collections, an increase of 15 792 during 1982. Approximately 12 200 collections were made during field trips by staff members in the Maritime Provinces, southern Ontario and Quebec, the Prairie Provinces, British Columbia, the Yukon Territory, the western United States, and the USSR. Some 8534 collections were donated to the herbarium, 6999 as exchange and 1535 as gifts from other herbariums. Some 46 loan requests totaling 8097 vascular plant specimens were received during 1982.

The holdings of the National Mycological Herbarium stand at 239 231 specimens, an increase of 3292 accessions during 1982. A total of 1660 specimens were donated, 623 as exchange from other herbariums and 1037 as gifts. Approximately 2550 collections were made during field trips by staff members in Ontario, Quebec, Nova Scotia, the Queen Charlotte Islands, the Yukon Territory, and Sweden.

The National Collection of Fungus Cultures has increased its holdings from 7128 to 7651, an increase of 523 cultures, received for deposit from other institutions, through the Identification Service, or from isolations made by staff members. At present, 2366 cultures have been successfully lyophilized for long-term preservation. A total of 310 cultures were sent out in answer to requests by

scientists in Canada and throughout the world.

## SECTIONAL RESEARCH AND TECHNOLOGY TRANSFER

### Coleoptera, Lepidoptera, and Trichoptera

*Coleoptera (beetles).* Alleculidae (comb-clawed bark beetles): One paper was published describing a new species of *Hymenorus*. Substantial progress was made on a review of the Canadian species of the family.

Buprestidae (metallic wood borers): The final draft of the handbook of the Buprestidae of Canada was completed and was sent out for review by specialists. Nearly 200 species are keyed and described, and most are illustrated.

Byrrhidae (pill beetles): A paper describing the immature stages of *Ctyilus alternatus* was submitted for publication.

Carabidae (ground beetles): Three papers on genera of carabid ground beetles were submitted for publication. Contained are a description of a new species of *Pterostichus* from beaver houses; a key and review of species of *Blethisa* from Alaska, with comments on their zoogeography and phylogeny; and a major study of the genera of Elaphrini and species of *Elaphrus*, including phylogenetic and zoogeographical considerations.

Chrysomelidae (leaf beetles): Two papers on the larvae of *Neochlamisus* and *Exema* were submitted for publication. A revision of the genus *Ophraella* is in progress; the adults at hand were identified and one species was reared.

Curculionoidea (weevils): Substantial progress was made on a study of the Canadian Curculionoidea. About half of Part 1 of a three-part handbook on the Canadian weevils was completed. Part 1 is to treat all of the families of this group, except the true weevils.

Histeridae (hister beetles): A handbook on the hister beetles of Canada was completed and will soon be submitted for publication. The manuscript was prepared on contract for the Institute.

Hydrophilidae (water scavenger beetles): A paper on the geographic distribution of *Hydrochara* was completed and is now in press; substantial progress was made on a handbook of the Canadian species of the family.

Scarabaeidae (scarab beetles): A handbook on the scarab beetles of Canada was prepared on contract and is nearing completion.

Scolytidae (bark beetles): A coauthored paper on the taxonomy and geographic variation of North American Scolytidae was published as a chapter in the book *Bark beetles in North American conifers. A system for the study of evolutionary biology*, edited by J. B. Mitton and K. Sturgeon, University of Colorado. Studies of bark beetle larvae have continued with emphasis on the genus *Ips*. Larvae of a majority of the species in the genus have been taken. A project to produce a comprehensive catalog of the Scolytidae and Platypodidae of the world was initiated as a joint activity involving the Canadian Forestry Service, Agriculture Canada, the United States Department of Agriculture, and an american university. Several small papers treating various genera and species of exotic Scolytidae were completed or published.

Silphidae (carrion beetles): A handbook on the silphid beetles of Canada was prepared as an unsolicited proposal and submitted for publication.

Staphylinidae (rove beetles): Two manuscripts revising the genus *Acidota* and describing *Mitosynum vockerothi*, a new genus and species from Eastern Canada, were published. In addition, manuscripts revising the genus *Olophrum* and describing new species of *Pycnoglypta* were accepted for publication. Memoirs revising the genus *Lordithon* and the subfamily Xantholininae were published and one revising the parasitoid genus *Aleochara* was completed for review. Eight more papers, most of them revising North American genera, were accepted or will be submitted in early 1983 for publication.

Miscellaneous: The preliminary draft of an inventory of destructive Coleoptera exclusive of the forest industry was completed. This manuscript is about 800 pages long and treats all beetles in Canada known to damage crops, ornamentals, stored products, and household pets. A project dealing with the identification and biology of stored products and household beetle pests was initiated. Substantial progress was made on a revision of the beetles of the Arctic.

Visitors: The Coleoptera Unit hosted a field trip of coleopterists, following their annual meeting in Toronto. Over 30 coleopterists

attended and assisted in curating the collection, identifying species, and borrowing specimens for further study. At the same time, Dr. J. M. Campbell and Dr. L. Watrous (Field Museum, Chicago) cosponsored a workshop, in Ottawa, on the systematics of rove beetles. This workshop was attended by 14 specialists.

*Lepidoptera (butterflies and moths).* Arctiidae (tiger moths): A paper on the reclassification and life history of the arctiid *Acsala anomala* was published. This arctic species lives on barren rock slides where the larvae feed on lichens; the flightless female moths hide under rocks.

Noctuidae (cutworms): During 1982, four papers on the cutworm genus *Euxoa* were published. A manuscript on an arctic group of cutworms (*Xestia* subgenus *Schoyenia*) was completed and submitted for publication.

Pyralidae (leafrollers): A paper on a new species of *Dioryctria* from Eastern Canada and northeastern United States was published. A study on the larvae of the tribe Spilomelini is nearly completed. The European corn borer, *Pyrausta nubilalis* (Hubner), was recorded on wheat in Ontario.

Tortricidae (budworms): A paper recording an introduced species, *Cnephasia stephensiana*, was published. The taxonomic study of the species complexes of the spruce budworm, *Choristoneura fumiferana*, and the western spruce budworm, *C. occidentalis*, is nearing completion. Papers revising the genera *Taniva* and *Proteoteras* were submitted for publication.

Biosystematics of cutworms: Two anatomically indistinguishable forms of *Euxoa ridingsiana* (Grote) were shown to be separable by electrophoresis, the differential characters being phenotypes of L-glycerophosphate dehydrogenase and certain malic enzymes. Isozyme data were also obtained on 14 enzymes from nine collections of *Euxoa messoria* (Harris); cluster analysis of genetic-distance data suggested the existence of two populations, one western and one eastern, with implications for identification and control.

*Trichoptera (caddisflies).* The third part of the *Trichoptera of Canada* and a paper describing many new species of the genus *Stactobia* were published. The fourth part of the *Trichoptera of Canada* series was initiated.

**Diptera and Hemiptera**

*Diptera.* The text of Volume 2 of the *Manual of Nearctic Diptera*, which is to treat 65 families, is nearing completion, and a catalog of type-specimens of Diptera in the Canadian National Collection is being prepared. Handbooks of the horse and deer flies (Tabanidae) and flower flies (Syrphidae) are nearing completion and a French-language guide to the mosquitoes (Culicidae) of Canada is in press. Taxonomic treatments have been completed for two genera of flower flies, two species-groups of horse flies, two genera of Lonchaeidae, one species-group of black flies (Simuliidae), one new species of Phoridae, one new genus of Heleomyzidae, and the *Megagrapha* group of Empididae. A new species of chironomid midge feeding on an introduced aquatic weed in the Okanagan Valley is being described from all life stages.

*Hemiptera.* A handbook of the spittlebugs (Cercopidae) of Canada is in press. Handbooks on the plant bugs (Miridae) of Eastern and Western Canada were initiated and a guide to the 207 leafhopper species attacking fruit and ornamental trees in Canada was completed. Ten new records of introduced plant bugs and 14 new records of introduced leafhoppers (Cicadellidae) were established and reported. The pest known as the aster leafhopper (*Macrosteles fascifrons* of authors) was distinguished from its eight siblings, and its name was changed to *M. quadrilineata* (Forbes). Seven new species of leafhoppers and two new species of spittlebugs were described. An invitational paper on the morphology and higher classification of the leafhoppers was presented at an international symposium in London, U.K.

**Hymenoptera and Arachnida**

*Hymenoptera.* Four scientists contributed papers as part of a special volume published on parasitic Hymenoptera, commemorating the 70th birthday of noted American colleague Henry K. Townes. These papers included the description and analysis of characters of new genera and species of a new South African subfamily of Braconidae; a comparison and key to members of 12 genera, including the description of two new genera of diapriine proctotrupoid wasps associated with ants, with discussion of the evolution of this association; a new genus of tetrastichine chalcidoid wasp from Brazil; and a cladistic analysis and description of a new genus and

new species of agathidine braconid wasps from South America. A paper on hymenopterous parasites of lepidopterous and sawfly larvae on honeysuckle in eastern Ontario was completed. A paper on the use of thoracic muscles as a character system for phylogenetic analysis of Hymenoptera (Terebrantes) was presented at the joint annual meetings of the entomological societies of America and Canada in Toronto in 1982. Draft accounts of the sawflies, woodwasps, ants, bees, and predatory and parasitic wasps of Gatineau Park, Quebec, were completed for inclusion in a survey report.

Ichneumonoidea: A paper on a new subfamily of braconid wasps from South Africa was submitted for publication.

Chalcidoidea: A large monograph on the chalcidoid wasp fauna of the Hawaiian Islands was completed. An important paper, giving evidence for chalcidoid wasps constituting a natural group and for relationships of two constituent families Mymaridae and Mymarommidae, was completed.

Proctotrupoidea: A paper on morphology of the abdomen of *Vanhornia* wasps was submitted for publication. Two papers, revising the species of the platygastrid genus *Trichacis* and those of the scelionid genus *Baryconus* for North America, were submitted for publication. A paper on new genera of African sceleonid wasps was completed. A paper, on evidence for the monobasic wasp family Pelecinidae constituting the sister group of the Proctotrupidae, was given at the joint annual meetings of the entomological societies of America and Canada in Toronto in 1982.

*Arachnida.* Araneae (spiders): A revision of North and Central American species of the wolf spider genus *Allocosa* was completed for publication. Illustrations of the Canadian species of wolf spiders were prepared for a contribution to the faunal series *The insects and arachnids of Canada.* A detailed account of the combfooted, orb, and wolf spiders of Gatineau Park was completed for inclusion in a survey report.

Acari (mites): A paper on the potential for use of mites in biological control, including a modified concept of parasitoidy as applied to mites, was given at a work conference (proceedings of which are now in press) on this subject at the University of California, Berkeley, in 1982. A major invitational paper, concerning current theories on evolution of the mites relative to other major groups of arachnids, was presented in a symposium at the Sixth International Congress of Acarology in Edinburgh, Scotland, in 1982. Six papers on description of previously unknown stages of water mites, including a new genus and comments on distributions and phylogenetic relationships of taxa, were submitted for publication or published. Three papers on oribatid soil mites were submitted for publication or published. They included descriptions of some new species and a new genus from the Soviet subarctic, a review of *Epidamaeus* species of arctic western North America and northeastern USSR, and information on feeding habits of oribatid species from acid peat bogs. Draft accounts of the mites of the suborders Gamasida, Actinedida, Oribatida, and Acaridida, and of the ticks inhabiting Gatineau Park, Quebec, were completed for inclusion in a survey report.

### Nematodes

Cooperative work with the Vineland Research Station showed that a rare, root-lesion nematode discovered on timothy in southern Ontario in 1981 is *Pratylenchus thornei* Sher & Allen. The species is now in culture under controlled conditions so that its variability can be assessed. Also, a survey of the nematodes infesting commercially grown mushrooms in Ontario was initiated. A species of lance nematode found in the roots of wild rice in Prince Edward Island was identified as *Hoplolaimus inducus* Sher, which was previously known only from southeast Asia where it is a serious pest of many crop plants including upland and lowland rice. Knowledge of the plant-parasitic nematodes was extended by the description of a new genus of Rhabditidae.

### Mycology

*Agaricales (mushrooms).* Documentation of the Canadian mushroom flora in preparation for a general treatment continued to reveal undescribed species and species new to North America or to Canada. The genus *Helotium*, with 39 species worldwide, was revised. Five species were new to Canada, two being new species. A new mycoparasitic *Typhula* from British Columbi was documented, in cooperation with a scientist from France.

In collaboration with scien ists in the Health Protection Branch, Canada Health and Welfare, lists of harvestable wild edible

mushrooms were drawn up. Also, in collaboration with their forensic laboratories, methods were developed for the identification of illicit drug-producing species from a variety of seized street materials. In cooperation with a member of the Chinese Academy of Science, four new species were described from The People's Republic of China, and four others new to that country, one a grass pathogen, were documented from China for the first time.

*Ascomycetes.* *Piedraia hortae* (Brumpt) Fonseca & Area Leao, causing black piedra disease of human hair in the Tropics, was described from an infected immigrant from Cambodia. *Endozylina allantospora* (Ell. & Ev.) Shoemaker & Egger on *Acer negundo* L. was revised and described from Canada for the first time. Two discomycetes on native or introduced *Ranunculus* species were described, as was the widespread *Pleospora herbarum* (Fr.) Rabenh., which occurs on many herbaceous plants. Three species of *Venturia* causing leaf diseases of willow, *Salix*, were described and a new variety of *Bertia moriformis* (Tode: Fries) DeNotaris, a wood-degrading species, was found.

*Coelomycetes.* Descriptions of eight species of *Septoria* and related fungi, all economically important pathogens of cereals and forage grasses in Canada, were completed. Monographic work on the *Phyllosticta* leaf spot fungi occurring in Canada is nearing completion. A manuscript was completed describing a new leaf spot disease on *Yucca* caused by a previously unknown species of *Guignardia* with *Phyllosticta* and *Leptodothiorella* synanamorphs. The genus *Tolypocladium* was monographed. Most of the species are pathogens with application in biological control of mosquitoes and other pests, but others are utilized in the production of pharmaceuticals. *Trichoderma* section *Longibrachiatum* was revised, and two new species were described. All the species are important for their cellulase isoenzyme systems, which have many applications in cellulose transformations for energy and feeds.

*Hyphomycetes.* A *Schiffnerula* disease of leaves of red osier, *Cornus stolonifera* Michx., found during the survey of one of our national parks, has been investigated. It is known from Quebec, Ontario, the northern United States, and Europe and represents one of the few temperate species of this predominantly tropical or subtropical genus. The organism causing silverscurf of potato was redescribed and the name was stabilized as *Helminthosporium solani* Darieu & Montagne in Durieu. *H. tingens* Cooke was shown to be *Dactylosporium macropus* (Corda) Harz.

*Mycorrhizae.* In the family Endogonaceae, *Acaulospora trappei* Ames & Lunderinan and *Giaspora calospora* (Nicol & Gerd.) Gerdeman & Trappe, as well as numerous species of *Glomus*, were collected, isolated, identified, and added to the collection. Single-spore axenic cultivation and studies in growth chambers permitted research on conditions of spore germination or on the production of specific root inocula. In collaboration with Laval University, a new taxon responsible for ericicoid mycorrhizae of blueberries, *Vaccinium*, was isolated and described for publication.

*Mycotoxin fungi.* Collaborative work with scientists at the Animal Research Centre, the Chemistry and Biology Research Institute, and the Plant Products Laboratory of the Food Production and Inspection Branch was directed to field and laboratory studies of various aspects of vomitoxin and zearalenone production by *Fusarium graminearum* Schwabe. Collaborative work with a scientist from the Plant Products Laboratory has been concerned with identification of zearalenone derivatives produced by *F. equiseti* (Corda) Secc. and, with additional assistance from a scientist at the Pennsylvania State University, a survey of mycotoxin production by species in the Section *Fusarium (Discolor)* of the genus *Fusarium* was initiated.

*Rust fungi.* Seven species of *Puccinia* parasitic on plants in Ranunculaceae were described and illustrated. An annotated listing of 263 microparasitic fungi on vascular plants in Northern Ontario (north of 48° lat.) was completed; about half of the species included were rust fungi and the rest were leaf-spotting fungi, mildews, or smuts. Remarks for each entry included observations on fungus characters, life cycle, distribution, and the hosts attacked; also included is an index based on host plant attacked.

A chapter dealing with taxonomy was prepared for the multiauthored work *The cereal rusts.* Work is progressing on the

phylogenetic arrangement of 16 rusts of Triticeae.

*Wood rots.* A world monograph for the genus *Coniophora* was published. These dry rot fungi cause structural weakening of wooden constructions such as buildings and bridges. The identification of the fungal stages typically found in decayed wood was emphasized. Several species were described as new and others were reported for the first time from North America.

The *Annotated index of Canadian plant disease fungi*, an up-to-date reference book for plant pathologists, ecologists, plant breeders, and other biologists, is nearing completion.

*Zoosporic fungi.* An ultrastructural study on the zoospore of *Polymyxa graminis* Ledingham, which is the vector of several economically destructive virus diseases of cereals, was completed and published. A monograph on *Spizellomyces, Kochiomyces, Gaertneriomyces,* and *Triparticalcar,* which are unicellular fungi of possible importance in soil fertility, was completed.

*Fungi Canadenses.* In 1982, 30 numbers of *Fungi Canadenses* were published, bringing the total of the series to 240. Taxa illustrated and described include new records of Canadian fungi, one new species, and three new generic dispositions. Species of parasitic and biodegrading fungi from the following genera were described: *Atheliopsis, Coelosporium, Dactylosporium, Endoxylina, Fusarium, Helminthosporium, Hyphoderma, Leptotrochila, Marasmiellus, Marasmius, Nyssopsora, Piedraia, Pleospora, Pseudobaeospora, Pseudopeziza, Pseudoseptoria, Puccinia, Stagonospora, Stemphylium, Stigmina,* and *Venturia.*

**Vascular plants**

*Alfalfa.* A study of chromosome numbers in various wild races and primitive cultivars of Turkey was completed. It was found that diploid wild races were restricted in distribution to northeastern Turkey, whereas wild races in the remainder of Turkey, and all cultivars, were tetraploid. A scanning electron microscope study of stigma characteristics showed that these are of taxonomic value in assessing similarities of the alfalfa genus (*Medicago*) and a number of related genera of the Leguminosae.

*Barleys.* Many breeders who received the first report of the worldwide barley registry that includes pedigrees, coefficients of parentage, synonyms, and other pertinent data answered favorably with constructive criticisms and with lots of supplementary data. At present, our efforts resulted in data for 6000 cultivar names. Taxonomic analysis of *Hordeum vulgare* in its broad sense, including *H. spontaneum* and related taxa, was carried out.

*Fescues.* Taxonomic problems in the genus *Festuca* are being considered, and leaf anatomy as a taxonomic tool is being assessed. An extensive field trip collecting *Festuca* species in Western Canada was undertaken, and living plants that are growing under uniform conditions in Ottawa are providing material for ongoing research.

*Trefoils.* A study of bird's-foot trefoil of Turkey showed that characteristics that have been used to date to delimit infraspecific groups are correlated with altitude. Indeed, there appear to be no sharp boundaries between the variants of bird's-foot trefoil, which gradually replace each other with increasing altitude. Lowland forms are mainly diploid, those of intermediate altitudes are mainly tetraploid, and those of the highest altitude are either diploid or tetraploid.

*Wheat group.* Phylogenetic classification of the tribe Triticeae based on cladistic analyses of morphological data was completed. The new phylogenetic scheme was also matched with data on genomes of various genera.

*Biology of Weeds series.* An account on Russian-thistle, *Salsola pestifer*, was carried out in Canada. The airborne pollen of this weedy species is known to cause considerable hayfever. A report on another important hayfever plant, giant ragweed (*Ambrosia trifida*), has been completed. Accounts of two *Galinsoga* species, hairy galinsoga (*G. quadriradiata* Ruiz & Pav.) and small-flowered galinsoga (*G. parviflora* Cav.), which have recently become troublesome weeds of low-growing vegetable crops in Canada, were completed. An account of Johnson grass, *Sorghum halepense* (L.) Pers., a new problem-weed in Ontario, was completed.

*Inventory of Canadian weeds of agricultural importance.* A revised list of weeds associated with cultivated and pasture lands is being prepared. For the approximately 600

species involved, data will be published on nomenclature, distribution, frequency, affected crops, species, and major bibliographic references.

*Sagebrushes and wormwoods.* A project on species of the genus *Artemisia*, important in crop and rangeland management, was initiated. Samples of 500 populations in the Prairie Provinces and British Columbia were collected; preliminary cytological and morphological studies were carried out.

*Leafy spurges.* A review of the genus *Euphorbia* section *Esula* was undertaken to facilitate Departmental programs in biological control. It was found that Canadian populations include a number of biotypes that have been recognized on the specific level by European authors as well as numerous intergradients. In order to better understand these, biosystematic studies are being carried out in such disciplines as cytology, cytogenetics, phenology, and morphology.

*Marsh hedge-nettle and its relatives.* Cytological studies were carried out on *Stachys palustris* L., an introduced weed in the Maritimes, and its North American allies toward a cytotaxonomic monograph of the New World taxa, north of Mexico.

*Impatiens.* Two papers were prepared on chromosome numbers, polysomaty, and cytogeography of *Impatiens* L., a source of popular bedding ornamentals. A sample of 44 taxa included first chromosome number reports for eight taxa and new dysploid numbers for three species. Based on floral morphology, palynology, and taxonomic distribution of chromosome numbers, the original chromosome number of the genus was probably $x - 8$. The cytogeography of the genus is considerably more complex than previously indicated.

*Pollen morphology of the genus Lotus (bird's-foot trefoil).* In a study of pollen morphological characters on North American *Lotus* spp. there appears to be a clear separation between this group and pollen of species from Europe and Asia. This could lead to a better taxonomical and biological understanding of the whole genus.

*Aquatic plants.* Work on the inventory of Canadian aquatic plants was continued. An article was prepared concerning the aquatic flora of Kejimkujik National Park and its relation to water chemistry. A manuscript on the water-milfoils and mermaid-weeds (Haloragaceae) including keys, descriptions, and distributions was completed for the new flora of the southeastern United States.

*Waterweeds.* A paper was completed concerning systematics, identification, ecology, and distribution of Canadian waterweeds (*Elodea*), and another paper was prepared on the biology of the principal weedy species.

*Sedges.* Parts of the *Ontario atlas of rare plants* were submitted and a note describing some new records for Canada was completed.

*Orchids.* Information was contributed for the *Ontario atlas of rare plants.* A new autogamous variety was described from the eastern United States (*Spiranthes ovalis* var. *erostellata*). A paper concerning morphometrics and ecological isolation in *Spiranthes* was submitted. A note outlining new combinations for forms and varieties of North American orchids was prepared.

*Floristic studies.* A preliminary report was submitted to Parks Canada concerning the flora of Cataraqui Marsh. A preliminary checklist of the vascular plants of York County, Ontario, was prepared. An introduction was prepared for the reprinting of the Prince Edward Island flora. A discussion of the vegetation of Gatineau Park, Quebec, was also prepared.

*Fern and fern allies of Canada.* A manuscript on the fern and fern allies of Canada has been submitted for publication. This definitive treatment includes 302 line drawings and 159 distribution maps. Several species are weedy in nature; at least one is reputed to be carcinogenic, one is a delicacy that is harvested and sold commercially, and some are used for decorative purposes, both living and dried.

*Documentation of weed research.* In order to facilitate proper documentation by weed scientists, a document was prepared outlining the importance of and methods for preparing herbarium voucher specimens and including a table of the key structures necessary for the identification of the 19 most important weedy families.

*Grass genera of western Canadian cattle rangelands.* A major bulletin is being published and is expected to be available by summer 1983. It is intended to assist students, technicians, research scientists, and agricultural workers in identifying the 64 genera of

**Zoological & Botanical identifications for 1982**

| | Arthropods and nematodes, number of specimens | Vascular plant collections[1] | Fungus collections[1] | Fungus cultures[2] | Total |
|---|---|---|---|---|---|
| **Canada** | | | | | |
| Agriculture Canada | 13 423 | 273 | 143 | 303 | 14 142 |
| Environment Canada | 7 296 | 878 | 31 | — | 8 205 |
| Other federal departments | 921 | 1 837 | 693 | 120 | 3 571 |
| Provincial departments | 7 063 | 1 175 | 65 | 59 | 8 362 |
| Industry | 83 | — | 3 | 4 | 90 |
| Universities | 11 015 | 2 903 | 145 | 173 | 14 236 |
| General public | 1 895 | 845 | 642 | 78 | 3 460 |
| **USA** | | | | | |
| Government departments | 7 729 | 1 762 | 162 | 11 | 9 664 |
| Universities | 7 463 | 1 240 | 229 | 3 | 8 935 |
| General public | 583 | — | — | — | 583 |
| **Other countries** | **3 842** | **73** | **175** | **10** | **4 100** |
| **Total** | **61 313** | **10 986** | **2 228** | **761** | **75 348** |

[1] The term collection refers to all of the plants of one species that were collected at a certain location at one time and may in fact comprise from one to more than a thousand individuals.

[2] The term culture denotes a living fungus population aseptically cultivated on various substrata under different conditions, usually to obtain identifiable structures of different states in the life cycle.

grasses found in cattle rangelands of Western Canada. A key to these genera is given, utilizing both vegetative and reproductive characters.

*Computer-generated key to the grass genera of Canada.* A list of more than 100 grass genera recorded for Canada was prepared; the existing data for these genera in the World Grass Genera Data Bank was thoroughly checked to assure accuracy for all Canadian species, and many modifications were made. The computer generations of a key or keys to the genera is being tested.

*Blueberries.* A monograph on the genus *Vaccinium* in North America, being prepared on a 5-yr contract to Acadia University, is nearing completion. A rough draft has now been completed, treating the 26 species of this continent.

*Pondweeds.* An article was prepared concerning the identification, ecology, and distribution of pondweeds in the Ottawa District.

*Improved technique for Hy- (hydrochloric acid) chromosome bands.* The Hy banding technique is considerably less time-consuming and less expensive than other banding techniques for karyotypic analysis. A paper was prepared on this finding.

*Genecology of new problem-weeds in Ontario.* Comparative growth trials of three new problem-weed species in Canada were completed. These included seven populations of silky bent grass, 14 populations of Johnson grass, and 42 populations of velvetleaf. Significant differences in germination, seedling and mature plant growth, time to flowering, and resource allocation patterns were found between overwintering and nonoverwintering biotypes of Johnson grass. Chromosome studies on five new grass weed species to Canada were initiated. A comparison of European and Canadian populations of silky bent grass was initiated.

### National Identification Service

A total of 1078 shipments of insects, arachnids, and nematodes were received for identification during 1982 and some 61 000 specimens were identified. The primary users of the service were Agriculture Canada (22%), Canadian Universities (18%), and Environment Canada (14%).

During 1982, 10 986 collections of vascular plants were identified, a substantial increase over the previous year. The major users of the service were Canadian universities (26.4%) and other federal departments (24.7%). An increased number of inquiries was received directly from the general public and through Communications Branch, Agriculture Canada. Assistance was provided to the Poison Control Centre for 33 cases of suspected poisonings from vascular plants.

A total of 3049 collections and cultures of fungi were identified during 1982. Principal users of the service were other federal departments (27.7%), the general public (23.6%), and Agriculture Canada (14.6%). Assistance was provided to the Poison Control Centre for 29 cases of suspected poisonings from mushrooms. An increased number of inquiries was received from Health and Welfare Canada, requesting assistance on hallucinogenic substances, suspected pathogens in cosmetics, contents of allergy serum, air quality in buildings, and food poisonings. Some 33 lots of urea-formaldehyde foam insulation material were sent in from the public and through federal departments for fungal content examination.

The accompanying table shows the number of specimens identified and their sources.

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# INTRODUCTION

The Chemistry and Biology Research Institute is engaged in various research programs of national significance to Canadian agriculture. The present research objectives are concerned with the development of effective and environmentally acceptable methods of weed and fungus control by pesticides; the development of analytical methodology to establish safe levels of fungal toxins in food and feedstuffs and to provide effective measures of decontamination and control; the increase of the nitrogen-fixing capability of forage legumes through selection and genetic engineering of the bacterial symbiont and host improvement; the epidemiology and transmission of virus and mycoplasma diseases of plants in relation to disease incidence, management, and control; the efficient use of soil nitrogen, the prevention of soil organic matter losses, and the mineralogy of Canadian soils; and the provision of new knowledge on the mechanisms of cold acclimation, freezing injury, and overwintering damage in relation to the development of crop plants, resistant to environmental stresses. The Institute also provides a comprehensive electron microscope service, analytical chemistry service, and mineral analyses service for Research Branch establishments across Canada.

This report summarizes only the highlights of our achievements in 1982. Reprints of research publications and copies of this report are available from the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

A. I. de la Roche
Director

# SOIL CHEMISTRY AND MINERALOGY

## Chemistry of humic and fulvic acids

A combination of chemical (methylation, acid hydrolysis, and acid hydrolysis followed by methylation) and $^{13}C$ nuclear magnetic resonance (NMR) spectroscopic methods provided new information on the chemical structure of humic acid (HA) and fulvic acid (FA). It was shown, for the first time, that all acidic carboxyl groups in these materials are attached to aromatic structures. This finding is of particular importance to metal–organic matter interaction studies where the strength of metal binding by organic ligands is strongly affected by the type of structure to which the functional group is attached. Studies also confirmed that phenolic OH groups are important functional groups in humic materials.

Water-soluble $Cu^{2+}$– and $Fe^{3+}$– FA complexes were examined by scanning-transmission electron microscopy and energy dispersive X-ray spectrometry. The complexing of metals did not change the physical configuration of FA. The metals were uniformly distributed in the FA particles, which appeared to react as flexible, linear polyelectrolytes. Specific element X-ray maps suggest an even distribution of binding sites in FA, which are readily accessible to metal cations.

The dissolution of elements in two chlorites and one biotite mineral by FA was investigated in closed and open systems. In closed systems, dilute FA solutions rapidly dissolved substantial amounts of Si, Al, Fe, Mg, and K (in the case of biotite). The concentrations of elements dissolved were proportional to FA concentrations when these were 0.1% (w/v) or lower. In open systems, fast dissolution of the minerals was observed during the initial 20–25 days of leaching. Following this, the extraction rate slowed to near constancy. With the dissolution rates observed, it would have taken a 0.025% FA solution about 22 yr to dissolve 1 g of chlorite but only 7.2 days to dissolve 1 g of biotite. These data demonstrate that FA can degrade soil minerals.

## "Unknown" soil nitrogen

The identification of the major components of soil fractions rich in "unknown" N was initiated. The fractions were first hydrolyzed with 0.5 *M* and 13 *M* sulfuric acid, then acetylated and separated by gas chromatography. The major peaks were identified by mass spectrometry. Several hydroxy- and oxyindoles and a number of benzyl amines and nitriles were identified. The analysis of additional fractions is now in progress.

In an alternate approach to preparing fractions rich in "unknown" N, several soils were separated into particle size fractions ranging from 0.2 to 1000 $\mu$m. Each fraction was analyzed after hot acid hydrolysis for total N, amino acid-N, amino sugar-N, and $NH_3$-N. Although particle-size separation did not yield fractions that contained essentially only "unknown" N, it was possible to isolate fractions that were either rich in amino acid-N (or protein-N) or in $NH_3$-N. The finer-size fractions tended to be rich in amino acid-N, whereas $NH_3$-N was more prominent in the coarser fractions. It was also shown that deproteinizing humic acids with enzymes was superior to the conventional hot acid hydrolysis in preparing "unknown" nitrogen-rich soil fractions.

NMR studies ($^{15}N$ and $^{13}C$) demonstrated that chemically synthesized melanoidins (polymers of reducing sugars and amino acids) strongly resemble N-rich organic soil fractions and humic acids. They are highly aliphatic, have the same distribution of carbon types, and are resistant to decomposition by soil microbes.

**Microbiology**

The fungus *Scytalidium acidophilum* grew in acid hydrolysates (pH 1.0) of waste paper and converted 97% of the sugars to cell biomass possessing high amounts (45%) of protein. The fungus also grew well in 15% sulfite liquor wastes, producing single-cell protein and reducing the liquor's pollution-causing characteristics.

**Aqueous chemistry of Al in acid environment**

The hydrolysis of aluminum in the presence of different anions showed that for similar concentrations ease of hydrolysis was in the order of $-NO_3 > -Cl > -SO_4$. It was concluded from solubility considerations of these hydrolytic studies that polymerization of polynuclear hydroxy-aluminum cations is not the formative process for gibbsite.

**Formation of alumina at room temperature**

The formation and coexistence of four crystalline aluminum compounds, namely gibbsite ($Al(OH)_3$), boehmite (AlOOH), alumina ($Al_2O_3$), and alumite ($NaAl_3(OH)_6(SO_4)_2$), was demonstrated. These solid phases were formed as hydrolytic products of aluminum sulfate solution under ambient conditions, indicating that thermal conditions are not essential to form boehmite and alumina.

**K-deficient Vineland soils**

Potassium deficiency in grapes grown on soils in the Vineland area was investigated by chemical and mineralogical analyses. Strength of potassium adsorption was related to vermiculite content and levels were sufficient to reduce potassium availability. Potassium availability to grapes was sufficient at energies of potassium exchange ($-\Delta G$) of 11.7 kJ/equiv or less and at potassium saturation of the base exchange capacity of 7% or higher.

**Removal of amorphous inorganic soil components**

The Tiron reagent was found to be effective in extracting noncrystalline inorganic components from soils. A single extraction with the reagent allows the determination of extractable Si, Al, and Fe. This method is advantageous over traditional determination methods, where two separate extractions with NaOH are required for Si and Al and one with ammonium oxalate for Fe and Al.

**Decomposition of organic matter in soils**

An improved method was developed for the chemical oxidation and removal of organic matter from soils using sodium hypochlorites. An oxygen plasma method was successfully applied to remove organic matter from two Podzolic soils and is now being extended to cover a wide range of soil types.

**Crystal chemistry of chlorites**

A Mossbauer investigation of three trioctahedral chlorites and their oxidation products indicated a marked difference in the $Fe^{2+}$-to-$Fe^{3+}$ ratio and crystal environments around iron atoms. Close examination of the computed parameters of all oxidized chlorites suggested that the residual $Fe^{2+}$ coordination in the Fe-clinochlore is a distorted octahedron. This may be significant in relation to structural changes in the chlorites on oxidation: Fe-clinochlore alters to a regularly interstratified chlorite–vermiculite, whereas chamosites alter to vermiculite.

## STRESS PHYSIOLOGY

### Overwintering damage to winter cereals

Overwintering potential and yield of a series of genetically different winter cereal cultivars were evaluated at the Central Experimental Farm and on commercial farms in eastern and central Ontario. Snow mold damage was prevalent at several of the sites, particularly in areas where snow accumulation was excessive and snow cover was maintained throughout late winter and early spring. Several species of fungi from snow mold diseased winter wheat have been isolated and identified. Some of these isolates are pathogenic to winter wheat in low temperature aseptic culture, and considerable variability in aggressiveness is observed within each species. Survival of winter cereals, not infected by fungal pathogens, was generally good throughout the region. Eighty winter cereal cultivars and lines from Ottawa and the University of Guelph (including the Canadian winterhardiness nursery) were evaluated for icing resistance under artificially modified field conditions. Excellent survival was observed in control plots, whereas good differential kill was obtained in plots that were encased in ice in January, enabling plant breeders to select lines with superior icing resistance. Ice encasement damage to Fredrick winter wheat was more severe in plots seeded both earlier and later than the recommended planting date for this area than in plots seeded in mid-September.

### Environmental stresses

Investigations of the effects of interaction among environmental stresses on physiological and metabolic processes of winter wheat seedlings showed that cumulative damage occurs during exposure of plants to a series of nonlethal stresses including flooding at low temperature, freezing, and ice encasement and provided evidence that the plasma membrane is a primary site of injury due to environmental stresses. Studies on the role of icing and exposure to ethanol on membrane properties of isolated winter wheat cells also indicated that the plasma membrane is a primary site of stress-induced injury, and that damage to the ion transport system is the earliest manifestation of this injury. The rate of decline in carbohydrates in winter wheat during icing parallels the increase in ethanol, carbon dioxide, and lactic acid.

Infection of winter wheat with barley yellow dwarf virus progressively reduces cold hardiness and ice tolerance with increasing length of the disease development period. After several months of low temperature growth, the virus further reduces cold hardiness but increases ice tolerance. An investigation of imbibitional chilling injury in soybeans demonstrated that environmental temperature during seed set is a major factor affecting imbibitional sensitivity of the mature seed during germination. Higher temperatures during this period produced seed more susceptible to chilling damage during uptake of water than was observed when seed set at lower temperatures.

Measurements of the degree of freezing tolerance induced by a 24-h desiccation stress at 40% relative humidity was extended to 21 cultivars of winter cereals. A strong correlation has been observed between freezing tolerance of epicotyls due to desiccation stress and cold acclimation. These results have firmly established the validity of using desiccation-induced freezing tolerance as a means of screening for cold hardiness in winter cereals.

The growth coefficients of spring and winter wheat are proportional to cultivar freezing susceptibility from the 2nd to the 5th mo of cold acclimation at 2–4°C. The winter wheat had a rate constant one-third that of the spring wheat in accumulation of dry matter, extension of stem, and respiratory and photosynthetic activity of whole plants.

### Mechanism of freezing injury

A molecular mechanism of freezing injury and tolerance was proposed based on studies with isolated rye cells and liposomes. Roll-up and loss of membranes is associated with susceptibility to freezing damage, whereas infoldings and invaginations are observed in cells and liposomes resistant to freezing injury. An investigation of freezing characteristics of isolated rye cells revealed that the incidence of intracellular ice formation was influenced by cold hardiness of the tissue from which the cells were isolated, composition of the suspending medium, cooling rate, and minimum temperature imposed. Depending on the minimum temperature attained, injury was manifested as either expansion-induced lysis during warming or the loss of osmotic responsiveness following cooling.

## SYMBIOTIC NITROGEN FIXATION

### Legume inoculants

Laboratory experiments were undertaken to characterize the competitive ability of field isolates of *R. meliloti*. Both phage typing and strain identification based on endogenous antibiotic resistance for extension to studies of competitive ability and host influence over strain population dynamics in field soils.

### *Rhizobium* genetics

Methods have been developed for investigation of the megaplasmid-borne multiple clusters of genes coding for the establishment of nitrogen-fixing nodules on legume roots. These methods are being applied to the characterization and modification of the microbial genetic systems responsible for effective nitrogen supply to host plants.

Three thousand transposon-generated mutants of *R. meliloti* were screened, yielding 40 mutants that were defective in either nodulation or nitrogen fixation when tested with alfalfa. These mutants will be used to determine the mechanism of nodulation and symbiotic nitrogen fixation.

Four methods for megaplasmid curing were employed with *R. meliloti*. These included use of acridine orange, ethidium bromide, and elevated temperature under reduced oxygen tension. A total of about 500 putative mutants were tested with alfalfa and although a high frequency of deletions of symbiotic genes was observed, in no instance was there a complete loss of the megaplasmid. Several potentially useful deletion mutants, for nodulation (NOD) and nitrogenase (NIF) genes, were obtained.

The development and testing of a conjugative system to restore the hydrogen uptake (HUP) phenotype to HUP mutants of *A. eutrophus* was completed with all 12 previously isolated mutants. The megaplasmid (PRMB1) containing the HUP genes was not autotransmissable but could be transferred by a mobilizing plasmid. The ability to achieve transfer of PRMB1 among *A. eutrophus* strains is a prerequisite for mobilizing the plasmid into *R. meliloti*. Limited success was met in mating experiments involving the transfer of HUP genes from *R. leguminosarum* into *R. meliloti*.

### Nodule physiology

Optimal concentrations and the ratio of concentrations of calcium and magnesium ions were determined for alfalfa seedlings grown on zero-N media. Total divalent cation concentrations of about 3 m*M* and a ratio of calcium to magnesium of 2 produced the highest total accumulation of dry matter after 28 days of growth under sterile conditions. Measurements of the effects of calcium ion on the bacteroid membrane potential and respiratory activity indicated that this essential cation exerts a major influence on respiration supported nitrogenase activity in symbiotic systems.

Low-temperature (4K) electron paramagnetic resonance spectra of nitrogen-fixing nodules provided a measure of the amount and functional state of the nitrogenase enzyme system, leghemoglobin and heme proteins of the nodule, and bacteroids. The effects of environmental conditions and various alfalfa cultivar – *R. meliloti* strain combinations on the nitrogenase system and the associated support systems will be assessable by this method.

### Plant physiology

The contribution of photosynthesis and translocation to diurnal variation in nitrogenase activity was determined. Nitrogenase activity, which had declined in darkness, increased only after illumination for 0.5 h. It was concluded that comparative tests of nitrogenase activities should be made 3–4 h after the commencement of illumination because of the lag in the supply of photosynthate to the root nodules.

The effects of raising the carbon dioxide concentration and high light levels on growth and nitrogen fixation in alfalfa seedlings were determined. The results showed a marked increase in nitrogenase activity but not of dry matter accumulation.

Comparative growth kinetics of 12 alfalfa cultivars were studied. In the cultivars Apollo, Saranac, and Apica, about 65% of the seedlings growth rate on chemical N was achieved under symbiotic conditions (low N) compared to 45% for the cultivars Thor and Dupuits.

## ENVIRONMENTAL CHEMISTRY

### Bound pesticides residues

Soil-bound $^{14}C$-labeled residues were released by four different physiological groups of microorganisms from an organic soil treated with $^{14}C$-ring-labeled prometryn. The extent to which the different microbial populations released bound $^{14}C$ residues (25–30% of the total) from the $\gamma$-irradiated soil after 28 days incubation did not differ markedly. Analysis of the extractable material from the incubated soil showed the presence of small amounts of the parent compound and its hydroxy- and mono-*N*-dealkylated analogues. The low level of $^{14}CO_2$ ($\simeq$3.0% of the total bound $^{14}C$) observed in the microbial systems indicated that ring cleavage was only a very minor reaction.

The release of bound residues from corn plants treated with $^{14}C$-atrazine was investigated by in vitro incubation of the extracted plant tissue with chicken liver homogenate and bovine rumen liquor. Liver homogenate released bound $^{14}C$ residues from the plant tissues. However, no such release was observed with rumen liquor in an in vitro incubation system. The $^{14}C$-bound residues in plant shoots and roots, mainly present as 2-chloromono-*N*-dealkylated compounds, were released into the incubation mixture and subsequently metabolized to 2-hydroxy analogues.

### Pesticidal activities of secondary plant metabolites

Two sesquiterpene lactones, helenin and isohelenin, were examined for their antifungal activities against 16 species of fungi. Differences in antifungal activities indicated that the two compounds show some species specificity. These secondary plant metabolites may be of potential use as antifungal agents, especially if their activity and specificity can be enhanced through modifications of their chemical structure.

Four sesquiterpene lactones (parthenin, helenalin, coronopilin, and tenulin) were tested for insecticidal activity. With the exception of tenulin, all lactones significantly reduced survival of the confused flour beetle. The $\alpha$-methylene on the $\gamma$-lactone, present in the three active compounds, appeared to be the toxic factor.

## MYCOTOXINS

### Deoxynivalenol production

Some 25 isolates of *Fusarium graminearum* were studied for their ability to produce trichothecene mycotoxins in liquid cultures. One isolate produced high yields (100 mg/L) of 3-acetyldeoxynivalenol. The major factors controlling fermentation included oxygen/carbon dioxide and sugar concentrations, pH, and the source of nitrogen. Fermentation has been scaled up in collaboration with the National Research Council and Atlantic Regional Laboratories to produce approximately 3 g of 3-acetyldeoxynivalenol per month. This 3-acetyldeoxynivalenol is readily hydrolyzed to deoxynivalenol in yields of 85%.

### Field study

The formation of deoxynivalenol, 3-acetyldeoxynivalenol, and zearalenone in *Fusarium graminearum* inoculated field corn was studied over a growing season. During the first 6 wk deoxynivalenol levels reached an average of 580 mg/kg and then declined. Low levels of 3-acetyldeoxynivalenol (average 64 mg/kg) were detected; however, appreciable amounts of zearalenone did not develop until after 9 wk. Once infection was established in the cob, the weather appeared to have no discernable effect on toxin concentrations. The mycotoxins were also detected throughout the plant.

### Processing of contaminated grain

Studies with Quebec hard spring wheat naturally contaminated with deoxynivalenol indicated that milling reduced the mycotoxin level by 80% in the flour, although levels in the bran fraction were higher. Processing the flour into bread further reduced these levels. Treatment of contaminated wheat with ammonia resulted in reduced levels of deoxynivalenol.

### Biosynthesis of mycotoxins

The biosynthetic pathway of secondary metabolites of *Fusarium graminearum* was studied using liquid cultures. A semi-defined medium was supplemented with $^{13}C$-labeled acetate at intervals after inoculation. Maximum incorporation (2–5%) of the radioisotope into the mycotoxins occurred following addition at 6 days after inoculation.

Zearalenone was more enriched than deoxynivalenol or 3-acetyldeoxynivalenol. The specific labeling pattern in deoxynivalenol is consistent with the farnosyl pyrophosphate model. The $^{13}C$-enriched fungal extracts were analyzed by multiplicity sorting and $^{13}C$ homonuclear two-dimensional NMR.

## PLANT PATHOLOGY

### Peach X-disease

Thirty-five plant species were tested as oviposition hosts for *Paraphlepsius irroratus* (Say), a leafhopper vector of the disease. Nymphs were observed on 28 species although the number varied among species. Vanier barley, winter rye, cinquefoil, and *Chenopodium vulvaria* L. were among the more favored oviposition hosts. Avoiding the use of such ground covers in peach orchards could result in lower vector insect populations and possibly less disease spread. *P. irroratus* acquired the disease agent more efficiently from infected annual chrysanthemum than from celery. Nymphs were less efficient than adults in acquiring the pathogen from celery and ladino clover. The incubation period of the pathogen in the leafhoppers was influenced by temperature, requiring an average of 15 days less at 28°C than at 21°C.

### Aster yellows disease

Sensitive serological methods, enzyme-linked immunosorbent assay (ELISA), and immunoelectron microscopy (IEM) methods were developed to detect mycoplasmalike organism antigens in preparations partially purified from 5-g samples of several host plants. Relative concentration of the mycoplasma, estimated by IEM, in aster and celery was about 80 $\mu$g; in periwinkle, oat, and wheat, 40 $\mu$g; and in ladino clover and red clover, 20 $\mu$g/g of leaf tissue. Applications of ELISA and IEM techniques reduced the mycoplasma detection time to about 3 days as opposed to several weeks required for transmission tests. In other studies, it was demonstrated that the aster yellows mycoplasma can be cryopreserved (in a biologically active state) in the vector leafhoppers *Macrosteles fascifrons* Stal for periods up to 6 yr.

### Forage legume diseases

The infection of red clover plants by white clover mosaic virus caused a significant reduction in the plant growth, nodulation, and nitrogenase activity in the nodules produced by *Rhizobium trifolii* in plants. Lucerne transient streak virus (LTSV), newly recognized in alfalfa last year, was found to infect many economically important plants, mostly in the legume family. A method of purification for the virus was developed, which gave high yields of chemically intact virions. A specific antiserum developed against LTSV was used to identify the disease in field samples of alfalfa. The virus was found to be widespread throughout Ontario and Quebec with incidences as high as 31%. LTSV was rare in New Brunswick and was not detected in Nova Scotia and Prince Edward Island.

### Barley yellow dwarf virus

Studies on incidence and pattern of infection in fields, virus variants, and development of aphid vectors suggested that perennial grasses, winter wheat, and corn were of little importance as virus sources for the cereal crops in Eastern Canada. Infective aphid vectors brought in by wind currents from the south were the main sources of virus infection.

## ELECTRON MICROSCOPE CENTRE

Seventy professional and technical staff of the research institutes, seven research stations, and eight outside agencies made use of the facilities of the Centre. The Postal Service responded to requests by research workers at the research stations at Regina, Harrow, Saint-Jean, Charlottetown, and St. John's West and at the experimental farms at L'Assomption and Smithfield.

The Centre contributed to research papers dealing with methodology development, the microstructure of dairy and food products, ultrastructure of fungi in relation to phylogeny and taxonomy, the detection of viruses and mycoplasma in diseased plant tissue and insect vectors, energy-dispersive X-ray analyses of soils, soils extracts and humic and fulvic acids, blood platelets and the rheological aspects of thrombosis, phylogeny and classification of Hymenoptera, pathological changes in plant tissue, and eggshell microstructure. Particulars of these publications appear under the individual listings of institutes and stations.

The capability of the Centre was increased by the addition of a device for the rapid, nondestructive freezing of specimens. An image enhancer was attached to the X-ray spectrometer to improve X-ray mapping of elements in biological and nonbiological specimens. Two new preparatory methods for high-resolution studies of cell interiors were developed.

The Electron Microscope Centre hosted visiting workers from France, Iraq, China, and Poland. Formal training was extended on behalf of international development programs and to local community colleges.

## ANALYTICAL CHEMISTRY SERVICES

Analytical Chemistry Services continued to provide Branch establishments with analyses in support of research projects in areas of soil management and protection, land use, energy production and conservation, environmental quality, production improvement of dairy cattle and poultry, production improvement of cereal, oilseed, forage horticultural and field crops, food processing, and new product development and food safety. Priority analyses were provided regarding the mineral composition of water used in animal housing facilities and amino acid composition of animal tissues for mycotoxin research.

A wide range of research materials were analyzed for constituents such as dietary fiber, fat, cellulose, lignin, ash, caloric value, macro and trace elements, nitrogen, protein, amino acids, carbohydrates, and organic functional groups. Approximately 62 000 determinations were provided to 130 scientists and technical staff of 20 Branch institutes and stations.

Improved methodologies for the measurement of neutral and acid detergent fiber, cellulose, lignin, several metallic elements, and total and reducing carbohydrates were developed and implemented. Automation and computerization of technical and administrative operations were continued by the incorporation of a microcomputer.

Development and preparation were completed of three maize agricultural biological reference materials for chemical composition, in cooperation with the Nutrient Composition Laboratory, United States Department of Agriculture, Beltsville, MD. These and related materials will serve the Section's data quality assurance program and will also be available for use by other Branch and government laboratories.

## MINERAL ANALYSES SERVICES

Thirty professional and technical staff of the Branch and eight outside agencies made use of the services of the Centre for X-ray diffraction, infrared (IR) absorption, Mossbauer effect, and thermogravimetric analyses. The Centre produced 1200 X-ray diffractograms, 350 IR spectra, and 27 Mossbauer spectra and contributed supportive data to research on mineral characterization of Canadian soils, weathering reactions, surface chemistry of clay minerals, clay–organic interactions, and K- and $NH_4$-fixation problems.

The installation of a new and fully automated X-ray diffractometer has increased the quality and versality of these analysis. Particle size analyses and their effects on IR, X-ray, and Mossbauer analyses established the importance of this parameter. Profiles of Yukon paleosols and loess soils were examined by X-ray and IR analyses for depth of weathering. Results indicated that the mixed-layer minerals found were unique to northern, strongly weathered soils.

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| B. K. Thompson, B.Sc., M.Math., Ph.D. | Statistics |
| C. J. Williams, B.S.A., M.Sc., Ph.D. | Statistics |
| M. S. Wolynetz, B.Math., M.Math., Ph.D. | Statistics |
| W. Watt, B.A. | Head, Systems and Programming |
| I. Hall, Cert.Info.Proc. | Systems and Programming |
| K. Heng, B.Sc., M.App.Sc. | Systems and Programming |
| J. D. Hobbs, B.Sc. | Systems and Programming |

## Technical Services

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|---|---|
| J. G. Caron | Head of Section |

## Departures

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|---|---|
| R. D. Hayes, B.Sc., M.Sc.<br>Resigned December 1982 | Biomass and food |
| G. F. Montgomery, B.Sc. (Agr.)<br>Resigned June 1982 | Mechanization |

## VISITING SCIENTISTS

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| C. G. E. Downing, B.E., M.Sc., D.Sc., F.A.S.A.E., F.E.I.C., F.C.S.A.E., F.A.I.C.<br>Retired April 1977 | Former Director, Engineering Research Service |
| G. L. Calver, B.A.Sc. | Contractor |
| F. R. Hore, B.S.A., M.S.<br>Retired December 1979 | Former Head of Section; Water resources |

# INTRODUCTION

The Institute continued to conduct research and provide services in engineering and biometrics. Some 217 projects were ongoing in-house, of which 64 were completed. Results were presented in 100 reports and scientific papers. The kinds of activities are discussed in this report and are indicated by the titles of the publications listed. Contracting out of research and development (R & D) involved 96 contracts on mechanization, buildings, and energy, with a total value of $9.6 million. On an annual fiscal basis, contracting out now represents 60% of the engineering R & D effort.

The major emphasis on energy research in the primary production and processing, distributing, and retailing sectors continued. The energy research and development in agriculture and food (ERDAF) contracting program is now fully operational on a National scale and remains the main initiative in this area, and was funded at $6 million in 1982.

The new food engineering program is now established and work on food physical properties and processing systems is under way. Support to research and regulatory activities in the Department continued with the development of new equipment and instrumentation. Notable is the outcome of the Institute's pioneering work on field spectroscopy, which has demonstrated that crop characteristics can be detected by remote sensing techniques.

## ENERGY

A tractor performance data acquisition system was developed, enabling tests to be carried out efficiently under field conditions. This development will also provide the design for a tractor efficiency indicator. A microprocessor to control ventilation and heating was installed in a calf barn to minimize energy consumption while maintaining a desirable environment.

A research facility to evaluate and optimize the cooling of grain as an alternative method of preserving grain was constructed.

Exploratory field cropping trials of Jerusalem artichoke and New Zealand fodder beets as energy crops continued. Of particular interest is the energy content of the Jerusalem artichoke tops.

A facility to produce and store ice using winter coldness has been constructed for spring and summer vegetable cooling.

A 50-m length of buried drainage pipe is being used to assess the potential of the ground to supply and absorb heat for agricultural ventilation air. The effect of a fluctuating water table was added to the study. Pilot-scale anaerobic digesters were constructed to scale up fixed-film techniques. These digesters are providing design information that is being integrated with contracting-out work to develop full-scale waste management systems in animal production and the processing of food waste.

An apparatus to scrub sulfur and carbon dioxide from biogas was constructed to clean the gas for safe and economical storage for later use on the farm.

Support material was prepared to enable the Department to participate in the funding allocated to energy R & D through the National energy program. An annual contracting out budget of $7 million was planned. It covers conservation in both the primary production and the processing, distribution, and retailing sectors. The use of renewable energy sources such as biomass and solar energy and liquid fuels derived from agricultural products are also included.

A request for 1983–1984 contract proposals was prepared, and 263 proposals valued at $30.7 million were evaluated. Scientific authority was provided for 75 contracts. Technical advice and instrumentation were provided for various contracts.

A 2-day contractor's workshop was held to coordinate the liquid fuels and energy crops activities. It provided a means to integrate the various developments and enhance the overall objectives of the program.

## FOOD ENGINEERING

Research is under way to determine equilibrium moisture in canola. Thermal properties of foods and model systems are being studied in the development of heat transfer data for retort pouch processing.

Excellent results were obtained in microwave processing of mustard. Debittered flour of excellent quality can be produced and yeast infections in oriental mustard can be eliminated without destroying the flavor. Microwave processing was successfully used to eliminate the trypsin inhibition factor in soybeans. Trials on dehydration of locally grown herbs were promising.

Modifications to a commercial laboratory mill have proven successful for very fine grinding of cereal samples to improve their extractibility and allow more accurate analytical work.

The Agriculture Canada/ABCO blancher saw its first commercial sale in the United States during 1982. This unit, developed and manufactured in Canada, was the central item of FMC's display at the International Exposition for Food Processors in Chicago. FMC now have the marketing rights to the blancher.

Preliminary patent disclosure was made to Canadian Patent and Development Limited (CPDL) on a process for the separation and concentration of immunoglobulin from porcine abbatoir blood.

Cells were developed for testing the properties of food powders and gels. A microcomputer-based system for texture data acquisition and manipulation was developed.

## RESEARCH SERVICE

Plot equipment developed included a corn-stalk-slitting guillotine, a corn-stalk-pulling machine with a dynamometer to measure root strength, and a snow-making nozzle to investigate the use of artificial snow for protecting nursery crops from winter damage.

Instrumentation developed included a soil frost-depth meter, a digital filter for anemometers, a grazing timer for individual beef cattle, an electronic counter for rating germinated seedlings, a digital recorder interface for leaf area meters, a data acquisition system for structural testing, and a system for counting and weighing apples from experimental orchards.

Spectroscopic equipment developed included an improved mobile laboratory to measure protein on standing crops, an open-path $CO_2$ greenhouse controller, and a spectroradiometer for individual plant studies that measures and integrates the total spectrum (350–1000 nm) and two partial wavebands.

## STRUCTURES AND MECHANIZATION

### Structures

The Canada Plan Service (CPS) completed 28 plans, 43 leaflets, and 2 bulletins (*Grain handling on the farm; Selection and use of oxygen-limited silos*). CPS is now 72% metric but had to revert back to publishing plans and leaflets in both metric and Imperial versions because of demand. The CPS celebrates its 30th anniversary in 1983.

The first full-scale testing of CPS trusses was completed. Tests done on doubled wood trusses with triple-gusset nailed connections revealed some strength irregularities. An improved design for 12-m-span gable roof trusses failed at 2.95–3.03 times design load, greatly exceeding requirements providing opportunities for construction economies.

Development of fiber–concrete walls and pen partitions for farm buildings was completed, followed by construction of three demonstration buildings, and spin-off technology was applied to many nonfarm buildings. Participation on the CSA Committee on Engineering Design in Wood has influenced new engineering design information. Progress was made in revising the Canadian Farm Building Code, which will be published in 1983. The silo gas problem was studied. More work was shown to be required on gas detectors before extension tubing can be reliably used for safe remote gas measurements in silos. A flexible extension drop-pipe connected into the top of the silo filler pipe improved the reliability of using the forage blower for purging deep silo headspaces to permit safer entry.

Both full-scale and small-scale field tests were used to evaluate nutrient leakage from CPS earth-lined manure storages. Little leakage has been detected. A study was completed on shallow silo foundations on frost-sensitive soils. The safety of two CPS plans was validated, but more information on foundation forces is needed before the cost of the foundation could be reduced.

Preliminary tests on two-tiered pig pens, for production efficiency advantages, were completed in cooperation with the Animal Research Centre. A CPS barn design was evaluated for suitability in the Eastern Ontario climate, beef animals showing a 12% loss in daily gain under these conditions.

Experiments on porous ceiling winter ventilation in barns showed that different ventilation behavior occurs with different ceiling construction.

**Mechanization**

Work on a number of mechanization projects progressed with the development of a range of machines at various stages between initial concept and commercial exploitation. A specialized tractor for use on peatlands was completed; and a soybean seed cleaner for continuous rather than batch cleaning was developed. Bed seeding techniques for vegetables were developed. The tractor has been used successfully for 5 yr at the Colinet substation of the St. John's West Research Station, Newfoundland, permitting bogland operations in severe conditions where drainage is lacking. Designs for bed seeding reduced the machine cost per row by 50%.

Several spinach harvesters were sold by the contractor in Quebec. A new leek harvester was satisfactory on muck soils but the crop needs market development. A multi-pick cucumber harvester was modified and field tested but still harvests a lower proportion of cucumbers than required.

A seed potato planter was developed to reduce costs and increase productivity of seed potato planting operations.

For stalk-cut tobacco mechanization, a curing barn and plastic hold-down structure were designed, and a harvesting aid incorporating curing racks was developed.

A round bale processor was completed. The machine was satisfactorily developed but will not be put into production by the contractor due to current market conditions.

Improvements were made and assessed on a juice apple harvester, a cauliflower leaf tyer, a cucumber harvester, a bare-root transplanter, a peanut harvester, and a Noble blade cultivator. A belt dryer was evaluated with white beans and similar crops. Concepts were originated for a broccoli harvester, an aromatic herb harvester, and a processed strawberry harvesting system.

A computer program to catalog agricultural engineering programs was completed and a catalog published. A study to define a systems program for ESRI was carried out. The Canadian situation was evaluated and compared with the situation at the United States Department of Agriculture.

The agricultural engineering data base was expanded and its accessibility improved through the publication of reports giving details of its contents and the classification system used for inputting and retrieving information. Reports summarizing in-house and contract work, as well as lists of published material, were issued. Accessiblility of the technical and scientific information developed by the Institute was improved by placing copies of all publications and contract reports on the data base at the Canadian Institute of Scientific and Technical Information at the National Research Council of Canada.

## STATISTICS

Support was provided to all Research Branch objectives by the design and analysis of experiments and through the provision of statistical software and training. Consultation and collaboration occurred in studies on trace mineral metabolism, reproductive performance of sheep, beef and dairy cattle production, factors affecting survival and growth of pigs, poultry production and nutrition, egg quality, and breeding for general disease resistance in poultry. Statistical support was provided for the corn, potato, barley, wheat, and canola programs by the design of breeding programs, investigation of genetic parameters, assessment of existing techniques, and designs to improve the efficiency of field experimentation. Characteristics and production methods of tobacco were investigated in support of the less hazardous cigarette program and to overcome the problem of gray tobacco. Food quality, preparation, and storage were investigated for poultry, beef, pork, milk, butter, and yogurt. There was collaboration in quantal assay applications assessing insect fumigants, herbicide activity, and synergism in insecticides. Research was carried out on statistical aspects of covariance analysis, more efficient experimental designs, clustering methods, presentation of data, genotype × environment interaction, crop loss assessment, and bioassay techniques.

All aspects of research were supported by the provision of general and specific computer programs for data entry and analysis on AgriNet and at Datacrown. A program to analyze lattice designs was put on AgriNet. The Statistical Research programs were run 15 000 times during the year.

## TECHNICAL SERVICES

Services were provided to all Ottawa establishments to install, maintain, and modify scientific equipment. A total of 2000 work orders were completed.

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# Food Research Institute

# Ottawa, Ontario

## PROFESSIONAL STAFF

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### Processing Technology and Food Quality

| | |
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| D. Paton, B.Sc., Ph.D. | Program Leader; Processing technology extrusion cooking |
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| B. D. Oomah, M.Sc., Ph.D. | Cereal processing |
| R. Sinha, B.Sc., M.Sc., Ph.D. | Dairy product microbiology |
| I. R. Siddiqui, B.Sc., M.Sc., Ph.D., D.Sc., C. Chem., F.R.S.C., F.C.I.C. | Program Leader; Food quality—carbohydrates |
| R. C. McKellar, B.Sc., M.Sc., Ph.D. | Dairy product microbiology |
| C. Y. Ma, B.Sc., M.Sc., Ph.D. | Protein functionality |
| M. Kalab, M.Sc., Ph.D. | Electron microscopy |
| D. Froehlich,[1] B.Sc., M.Sc. | Sensory evaluation |
| L. M. Poste, B.A.Sc., Dip.Tech. | Sensory evaluation |

### Ingredients and New Product Development

| | |
|---|---|
| P. J. Wood, B.Sc., Ph.D. | Program Leader; Carbohydrates |
| D. B. Emmons, B.S.A., M.S., Ph.D. | Dairy products |
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| M. R. Sahasrabudhe, B.Sc., M.Sc., Ph.D. | Lipids |
| V. R. Harwalkar, B.Sc., M.Sc., Ph.D. | Protein chemistry |
| J. D. Jones, B.Sc., M.Sc., Ph.D., C.Chem., F.R.S.C., F.I.F.S.T. | Oilseed fractionation |
| G. Paquette, B.Sc. | Dairy products |
| J. Weiss, B.Sc. | Carbohydrate analysis |

## Food Safety and Nutrition

| | |
|---|---|
| W. J. Mullin, L.R.I.C., Ph.D. | Program Leader; Analytical methodology |
| R. A. Holley, B.Sc., M.Sc., Ph.D. | Meat microbiology |
| A. Paquet, B.Sc., Ph.D. | Amino acid and peptide chemistry |
| F. Russell, B.Sc., M.Sc. | Nutrient analysis |
| L. Nadeau, B.Sc., M.Sc. | Vitamin analysis |
| S. Yiu, B.Sc., M.Sc., Ph.D. | Microscopy |
| C. Willemot, B.Sc., M.Sc., Ph.D. | Lipid biochemistry |
| B. Picard, B.Sc., M.Sc., Ph.D. | Microbial biochemistry |

### Departure

| | |
|---|---|
| C. G. Zarkadas, B.Sc., M.Sc., Ph.D.[1]<br>Transferred to Agriculture Canada Research Station, St. Jean, Que., 1 April 1982 | Meat proteins |

## VISITING SCIENTIST

| | |
|---|---|
| B. W. Smallbone, B.Sc., Ph.D.<br>National Research Council of Canada visiting fellow 1981–1983 | Lipid chemistry |

[1]On educational leave, University of California, Davis, August 1982–1985.

# INTRODUCTION

The Food Research Institute (FRI) registered good progress toward achieving its goals in 1982. Many effective collaborations were established with the private sector both through research projects and through contracts administered under the plant protein, meat, and processing, distribution, and retail (PDR) programs. The Institute continued to act as scientific authority on numerous contracts funded by the Canadian Dairy Commission (CDC).

Patent applications were filed for a new cereal fractionation process and efforts continued toward commercialization of previously patented rapeseed technology. The development of prototype new food ingredients from a variety of agricultural commodities, particularly in the dairy field, remained a strong program. Effective technical service was provided to other Departmental establishments, to universities, and to the food industry in the areas of sensory evaluation, food microstructure, extrusion cooking, carbohydrates, dairy, and safety and nutrition.

The food safety and nutrition program was further strengthened by the addition of four new staff members. Ms. L. Nadeau is working on vitamin analysis in foodstuffs; Dr. C. Willemot transferred from Sainte-Foy Research Station to work in lipid biochemistry; Dr. B. Picard joined the staff to work on microbial biochemistry relating to nitrite in meats; and Dr. S. Yiu is establishing appropriate microscopic methodology for the identification and localization of minor components in cereals and oilseeds. Ms. L. Poste joined the Institute in sensory evaluation and will head this unit during Ms. D. Froehlich's absence on educational training. Dr. A. Paquet returned in September from a transfer of work at the University of Ottawa and continues research on peptide synthesis.

As this report was in preparation, Dr. J. Holme, the Institute's Director for the past 9 yr, surprised everyone by resigning to take up a senior position in the Canadian food industry. His experience and counsel were major factors in shaping the Institute and its programs to align with the new Departmental thrusts in agri-food policy.

This report covers only highlights of the total program. Further enquiries should be directed to the Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. Holme
Director

# PROCESSING TECHNOLOGY AND FOOD QUALITY

## Extrusion cooking

Treatment of extruded wheat starch with $\beta$-amylase, pullulanase, and combinations of these enzymes indicated that the degradative action in the extruder appears not to produce new starch species. The conversion to di- and tri-saccharides by $\beta$-amylase was similar for all extruded samples regardless of processing conditions. Pullulanase digestion of extrudates did not indicate any more branching than is present in the parent starch. The joint pullulanase–$\beta$-amylase treatment of extrudates indicated that all debranched starch species were linear. These results support the theory that the amylopectin component of starch is preferentially degraded and the extent of reduction is a first-order function of the nominal shear stress and residence time in the extruder barrel.

Some relationships were noted between the changes in structural modification of extrudates and their functional behavior using the Ottawa starch viscometer. The viscosity at 95°C and at the end of the cooling cycle were both lowered as the extent of degradation of the amylopectin component increased. Further, as the average molecular size of starch species decreased, the amount of soluble starch increased. These data are currently being reexamined in relation to the storage stability of extruded starch pastes.

## Meat processing

The thermal shrinkage temperature ($T_s$) of bovine collagen has been studied, for different animal age groups, using differential scanning

calorimetry (DSC). The $T_s$ value of veal calves was found to be about 1°C lower than that for mature beef animals. This difference increased to 1.5°C in 0.15 *M* NaCl and to 2°C in 0.5 *M* NaCl. However at ±2 standard deviations there was considerable overlap of the $T_s$ values, thus eliminating the method as a means of determining whether an animal should be considered in the veal or baby beef category. Through contracts, a new meat parameter for use in least-cost formulation of comminuted meats has been developed.

**Milk quality**

With a view to developing a rapid test for the presence of psychrotroph proteinases in milk, the properties of three extracellular proteinases isolated from strains of *Pseudomonas fluorescens* were examined.

Molecular weights, electrophoretic mobilities, amino acid compositions, and sensitivity to inhibitors were similar to those of previously reported enzymes. One of the three enzymes differed from the others with respect to amino acid composition, sensitivity to heating at 35°C, pH optimums, sensitivity to inhibitors, and substrate specificity. These results emphasize the difficulties inherent in developing tests specific for all psychrotroph proteinases. During these studies, a proteinase assay based on the use of an insoluble protein–dye complex (hide powder azure) was adapted for research purposes. Studies are in progress to assess the use of this method to detect proteinases in milk.

The role of extracellular proteinases in the growth of psychrotrophs in milk has been examined. A mutant strain of *Pseudomonas fluorescens* lacking proteinase grew well on laboratory medium and on raw and sterile milk but failed to grow when casein was the sole source of carbon and energy. The proteinase-deficient mutant was unable to compete with the parent strain in raw milk at 5°C. Extracellular proteinases do not appear to be essential for the growth of psychrotrophs in milk but do provide a selection advantage to the producer organism.

*Gelation of milk proteins.* Changes in the structure of casein micelles of milk subjected to ultra-high-temperature (UHT) sterilization treatment are considered important to the problem of storage gelation. It is believed that the UHT treatment causes the breakdown of casein micelles into submicelles which, upon cooling, reassemble into a new type of micelle that is susceptible to gelation. Electron microscopic examination of casein micelles, fixed at different temperatures including UHT, revealed no indication of gross breakdown of casein micelles, thus ruling out their involvement in the mechanism of gelation of sterilized milk.

**Sensory evaluation**

The Sensory Evaluation Unit has continued to provide a significant effort in collaboration with other researchers in FRI, other Agriculture Canada establishments, provincial agencies, and industrial laboratories in the conduct of sensory evaluation experimentation essential to the programs of these centers. During the past year projects have involved flavor, texture, and aroma evaluation of products such as eggs, beef, and poultry, to study the effects of such factors as processing, feeds, age, housing, and breeds.

The second phase of an egg-quality characteristics study was completed. This study was in response to consumer concerns over aroma and flavor of eggs purchased at the retail level. The effects of egg washing and storage time on the flavor and aroma perception were evaluated on both "clean" and "dirty" producer eggs. "Clean" producer eggs showed no significant differences in aroma and flavor over a 5-wk storage period with the exception of an age effect on "barny" aroma. "Dirty" producer eggs showed significant differences in aroma and flavor over a 5-wk storage period. It was concluded that "clean" producer eggs were not affected by wash water treatment, whereas "dirty" producer eggs were significantly affected.

A collaboration study conducted with the Animal Research Centre evaluated the effects of breed (Charolais and Hereford), diet (silage and silage plus barley), and housing (inside and outside) on the eating quality of beef. Trained panelists evaluated the flavor, tenderness, and juiciness using a descriptive analysis with scaling. There were significant differences found in the sensory parameters of the treatments.

Development and research of new methodology by which to evaluate panel responses in sensory work is ongoing. In addition, workshops, seminars, and personal communication on the part of the Sensory Evaluation Unit continue to provide increased knowledge and

awareness of the importance of sensory evaluation to personnel from industry, government, and universities.

In a cooperative project involving industry and other government agencies, 14 different types of butter wrappers were exposed to four treatments: 400 lx of light for 1 and 6 days and 2000 lx for 2 and 4 days. Wrapped butter was also exposed to light intensities in the range 50–400 lx for 2 days. Results showed that detectable oxidation and flavor deterioration occurred in samples receiving only 2% of 2000 lx for 2 days. Some commercially obtained butter wrapped in parchment showed much higher levels of oxidation than were observed in the controlled experiments. Recommendations are being prepared that butter wrappers transmit no light, with a tolerance of no greater than 1%.

**Baking mechanisms**

Composite blends of wheat and oat flours were evaluated in terms of their bread- and cookie-making quality. Two different oat flours were investigated in composites containing up to 25% oat flour. Dough development time, dough strength, centrifuge water retention, and loaf volume decreased, and mixing tolerance increased as the amount of oat flour in the composite increased. Slight differences existed between the two oat flours in the magnitude of effects, pasting behaviors, and loaf-volume response to oxidants and sodium stearoyl-2-lactylate. There was no significant difference in the rate of gas production of wheat flour and composite doughs. Cookie spread factors increased with increasing amounts of roller-milled oat flour in the formulation, whereas those of commercial oat flour composites remained constant.

The effects of succinylation and deamidation on bread baking and other functional properties of vital gluten were studied. Succinylation increased solubility but the water hydration capacity and baking performance were not affected. Deamidation caused a gradual increase in solubility and decrease in molecular size distribution and baking performance. The results suggest that the bread-making property of gluten depends on the amide content but is not influenced by the charge density of the protein molecules. Egg white solids (EWS) were modified by succinylation and carboxyl modification. The baking performance in a layer cake system was not affected, although the modified EWS were resistant to heat coagulation at pH near neutral.

**Microstructure**

Methodology has been developed for the fixation and staining of fat globules in milk and milk products. The fat globules thus prepared are embedded in a resin and the crystalline microstructure of fat is revealed in thin sections examined by transmission electron microscopy.

Methodology was also developed for the detection of curd granule and milled curd junctions in Cheddar cheese. Traditional, mechanized, and automated cheddaring processes produced different junction patterns in the finished Cheddar cheese and made it possible to trace the origin of the cheese to the equipment and processes used.

Development of microstructure in yogurt was studied by methods developed earlier (rotary shadowing). In heated milk, casein micelles formed a matrix composed of short chains and small compartments in which whey was firmly immobilized. In heated milk, the casein micelles aggregated in large clusters that led to the formation of large compartments; whey was immobilized insufficiently, which resulted in severe syneresis of the milk gel.

Dimensions of the compartments, and hence the extent of syneresis, were correlated with the total solids contents in the yogurts: the higher the total solids contents (within the range of 10–30%), the smaller the compartments and the firmer the binding of whey in the matrix.

Void spaces in yogurt occupied by lactic acid bacteria were clearly evident at the total solids contents over 15%; the void spaces were found to be caused by bacterial action.

Whey protein used to fortify yogurt changed the microstructure of the yogurt by entering between casein micelles and spacing them in the chains over longer distances; in unfortified yogurt the micelles were directly linked with each other.

Emphasis was placed on collaboration with various laboratories and institutions in North America and Europe; a simple technique in which air bubbles are eliminated from vials in which fragile samples are shipped makes it possible to exchange such samples at long distances without damage to the samples.

### Carbohydrates

The work on the collaborative project on tobacco with Dr. N. Rosa (Delhi Research Station) and Dr. G. Woolard (Rothman's Canada) has been extended to the identification and characterization of the water-soluble, cell-wall polysaccharides of cured tobacco leaf laminae (*Nicotiana tobacum* L. 'Delhi 76'). Fractionation of the water-soluble polymer yielded a minor neutral fraction and a major pectic polysaccharide fraction, $\alpha_D^{28}$ + 136.5. Using a combination of acid hydrolysis, paper chromatography, gas–liquid chromatography (GLC), and GLC–mass spectroscopy on the unmethylated, methylated, and reduced methylated polysaccharide has revealed its main structural features. The methylation and sedimentation analysis and further fractionation studies have shown the presence of a polymer exclusively composed of (1→4)-linked β-D-galactopyranosyluronic acid residues and a second pectic polysaccharide containing both D-galacturonic acid and neutral sugar residues composed of L-arabinose, L-rhamnose, and D-galactose. The detection of small amounts of D-glucuronic acid is indicative of the presence of a small amount of an associated acidic arabinogalactan.

## INGREDIENTS AND NEW PRODUCT DEVELOPMENT

### Oats

*Carbohydrates.* Spectral changes in the dyes Congo Red and Calcofluor and staining as observed by fluorescence microscopy with cell wall preparations and polysaccharides from oats, wheat, and barley were abolished by treatment with a specific β-D-glucan endohydrolase from *Bacillus subtilis*, thereby establishing the specificity of the dye binding. Thus cereal (1→3)(1→4)-β-D-glucan can be identified in the endosperm cell walls and inner aleurone cell walls of oats, barley, and wheat, and its fate during processing and digestion monitored both microscopically and chemically.

The interaction of cereal (1→4)-β-D-glucan with Congo Red has been exploited to detect and estimate (1→3)(1→4)-β-D-glucanase activity. Enzyme action in solution, normally monitored viscometrically, could be followed by monitoring the wavelength shift induced in the absorption spectra of Congo Red. The lack of dye-binding ability of oligosaccharide reaction products was exploited in a gel diffusion assay system in which radial diffusion of enzyme into a substrate-bearing gel slab was detected by Congo Red staining. Similar assays for (1→4)-β- and (1→3)-β-D-glucanase were developed using *O*-(hydroxyethyl)cellulose, *O*-(carboxymethyl)cellulose, *O*-(carboxymethyl)pachyman, and (1→3)-β-D-glucan as substrates. The method was applied to monitor (1→3)(1→4)-β-D-glucanase activity in germinating barley, to survey commercial amylolytic enzymes for β-D-glucanase contamination, and to check the purity of enzymes required for cereal cell wall studies.

A new method for analysis of (1→3)(1→4)-β-D-glucan in oats has been refined, based on our previously published technique of precipitation by the dye Calcofluor. In this procedure the precipitated β-D-glucan–dye complex is directly hydrolyzed to glucose, which is analyzed by high-performance liquid chromatography (HPLC). Results agreed well with conventional analysis, and the method has been applied to a study of effect of particle size of cereal fractions on extractability of the β-glucan.

$^1$H- and $^{13}$C-nuclear magnetic resonance (NMR) spectra (Bruker 250, 62.8 MHz) of (1→3)(1→4)-β-D-glucan, curdlan, and laminaran in oats were examined. Good $^{13}$C-NMR spectra were obtained in deuterium-labeled dimethyl sulfoxide ($DMSO_{d6}$) at 90°C. Multiplicity of the signals from the 4-*O*-substituted glucopyranose ring indicated a sequence sensitivity for the $^{13}$C shifts. The 3-*O*-substituted unit signals, however, appeared to be single resonances, indicating a single environment. Thus no evidence was found for significant runs of contiguous 3-linked β-D-glucopyranosyl units in the oat β-D-glucan. Similar results were observed with pure (98%) and crude (75%) β-D-glucan preparations.

Analysis of cereal β-glucan by acid hydrolysis with *M* $H_2SO_4$ at 100°C for 3 h gives lower glucan values than by colorimetric assay. Problems inherent in the analysis of cereal β-glucan and starch by acid hydrolysis techniques were examined, and an improved procedure using 0.5 *M* trifluoroacetic acid (120°C for 1 h) was developed. An improved procedure for starch analysis was developed, in which the starch is first liquified by bacterial α-amylase prior to conversion to glucose for automated analysis using the

glucose oxidase procedure. The bacterial $\alpha$-amylase was shown not to release glucose from $\beta$-glucans.

*Proteins*. Oat proteins were chemically modified by acetylation, limited proteolysis by trypsin, and linoleate treatment. All the modified proteins had improved emulsifying activity and much higher emulsion stability than the unmodified proteins, both in the absence and presence of salt. Water hydration capacity was not affected, whereas fat binding capacity was significantly increased by acetylation and trypsin treatment. Acetylation also increased the yield of protein when compared with oat concentrates prepared by alkaline extraction.

Oat isolates were prepared by isoelectric precipitation of an alkaline extract and by dialysis of a salt extract. Both isolates contained over 90% protein and a balanced amino acid profile, but the alkaline procedure had a much higher yield and the alkaline isolate had a higher essential amino acid content than the salt isolate. The isolates were characterized by various electrophoretic techniques and differential scanning calorimetry (DSC). Globulins were found to be the major protein comparable to or superior than vital gluten and soy isolate, suggesting potential use in selected food systems such as meat and bakery products. The Osborne fractions from oats were characterized by chromatography, electrophoresis, and DSC. Only albumins and globulins showed an endothermic response.

*Lipids*. A method was developed for the measurement of lipase activity (LA) in single grains of oat (*Avena sativa* L.). LA was measured as the increase in free fatty acid (FFA) content by lipolysis of the endogenous lipid in a crushed sample of seed incubated at 38°C for 30 min. FFA content was determined by a modified copper soap method. The dough stage, about 2 wk before the normal harvest, showed the highest LA. Stored samples of mature grains showed 45–50% loss of LA in 2 yr.

Under contract research at the University of Ottawa, LA was assayed in developing oat grains from 2 to 44 days following anthesis. LA in three cultivars (Hinoat, Sentinel, 0A 424-1) was detected at low levels in grains 2–10 days following anthesis. Activity increased as the grains matured and reached maximum levels at 23–30 days. The peak of activity corresponded with maximum fresh and dry weights. Hinoat had the highest activity of 30 $\mu$mol fatty acid released per minute per 100 grains at 23 days. In Sentinel and 0A 424-1, peaks of activity (31.8 and 32.6 $\mu$mol, respectively) occurred at 30 days. LA declined as the grains dried to harvest maturity. In Hinoat, LA was maximum at late dough stage. Lipid and nitrogen contents increased throughout development, both reaching maximums at maturity. During germination a 50% increase in the activity occurred in the first 12 h following imbibition. LA in the embryo, negligible at 24 h, increased during the next 3 days. LA in the rest of the kernel decreased gradually. Oat grain was fractionated by using fine dental drills and abrasive discs to produce embryo, endosperm, and bran layers. Most of the lipase (80–90%) was found in the outer bran layers.

## Oilseeds

Under contract research, the effect of heat on rapeseed during processing (oil extraction) was studied by differential scanning calorimetry to observe changes in enthalpy ($\Delta H$) and the temperature ($T_d$) at which these changes take place.

Heat had a pronounced effect on meal protein solubility in water at various pH's. The phytate solubility in the meal was also decreased with increased heat treatment.

Meals prepared without heat treatment showed a $\Delta H$ of 5.9 J/g protein at a $T_d$ of 88°C, whereas commercially processed meals which are heat-treated had a $\Delta H$ of 2.1 J/g protein at $T_d$ 92°C. The difference in $\Delta H$ between these two extremes was small and consequently of limited use for evaluating the protein solubility of processed meals. Protein solubility varied from 70–80% for untreated meal to a low of 5–10% for heat-treated meal.

Gel filtration separation of solubilized protein from heat-treated rapeseed and recovery of the 12 S and 2 S protein peaks revealed the 12 S protein to have a $\Delta H$ of 6.0 at $T_d$ 96°C, whereas the 2 S protein showed no $\Delta H$ on the thermogram. Dilution of the 12 S protein with the 2 S protein decreased the $\Delta H$ value but did not affect the $T_d$. The $\Delta H$ value appeared to be related to the content of undenatured 12 S protein. In rapeseed meals the $\Delta H$ value appeared to be decreased by other components present in the meal.

The loss in protein solubility (denaturation of the protein) of commercial rapeseed meal appeared to occur in the desolventizing–toasting step where the solvent-extracted meal

was exposed to both heat and moisture. It was concluded that under low moisture conditions and the presence of oil, rapeseed protein can withstand appreciable heat without denaturing the protein. However, under higher moisture levels the protein is much more readily denatured and thereby rendered insoluble.

### Dairy products

*Whey protein denaturation–aggregation.* With a view to understanding and improving the functional properties of whey proteins, a study of the effects of chemical modification of $\beta$-lactoglobulin upon its physicochemical properties and thermal behavior was undertaken. The electrophoretic mobility, optical rotation, fluorescence spectra, and calorimetric behavior were altered by modification of $\epsilon$-$NH_2$ and -COOH groups of $\beta$-lactoglobulin. The thermal denaturation, gelation, and aggregation behavior of succinylated and carbonyl-modified proteins were affected by pH, ionic strength, and protein concentration. Upon heat treatment the chemically modified proteins showed varied extents of unfolding, gelation, and aggregation. The properties that govern the functionality of these products remain under investigation.

*Whey utilization.* A number of whey and casein-based protein ingredients were evaluated in 18 skim milk yogurt formulations to determine if gelation or other vegetable hydrocolloids could be replaced and properly stabilized with dairy proteins. Gelatin was still found to be the best stabilizer in terms of reducing syneresis and was followed by casein-based proteins and whey protein concentrates (WPC). The control samples, prepared with gelatin, had firmness values similar to WPC whereas casein-based yogurts were much firmer.

The casein-based proteins, particularly sodium caseinate, produced yogurts that were generally inferior to gelatin in terms of smoothness and appearance. Yogurts prepared with WPC were very similar in appearance and smoothness to the gelatin control. Use of WPC to totally replace gelatin is not possible in skim milk yogurt because of excessive syneresis, but in milk fortified to higher solids and fat levels, the use of WPC is acceptable.

Scanning and electron transmission micrographs revealed that casein-based yogurts had a high degree of micelle fusion whereas the WPC-fortified yogurts had many fibrous appendages interconnecting the casein micelles.

*Cheddar manufacture.* Two projects have been conducted under contract research to determine if reverse osmosis (RO) and ultrafiltration (UF) can be used to preconcentrate milk for cheese manufacture. Although the use of UF offers no distinct advantages, other than the saving of vat size, RO presents problems. Cheddar prepared from milk concentrated by a factor of 1.5–2 by RO was acid and gritty and preconcentration of cheese milk must therefore be limited to less than 1.5 times.

*Cottage cheese.* Cottage cheese tends to be brittle, mealy, broken, and soft when made from skim milk heated to high temperatures. This heat treatment denatures whey proteins, which then can form part of the curd structure. There is considerable economic incentive to do this, because yields are significantly increased, up to 15% or more. Compared with making cottage cheese from pasteurized milk, it is useful to use more rennet and to cut the curd at a higher pH; careful control of pH is very important. Another important factor is the rate of heating; fast heating, surprisingly perhaps, reduces mealiness and the amount of broken curd, presumably because the pH does not drop as much during cooking. This work has been done with vat pasteurization (79.4°C, 30 min). Work will continue using high-temperature, short-time continuous heating of skim milk.

### Vegetable oils and fats

Representative samples of canola, soybean, and sunflower oils at various stages of processing were analyzed for fatty acids (FA) with particular reference to minor unsaturated FA isomers. Degumming does not alter the FA composition. Deodorization of all oils causes measurable isomerization (2–3%). Some hydrogenated oils (all sources) and products (margarine and shortening) show measurable quantities of *trans,trans*-18:2 and *cis,trans*-18:2 fatty acids.

## FOOD SAFETY AND NUTRITION

### Yeast contamination of mustard seed

The nature of the endogenous toxicity of oriental mustard seed toward a naturally occurring parasitic yeast, *Nematospora*, was

studied. Aqueous homogenates of both oriental and yellow mustard, but not rapeseed, were found to be highly toxic toward artifically added *Nematospora*. When myrosinase in yellow and oriental mustard was destroyed by microwave heating, toxicity was lost. When myrosinase was added back to heated yellow and oriental mustard seed, toxicity was noted. Although myrosinase itself was not toxic, allyl isothiocyanate (produced by myrosinase action on the naturally occurring sinigrin in oriental seeds) was lethal at 20 $\mu$g/g. Yeast infection did not significantly affect oriental mustard seed germination but yeast viability was drastically reduced in seed germinated for 24–48 h at 25°C. By selective use of the continuous-process microwave system, it was possible to eliminate *Nematospora* contamination by heating seed to 65°C at 10% moisture. This procedure has maintained seed viability above 96% even after storage at 22°C for 1 yr. Thus the process may have application for the certification of otherwise diseased oriental mustard seed.

**Poultry hatchery sanitation**

A comparison of available methods for the evaluation of hatchery sanitation practices was made. A commercial swab kit under study was as effective as the reference method for the recovery of *Pseudomonas fragi, E. coli, Proteus,* and *Staphylococcus* and was better for the recovery of *Paecilomyces*. The reference method more effectively recovered *Salmonella hadar* and another pseudomonad.

**Meat microbiology**

A bacteriophage (fri) isolated from a commercial meat starter culture was studied and assigned to Bradley's taxonomic group A. The phage was further characterized as to its morphological and physicochemical properties. Two commercial *Lactobacillus plantarum* starters were sensitive to its lytic action.

A comparison of frankfurter storage life when packed with $O_2$-impermeable film under vacuum or with $N_2$ was made at several temperatures. The pattern of dominance by lactobacilli was similar in all treatments. Notably, $N_2$ packaging was more effective in reducing the development of yeasts and mold. The use of low-temperature storage was a more important factor in reducing proliferation of contaminating microorganisms. Frankfurters packed under $N_2$ at 70°C could be stored for an additional 7 days, were of better acceptability, and showed a lesser degree of undesirable color change when compared with a control.

**Amino acid derivates**

Research in the field of amino acid derivatives has resulted in the preparation of a further series of new reagents that may prove of value in peptide synthesis.

**Nutrient data for Canadian food sources**

*Vitamin C.* The work on field-grown and commercial samples of fresh spinach was continued. Over a 3-yr period L-ascorbic acid content of field grown spinach was found to range from 18 to 93 mg/100 g fresh weight and commercial samples from 8 to 88 mg/100 g fresh weight. In field-grown spinach, variations were noted between cultivars, between spring and fall crops of the same cultivar, and between different crop years. Visual inspection of commercial samples gave some indication of the potential L-ascorbic acid content, i.e., firm, dry, pliable leaves usually gave higher values. It was concluded that spinach is an unpredictable source of vitamin C and should be consumed as soon as possible after harvest.

Cans of tomato juice from the 1980, 1981, and 1982 crop years were assayed for L-ascorbic acid. The products of four major processors gave L-ascorbic acid values of 6.5–14.1 mg/100 g juice, the majority being in the 10–12 mg/100 g range.

*Folacin.* In the past year 40 samples of wheat brans have been analyzed. Initial work on finely ground (–200 mesh) soft white winter wheat bran was followed by analysis of several varieties of soft white winter and spring, hard red spring, and durum wheat brans. It appears that each wheat type has a distinct range of folacin content. The data also suggest that significant loss of folacin occurs during storage and due to grinding. The highest amounts of "free" folacin were found in hard red spring and durum wheat brans, though these wheat types were not the highest in "total" folacin. The amount of moisture used for conditioning the wheats before milling may have some influence on the conjugase activity increasing the "free" folacin content.

### Lipids, fats, and oils

*Beef.* Six solvent extraction procedures for the determination of neutral and polar lipids in beef were comparatively evaluated.

Samples of lean (<5% fat), medium-fat (13–15%), and high-fat (>20%) ground beef were extracted for total lipid by four methods of wet extraction employing chloroform–methanol (CM), *n*-hexane–isopropanol (HIP), and ethyl alcohol–ethyl ether (AE), and by three methods of Soxhlet extraction of freeze-dried material by petroleum ether (PE) or ethyl ether (EE), CM, and methylene chloride–methanol (MM). The purified lipid was fractionated into neutral and polar lipid fractions by silicic acid chromatography and the fractions were analyzed for fatty acid distribution by gas–liquid chromatography (GLC). The Soxhlet procedure employing either PE or EE extracted less than 75% of total lipid, 89% of triglycerides, and 15% of polar lipids from lean beef as compared with other methods, and as the fat content increased from 3 to 20%, extracted amounts of polar lipid that increased to 40% of that extracted by other methods. The fatty acid distribution of the fractionated triglycerides and polar lipids was generally within experimental error for each fraction, irrespective of the method of extraction. The percentages of 16:0 and 18:1 were significantly less in polar lipids than in triglycerides. In addition to significantly higher percentage of 18:2, the polar lipids contained up to 20% of long-chain fatty acids not detected in triglycerides. The Soxhlet procedures with CM or MM were as effective as wet extraction procedures in extracting neutral and polar lipids.

*Poultry.* Neutral and polar lipid in adipose tissue, meat, and skin from the breast, thighs, and drumsticks of broilers and roasters (15 each) were determined. These data are required for input into the Nutrition Data Bank.

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# Land Resource Research Institute

# Ottawa, Ontario

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| H. N. Hayhoe, B.Sc., M.S., Ph.D. | Biomathematics |
| D. W. Stewart, B.S.A., M.Sc., Ph.D. | Crop-weather modeling |

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| W. Bailey, B.Sc., Ph.D.<br>Resigned 1 July 1982 | Climatology |
| A. K. Ballantyne, B.S.A., M.Sc.<br>Retired 3 May 1982 | Party leader |
| B. H. Cameron, B.Sc. (Agr.)<br>Resigned 30 July 1982 | Party leader |
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| P. L. Maharjan, B.Sc., M.Sc.<br>CIDA training fellowship from Division of Soil Science and Agricultural Chemistry, Kathmandu, Nepal | Soil survey |
| E. Ojeda Ochoa, B.S.A.<br>Canada–Mexico Exchange Program, Sinaloa, Mexico | Land evaluation |

# INTRODUCTION

The Land Resource Research Institute (LRRI) has responsibility for national programs in land resources and agrometeorologic services. The programs of the Institute include the national soil survey program, a supporting program in soil classification research, a program involving studies in land evaluation agricultural land use and soil degradation, and an agrometeorological program that includes agrometeorological services, farm weather service, crop-weather modeling, and crop information.

The Institute is organized on a regional basis, with soil survey units located in each of the provinces where cooperative survey work is carried out. The central group in Ottawa is responsible for national correlation and map production, and research in the various aspects of soil, water, and agrometeorological disciplines.

This report gives the outcome of the ongoing activities of the Institute during 1982. More complete information can be obtained from the Land Resource Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. S. Clark
Director

## INSTITUTE ROLES

The activities of LRRI include research, development, and services related to Canada's land resources. These activities not only support other research within the Research Branch but also provide information essential to policy and decision-making for regional and national levels of government, educational institutions, and agri-business. The Institute, in pursuit of these activities, provides leadership and is responsible for a number of national programs related to land, including those outlined below.

*Soil inventory.* Soil mapping is done by LRRI staff in cooperation with provincial and university personnel throughout the nation, and correlation provides quality control on soil maps and reports. Maps are prepared showing the distribution of soils and land capability for various potential uses.

*Canada soil information system (CanSIS).* Soil survey, soil management, crop yield, and cartographic data are stored in a computerized system so as to be available to users throughout Canada.

*Soil taxonomy and interpretations.* Improvements are developed in taxonomic and interpretive soil classification systems through research and integration of information from many sources.

*Land evaluation.* Data on soils, climate, agronomy, and economics are being integrated to develop improved methodology for predicting crop yield potentials and assessing the quality of the land resources of Canada for various uses.

*Agrometeorological data archive.* Agrometeorological data and processing services are provided.

*Crop information system and agroclimatic resources.* Procedures are developed monitoring the areal distribution of growing conditions and crop production prospects from meteorological, environmental, remotely sensed agriclimatic, and crop statistical data. Agroclimatic resources are assessed to provide information for efficient management of agricultural resources.

*Committees.* LRRI contributes to the integration of land-related activities of Agriculture Canada and other federal and provincial agencies through participation in a number of committees. These include:

- Canada Committee on Land Resource Services (CCLRS) and the associated expert committees
- Provincial agricultural services coordinating committees and soil survey committees
- Canada Committee on Ecological Land Classification
- Interdepartmental Committee on Land Use

- Interdepartmental Committee on Water
- Geotechnical Committee of the National Research Council and the Peatland Subcommittee
- Canada Advisory Committee on Remote Sensing
- Committee on Great Lakes Water Quality
- Interdepartmental Committee on Air Surveys

## INSTITUTE PROGRESS AND ACHIEVEMENTS

### Soil resource inventory and mapping

*Newfoundland.* Reports for the Gander Lake, Bonavista, Red Indian Lake – Burgeo, and Terra Nova areas were completed to the technical edit stage. A manuscript report for the Green Bay area was compiled. Mapping was completed in the Port aux Basques–Stephenville area. A manuscript report was completed on the pedoclimatic zone for the island and Labrador. A key to the soils of eastern Newfoundland and official series descriptions were completed.

*Prince Edward Island.* All detailed soil maps were completed and are ready for distribution. The generalized soil map and legend for Prince County was forwarded to the Cartographic Unit. The first draft of the *Soil survey report* is approximately 50% completed. Soil temperature and moisture sites were instrumented for bimonthly monitoring.

*Nova Scotia.* Thirteen soil temperature sites and 10 soil water-table wells were installed. Guidelines were developed for rating soil suitability for alfalfa, spring cereals, and winter wheat. Correlations were conducted in the Hants and Kings counties projects.

*New Brunswick.* Recompilation of the soil maps for the Chipman–Minto–Harcourt area was completed and a draft report prepared. Detailed soil surveys of the Agriculture Canada Fredericton Research Station's main farm and the satellite station, the Senator H. Michaud Experimental Farm in Buctouche, were completed. Monitoring of soil moisture and temperature regimes continued at the Research Station, and a network of 12 new sites in westcentral New Brunswick was established. The field work was completed in the Sussex area.

*Quebec.* About 31 000 ha were surveyed. Mapping was completed in Richelieu and the draft map manuscript was 70% completed. Mapping of peatlands has progressed rapidly, with developed methods being introduced into other sectors in the province. In response to a request of the sugar-beet producers, several extensive clayey soils have been studied: physical tests reveal degradation of soil structure attributable to cultural methods.

*Ontario.* Approximately 23 000 ha were mapped in the Niagara region, and the upgrading of soil surveys was supervised for an additional 870 000 ha throughout the proposed Ontario Hydro corridor study area. Preliminary soil maps for two areas were prepared for printing, and 13 final maps were completed for the Haldimand–Norfolk region. Reports for one county were submitted for printing, and cartographic compilation of soil maps for five map sheet areas of Northern Ontario was continued. A preliminary map of soil landscapes of Ontario was partially completed. Soil data analysis, the correlation of soils with vegetation types, and a report on the ecosystem types of the Claybelt were completed for the Claybelt region. Field guides were prepared and intensive training sessions were given to foresters of the Ontario Ministry of Natural Resources. Reports on soil interpretations for woodland management were prepared for two regions of southern Ontario, and sections on soil interpretations for forestry were prepared for one county soil survey report. A report was prepared for the Ontario Ministry of Agriculture and Food on the agricultural strategy employed by Ontario Hydro in selecting transmission line corridors from the Bruce Generating Station to southwestern Ontario, and it was defended before the Consolidated Hearings of the Environmental Assessment Board and Ontario Municipal Board.

*Manitoba.* Resurvey was completed for 135 680 ha in the Labroquerie–Sainte Anne D49, Westbourne D51, South Norfolk D52, Montcalm–Rhineland D53, and Russel D54 municipalities. Reports were completed to publication stage for Flin Flon D48 and south central D17. Reports were published for The Pas R19, Pelican-Rock Lake D19, West Portage–McGregor D20–D44, West Interlake D36, Duck Mountain D42, Pine

Creek D45, and Brandon City D50. The south half of a 1:1 million soil map of Manitoba and the 1:1 million soil salinity map for the province were completed. Land evaluation studies were continued or initiated to review irrigation standards for rating soils; evaluate irrigation suitability of soils in southern Manitoba; complete a detailed study of drainage requirements of soils in the Assiniboine–South Hesplar irrigation project; develop a land productivity model for Manitoba and the prairie region; and monitor crop growth conditions for four sites in southern Manitoba.

*Saskatchewan.* Mapping was completed on approximately 210 000 ha in the Melville–Riding Mountain area and initiated on another 167 000 ha in the Battleford map area. A report on the Wolseley rural municipality was published and report writing continued for an additional eight municipalities. Improved methods for handling soil survey data and making soil interpretations were developed. A report for the Swift Current map area was published and report writing continued for the Amisk–Cormorant Lake and Weyburn–Virden map areas. Maps showing the extent of salinity and sensitivity to salinization and the degree of extent of acid soils were completed. Research on the nature of soil acidity was continued. Studies were undertaken to characterize the soil morphology, chemistry, and mineralogy and to investigate genesis and erosion characteristics of clay soils.

*Alberta.* The Yoho report and a 1:1 million map of Solonetzic soils in Alberta were published. Interim maps and legends were made available for Warner County. A depth-to-bedrock map and its correlation with saline seep problems in the County of Warner have been well received and are being extensively used. Field tours for county, research, and extension personnel have created an awareness that soil erosion is a more extensive problem than salinity. A new survey was initiated in the Cardston area with about 85 000 ha mapped and four new soil temperature monitoring stations established. Field mapping in Mount Revelstoke, Kootenay, and Glacier national parks was completed and map compilation is under way. Land evaluation concerns have generated several cooperative projects with provincial agencies.

*British Columbia.* The completion of three medium-intensity soil surveys in the Cariboo area (Quesnel, Horsefly, and Barkerville) will assist forest and rangeland managers in the planning and development of their resources. Information from the more-intensive soil surveys of important Gulf Islands (Saltspring, Galiano, the Penders) will provide important soils information and interpretations for land planners, farmers, foresters, biologists, and others.

*Yukon.* A qualified person has been recruited to serve as unit head based in Whitehorse. Field studies were conducted in the McQuestern area in cooperation with personnel of Geological Survey of Canada to elucidate soil-forming processes in the area, and to plan future cooperative projects.

*Northwest Territories.* Sites were prepared for the International Permafrost Conference tour in 1983, and the soils section of the guidebook was completed. A field survey was conducted in the Great Bear – Slave River map area.

*Ottawa.* The soil survey project plan document was completed and distributed for use on new projects. The correlation document was tested on new projects. The CanSIS manual for describing soils in the field was revised and submitted to Research Program Service for printing. Small-scale generalized soil landscape maps and legends were compiled, or contributed to, for the Canada Land Inventory areas of Saskatchewan and Manitoba and for southern Ontario. A working legend and ecodistrict maps for Canada Land Inventory areas of Saskatchewan and Manitoba were developed in consultation with Lands Directorate personnel. An aridity index map for perennial grasses in Saskatchewan was compiled. A draft manuscript was compiled on the soil water investigations methods manual. Section 400 of the *Soil survey procedures handbook* was sent to provincial members for review, and editorship of other sections was assigned. Peatland survey methodology studies were conducted in the St. Lawrence Lowland and Pacific Coast regions, and a methodology workshop was organized and convened. Twelve chapters of a book entitled *Soil landscapes of Canada* were written, reviewed, and revised. A draft manuscript of another book entitled *Soil survey procedures in forested lands* was compiled. All of these activities on manuals, project

plans, and correlation procedures are dedicated to the improvement of national standards and increased efficiency.

*Cartography.* The Cartographic Unit completed 106 maps for Agriculture Canada and Environment Canada. All maps scheduled for 1983–1984 were digitized and are continuing on schedule. Five special projects, including two public displays, were completed. For all branches of Agriculture Canada 144 miscellaneous projects were completed. For the Canada soil information system 150 maps were completed and 270 derivative maps produced.

**Soil classification**

Research by the Soil Classification Section supports soil inventory and interpretations and adds new information on soil properties and genesis. Progress is reported for each of the three projects: organic soils, mineral soils, and soil water-structure.

*Organic soils.* In the context of subsidence-mitigating effect of Cu in organic soils, various levels of Cu in organic and mineral soils, and in mixtures of the two soils, were used in greenhouse and field studies with several different crops to find a criteria for setting a safe-loading limit for Cu in soils. The results showed that Cu becomes phytotoxic only when its total amount in soil is in excess of the equivalent of 5% of the soil's cation-exchange capacity. The studies also revealed that incipient Cu phytotoxicity was best indicated by foliar Fe-to-Cu and Zn-to-Cu ratios of less than 4 and 2, respectively.

The Ontario system of land capability rating for organic soils was examined and tested in several field trips in Ontario, Quebec, British Columbia, and New Brunswick in the light of agronomic performance. Several modifications pertaining to degree of decomposition, kind of peats, and underlying materials were proposed.

A method for quantifying plant macrofossils in peat materials was developed and tested. Multiple counts of not less than 500 fragments obtained from five different size fractions for each peat sample constituted the basic elements; these were used to define and identify the main botanical components.

A system for describing the micromorphology of organic materials at low magnification was developed. The descriptive system bridges the gap that exists between macromorphological descriptions of organic soil horizons and descriptions at the cellular level using high magnifications.

Six research papers and 11 miscellaneous articles were published on various aspects of organic soils.

*Mineral soils.* The genesis and weathering sequence of some nonglaciated soils in Quebec has been studied. A near pure halloysite (rather uncommon in the North America environment) was found in a saprolite soil of Mount Jacques Cartier and indicated an advanced degree of weathering.

The remnants of saprolite (deeply weathered rock) were found in several locations of the Appalachian region, and advanced weathered clay minerals were found 15 m below the bedrock surface. In spite of the glaciation of this region of Canada, some saprolite remnants remain.

An improved method for the analysis of kaolin minerals by scanning electron microscopy and energy dispersive X-ray analysis (SEM-EDXRA) was developed. The new procedure permits the separation and identification of individual clay particles while improving X-ray analysis and obtaining better photographs.

An effective method for the removal of suspended material from pyrophosphate extracts of soils was developed. The new method combines the use of a floculating agent (Superfloc) and centrifugation; it is recommended for tropical soils and for soils giving doubtful results with centrifugation.

Four research papers and seven miscellaneous articles were published or are in press.

The soil service laboratory analyzed some 3500 soil samples, mainly from soil survey units in the Atlantic Provinces, Ontario, and British Columbia, and all sections of LRRI in Ottawa. In addition, a large number of water samples, various soil extracts, manure samples, and other samples were analyzed (approximately 25 000 total determinations). Some soil analysis was done for other agencies of Agriculture Canada and for other federal agencies.

*Soil water-structure.* The application of the time-domain reflectometry (TDR) method for measuring soil water has progressed both through the completion of the prototype instrument on the pilot industry laboratory program (PILP) contract and also by completion of some in-house evaluation of TDR. The technique has considerable potential for wide application.

A study of the soil water regime showed that the capacity of the soil to transmit water (hydraulic conductivity) could be estimated satisfactorily from observations of soil morphology. Therefore, soil porosity should be included as a basic aspect of structure description for interpretation based on structure.

Intermittent infiltration and evaporation from soil columns were studied and results showed that for a saline sodic clay soil the evaporation from the soil columns was similar to that reported for nonsaline coarser textured soil. It was possible to predict the amount of evaporation using analytical, numerical, or empirical models, provided the necessary assumptions and conditions applying to each model were met.

Porosity measurements obtained both from point counting on thin sections and from water desorption curves revealed good qualitative relationships. The study also showed that soil shrinkage affected the pore geometry of both the thin sections and the desorption data from soil cores.

Seven papers and two miscellaneous articles were published or are in press.

**Land use and evaluation**

The land use and evaluation program undertakes to develop improved techniques for integrating and interpreting soil climate, landform, agronomic, and economic data to evaluate the production potential of land for alternate agricultural uses. Progress for each of the projects is as follows.

*Canada soil information system (CanSIS).* A major effort was made to utilize the new VAX computer, and this has resulted in some cost savings, primarily in job submission. Additional savings cannot be expected unless the VAX installation is reconfigured. Progress was made in Alberta and Saskatchewan on provincial application of the performance–management file, with the development of cooperative projects. These developments will be pursued further in other provinces and through the Expert Committee on Soil and Water Management. A preliminary version of a CanSIS user's policy and a national assessment of soil survey needs were completed. Aspects of these will be used in the development of a long-term plan for CanSIS.

*Crop production potentials.* Potential yield models (1:5 million) were completed for sunflower, rapeseed, oats, barley, and sorghum. The results have been partially verified but require further work. Preliminary estimates of soil moisture for Saskatchewan soils were made, and a computer file of soil physical variables was created. A study of crop yields on the major soils of Alberta was partially completed and progress was made on the development of a very large, integrated computer file of Alberta soils (4-yr project). A study was carried out to interpret the effects of high water tables for crop production in Manitoba.

Work on cereal models for the Great Plains is continuing under contract in Manitoba. The contract for a forage model for the Peace River area has been completed favorably, and the final report is pending. Results of this latter contract have been applied by the British Columbia Ministry of Agriculture.

*Land resource protection.* Reports and papers have been prepared on measuring the deterioration of soil structure, agronomic effects of pipeline construction, earthen storage structures for manure management, and soil management practices for improved water quality in the Great Lakes Basin. Some of these have been used as background papers for conferences and symposiums, and have been applied to the planning and construction of new pipelines. The extent of soil erosion in the Peace River area was reported in a poster session at the Canadian Society of Soil Science meetings. The Research Branch bulletin on soil erosion has been revised, and a new bulletin on agriculture and water quality was prepared. A working group was established to prepare criteria and procedures for interpreting soil survey data for soil degradation assessment.

Under contract, soil erodibility in Ontario was related to frozen soil layers, soil density, and surface water content. Also, the study of design criteria to reduce the maintenance costs for municipal drains has resulted in a preliminary manual, which will be published. This should significantly reduce maintenance costs of drains, which currently are about $10 million annually in eastern Ontario alone.

*Land use and socioeconomic evaluation.* Reports and papers were prepared on crop production assessment for Eastern Canada, land use inventory procedures, soil resources in Canada, and land use and tenure changes. Also, a user's manual describing the land potential data base was prepared. Some of these publications were used as background documents for the Eastern Grains

Conference. Also, hydroelectric companies used some results to calculate the economic impact of transmission lines.

The land evaluation contract team at the University of Guelph produced reports discussing land needs for urbanization, the effects of food import restrictions and land degradation, and alternate agricultural development strategies for Ontario. Some of these have been packaged into an agricultural development proposal for Ontario and submitted for funding.

**Agrometeorology**

The major challenge facing agriculture is to adapt to the extremes of weather and climate. The Canadian climate is extremely variable in both time and space; consequently, its impact can be far-ranging and most disruptive. For this reason, a very high proportion of research and development within the Research Branch can be considered in response to climatic variability. The possibility that the climate is changing because of an ever-increasing carbon dioxide level adds to the need for greater understanding of biological and physical processes and their interaction.

*Crop environment assessment.* With the greater interest in the global carbon dioxide ($CO_2$) balance and climatic change, the rapid large-scale determination of $CO_2$ exchange has become very important. Using a Twin Otter aircraft equipped with temperature sensors, a gust-probe assembly and doppler radar for determination of high- and low-frequency components of air motion, and an open-path infrared $CO_2$ analyzer, the feasibility of this methodology was established on two counts: it could distinguish clearly between fluxes from ecosystems with greatly varying $CO_2$ exchange characteristics; and a reasonable order of magnitude of fluxes was measured by an airborne eddy-correlation technique. This research indicates a practical application in order to measure directly biomass productivity. It also provides a technology that makes it possible to obtain rapid estimates of crop growth, plant viability, and ultimate yield over large land areas.

A wheat yield-protein model system has been intensively evaluated to estimate accumulated N from meteorological data. Extensive modifications were carried out to increase the association between derived N values and the various meteorological factors affecting plant growth and N accumulation. The simulated N patterns are agreeing with experimental plant studies reported in the scientific literature whereby most of the N uptake occurs during early phases of plant development.

The software for operationally estimating crop yields for Western Canada (Williams' model, 1981) was fully revised to minimize operator's time and computing costs. The software was used to calculate yields for the four Prairie Farm Rehabilitation Act (PFRA) drought periods (1934–1937, 1947–1948, 1954–1955, and 1958–1961) using the complete network of station data for Manitoba and Saskatchewan obtained under the PFRA agreement. The results are being evaluated as yields for crop districts for the respective years (1934–1937, 1947–1948, 1954–1955, 1958–1961). All climate station files were reviewed and period of records completed for missing periods. Number of stations with complete records were doubled for these years under agreement with PFRA. In addition, weekly yield estimates of cereal crops were provided for 42 crop districts in Western Canada from 1 May to 31 July.

*Agroclimatic resource assessment.* Agroclimatic resource assessment has become an integral part of forage crop zonation work designed to improve production and management recommendations in the Atlantic Region. Accumulated growing degree-days above 5°C (GDD) in spring are used to estimate critical maturity stages in several forage species for first cut. GDD's remaining in the fall are used to indicate probable variation in the critical fall period during which alfalfa and possibly other species susceptible to winterkill should not be harvested. The length of season between specified GDD's accumulated in spring and remaining in fall is used as a criterion for designating variation in suitable cutting frequencies of forages. Finally, simplified moisture criteria based on rainfall and estimated potential evapotranspiration are used to describe regional differences in hay-making conditions and in the likelihood for moisture stress during summer months.

Freezing temperatures in the spring and fall are a major constraint to agricultural production in Prince Edward Island. Relatively detailed estimates of spring and fall frost risk are available for selected areas within the province. Freeze (frost) maps at a 1:10 million scale are being prepared in

cooperation with the Prince Edward Island Department of Agriculture and Forestry.

A system was developed that incorporates a computerized grid mesh technique for determining the Thiessen weighting factors to estimate areal averages from point data. The system requires the latitudes and longitudes of climatological stations, as well as boundary coordinates obtained from digitizing a map showing the crop-reporting districts. The package of computer programs includes transformations that reduce climatological station coordinates and digitized crop district boundaries to a common rectangular coordinate system. The effectiveness of the procedures is demonstrated numerically and graphically through the use of the SyMAP computer mapping program. This system was used to estimate crop yields in Western Canada, utilizing current weather and soils data.

An investigation was made to evaluate the applicability of the equations derived by Clapp and Hornberger to estimate soil water characteristics, using data selected from Canadian soils. This approach would reduce the need for extensive laboratory measurements of soil water characteristics for large areas of soil that display a certain degree of homogeneity in terms of texture. Measured soil water characteristics can be adequately described by a power curve. The averaged coefficients that characterize this power curve were found to be similar to the ones reported by Clapp and Hornberger (1978). Regression analysis showed a satisfactory agreement between measured water contents and those predicted from the Clapp and Hornberger parametric equations for all textural groups, except the loamy sand and clay loam groups. For specific individual soils the prediction equations were found to be less applicable, and dependent upon the selected variability criteria.

The effects of frequency and quantity of irrigation water applied under intermittent ponding conditions were studied. The effects considered were cumulative evaporation, and patterns of the water content and salt profiles for a saline-sodic clay soil. The results from a diffusion based numerical deterministic model, an empirical model, the versatile soil moisture budget, and an analytical solution of the soil water flow equation were compared with the experimental measurements. The numerical solution to the Richards' equation gave satisfactory estimates of evaporation for the latter stages of the experiment, but in the earlier stages it underestimated evaporation because of the too deep distribution of water in the soil given by this model. The "versatile soil moisture budget" empirical model also gave satisfactory prediction of evaporation, but the successful prediction of water content profiles depended on "field capacity" values measured in situ.

In order to enhance the physical–biological contribution toward crop-weather modeling, a field experiment working with three crops (corn, soybean, barley) on four soil types was initiated. Growth and environmental data were collected to test a nonlinear model developed to estimate crop yields, to provide data for a water stress-sensitive phenological index, and to quantify the significance of osmotic adjustment to production over a growing season.

Additional work in water use by field crops has resulted in development of two physically based models, one on stomatal response to water stress and the other describing the transpiration process. Concepts from these relatively detailed models are being incorporated in the more generalized crop growth and yield model mentioned above. In addition, a simple field measurement, basal leaf water potential, was evaluated as an indicator of field crop water stress.

*Operations management.* The Agrometeorology Section, in addition to carrying on original research, cooperates with other agencies in national programs relative to specific problems involving weather and climate. One of the most recent involvements and most significant is the Canadian climate program (CCP). This program, initiated by the Atmospheric Environment Service, is an interdepartmental, interdisciplinary approach to facilitate greater usage of climate and weather in economic planning and environmental management with a special emphasis on agriculture. There remains a great need for fundamental research into a number of problems concerning plant–weather relations, the effects on animals, and general farm operations. A large number of central issues are outstanding and require immediate attention to include land use, yield assessment, soil degradation, pollution, disease, pests, and so on.

Field data collection projects have resulted in data sets that will form the basis for

analysis and model development to characterize snow cover features related to soil temperature and overwintering of plants and insects and to study the role of spring conditions on micro-environment features pertinent to pest and disease development and persistence. Soil temperatures for northern Manitoba were simulated to provide insight into the life cycle of the bertha armyworm. Weather data files for Roblin, Swan River, and Dauphin, Man., were prepared and used as input to a soil temperature model. The winter soil temperatures as predicted were used for input into a bertha armyworm temperature-based survival model. Similarly, data sets were constructed associating observed grasshopper populations with geographic locations as related to rural municipalities in Saskatchewan. Such data sets were then used as input to generate 3-D displays of spatial variations as related to grasshopper population densities.

Information services of the future rely heavily on computer-generated techniques and models. This may include weather observations, biological information, data handling, interpretation, and dissemination of the finished product. Agricultural producers need information that pertains to their individual enterprises. Therefore it is imperative that any delivery system of the future be tailored explicitly to meet the "farm-gate" needs. Utilizing Telidon technology, graphic displays and text on soil moisture conditions, growing degree-days, and other agrometeorological information were provided on a real-time weekly basis throughout the growing season. Standard climatic data as observed at 66 stations in the prairies was used to drive various computer programs to generate the required information. This information was made available to subscribers on the current "Grassroots" service to agricultural users. Because much of the advisory content is based on the monitoring of past and present weather, the reliability and thus the usefulness of the information is greatly enhanced, making a substantial contribution to operational decision-making on a day-to-day basis. In this same context, the soil moisture evaluation project (SMEP) was continued in 1982 and provided "real-time" information on the availability of soil moisture for the 42 crop reporting districts in Western Canada. A total of 22 weekly reports was distributed to researchers, grain elevator agencies, PFRA, and various provincial departments.

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# Research Program Service

# Ottawa, Ontario

## PROFESSIONAL STAFF

### Administration

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| D. W. Friel | Administration and awards |
| W. L. Fettes | Branch liaison |

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| C. N. Halchuk | Art and design |
| W. G. Wilson[2] | Photography |
| G. Bourgon | Acting, Photography |

### Scientific Editing

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|---|---|
| J. A. Perrin,[3] B.Sc. | Head of Section |
| D. M. Archibald, B.A. | Acting Head of Section |
| S. V. Balchin | Editing |
| N. Rousseau, B.A., M.A. | Editing |
| S. M. Rudnitski, B.Sc. | Editing |
| F. Smith, B.A. | Editing |
| J. M. Tomlinson, B.A., M.A. | Editing |

### Scientific Information Retrieval

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| J. Taky, B.A., B.Sc. | Head of Section |
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| J. S. Kelleher, B.Sc., M.Sc., Ph.D. | Biological control |
| H. S. Krehm, B.A., M.A., Ph.D. | Fungicides and insecticides |
| C. D. Laing,[2] B.Sc., M.Sc. | Inventory |
| J. Whelan,[4] B.Sc. | Systems |

## Departures

| | |
|---|---|
| M. M. Ellis<br>Deceased 22 April 1982 | Text processing |
| D. Presley<br>Resigned 29 January 1982 | Systems |
| A. Thomassin, B.A., B.A. (Geog.)<br>Resigned 7 September 1982 | Editing |

[1]Appointed 5 July 1982, on secondment from Branch Headquarters.
[2]On Official Language Training.
[3]Seconded to Branch Executive.
[4]Appointed 23 August 1982.

# INTRODUCTION

Research Program Service supports research and development in the Branch by maintaining computerized scientific and technical information systems, providing publications services, and administering Branch awards and international scientific exchange programs. The Service is divided into four sections: Administration, which contains the Awards, Branch Liaison, and Text/Word Processing units; Graphics, which contains the Art and Design and the Photography units; Scientific Editing, which contains the English and French editing units; and Scientific Information Retrieval, which contains the Biocontrol, Systems, Pesticides, and Inventory units.

The Scientific Information Retrieval Section developed a computerized Research Branch project system to supplement and improve upon the Branch's already close monitoring of progress in federal agricultural research. The Administration Section continued to administer the programs for operating grants, extramural research grants, and visiting fellowships and to coordinate international missions and visits along with Canada/France, Canada/Japan exchange programs. News of happenings in the Branch was circulated to all staff members in seven issues of *Tableau*.

The Graphics and Scientific Editing sections continued their high-quality production of Departmental and Branch publications. A new technical bulletin series was started, and in addition new specifications for Branch publications evolved during 1982, which proved to be a boon to authors, editors, and artists alike.

Further information can be obtained from the Director, Research Program Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Jean-Claude St-Pierre
Director

## AWARDS AND BRANCH LIAISON

Research Program Service continued to administer the extramural research grants, operating grants, visiting fellowships, and scientific exchange programs during 1982.

Under the extramural research grants program, specific research projects are solicited from university scientists to augment current research programs. The program is the responsibility of a Departmental committee appointed by the Deputy Minister. In 1982, a total of 72 applications were received.

Operating grants are awarded to individual researchers at Canadian universities as contributions toward the costs of proposed research projects that will be of value to the agricultural industry. The selection committee is made up of three representatives from Agriculture Canada and seven from faculties of agriculture and veterinary science. In 1982, the committee received 277 applications.

The visiting fellowship program gives promising young scientists, from all over the world, the opportunity to work with distinguished researchers in their respective fields before embarking on careers in scientific research. The program is administered by the Natural Sciences and Engineering Research Council on behalf of Canadian government departments and agencies. Research Program Service acts as liaison between the Council and Agriculture Canada. In 1982, there were 312 applications for fellowships in the Department.

The Branch Liaison Unit arranged for 25 delegations to visit Branch establishments during the past year: five from the People's Republic of China, four from France, three each from Czechoslovakia and the USSR, two each from Zaire and Hungary, and one from Somalia, Israel, the Philippines, Denmark, Egypt, Thailand, and Japan. The Unit also made arrangements for 10 delegations from Canada: two to Romania, one to the USSR, and eight to France.

## GRAPHICS

A wide variety of services in research photography and art production and illustration were provided to the Branch and other agencies within the Department.

The turnaround time for graphics jobs was 10.5 days, 0.5 day less than the standard of 11 days established in 1981. Standards for cover design and preparation of camera-ready texts for printing established in 1981 helped in alleviating some of the work load in the Art and Design Unit.

A new in-house information system for recording, monitoring, and analyzing Graphics jobs has been developed in order to more closely relate resources used to product output. In addition, a new job evaluation card system, used to evaluate client satisfaction, has confirmed the high quality of the graphics being produced.

Specifications for Branch publications evolved during 1982, and as they became fully operational much time and effort were saved with the deletion of much of the checking between authors, editors, and artists that had been commonplace in the past.

## SCIENTIFIC EDITING

This Section continued to help meet the technology transfer requirements of the Research Branch by providing editorial services for scientific and technical publications of the Branch and Department.

A total of 45 Departmental and 100 Research Branch publications were produced during 1982. This output represents an increase of 29 publications over the total number produced in the previous year. Some of the publications issued during the year were: *Prairie grasses identified and described by vegetative characters, Growing trees in Canadian gardens/La culture des arbres dans les jardins canadiens, Home vegetable growing/Le potager, Feeding beef cows and heifers/Alimentation des vaches et des génisses de boucherie, The insects and arachnids of Canada Part 9, Sac spiders of Canada and Alaska, Growing and managing alfalfa in Canada/Culture et régie de la luzerne au Canada, Pesticide research report, Pesticide information newsletter,* and *Tableau.* A new Research Branch technical bulletin series was started in order to provide timely publication of research results for technology transfer to specialized audiences.

In 1982 a revenue of $111 000 was generated by the sale of Research Branch publications through Supply and Services Canada.

Guidelines for the preparation of camera-ready manuscripts were established and distributed to all Branch establishments.

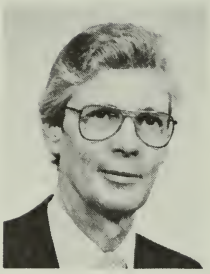
## SCIENTIFIC INFORMATION RETRIEVAL

A computerized Research Branch project system has been developed by the Scientific Information Retrieval Section (SIRS). This system is intended to supplement and improve upon the Branch's already close monitoring of progress in federal agricultural research. The system will become available to all Agriculture Canada research establishments by 1 April 1983. SIRS has also sustained its emphasis on development of a national computerized pesticide research information system (PRIS). Phase II was completed in 1982. The section also prepared for an update of the inventory of Canadian agricultural research (ICAR), which will become publicly accessible in 1983 through the Canadian Institute for Scientific and Technical Information (CISTI).

In addition, the Biocontrol Unit of SIRS has imported, reared, and distributed, among other foreign parasites and predators used as biocontrol agents, a record 48 112 *Anastus disparis*, a gypsy moth parasite.

# ATLANTIC REGION
# RÉGION DE L'ATLANTIQUE

Dr. E. E. Lister



Dr. W. B. Collins

Mrs. S. M. Bowes

## EXECUTIVE OF THE ATLANTIC REGION
## *L'EXÉCUTIF DE LA RÉGION DE L'ATLANTIQUE*

**Director General**
***Directeur général***
E. E. Lister, B.Sc., M.Sc., Ph.D.

**Program Specialist**
***Spécialiste en programmes***
W. B. Collins, B.Sc. (Agr.), M.Sc., Ph.D.

**Regional Administration Coordinator**
***Coordonnateur de l'administration régionale***
S. M. Bowes

# PREFACE

The Atlantic Region, with headquarters in Halifax, consists of four research stations, two experimental farms, and two substations. These research establishments serve the agricultural communities in New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland. In 1982, the Region managed a budget of $16.7 million and employed 92 professionals to carry out its various programs.

The new Hervé J. Michaud Experimental Farm was officially opened during the year. All stations in the region now house both federal and provincial personnel. This arrangement facilitates cooperative approaches to solving the agricultural problems of the region. Establishments regularly interact with the Regional Development Branch in the planning and delivery of regional development initiatives.

In livestock and livestock feeds research, the economic advantage of utilizing locally available feeds, especially potatoes, was confirmed. The usefulness of computer modeling systems in indicating management systems that have economic potential under well-defined sets of circumstances was also verified. The incorporation of fish silage into swine rations as a protein source was shown to be a viable alternative to other protein sources, in terms of feed conversion and carcass quality. It was conclusively demonstrated that aspirin is not effective as a pharmaceutical for sudden death syndrome (SDS) in poultry; that the micronutrient dietary component is not involved with the incidence of SDS; and that fats are not involved, but that dietary protein may play an important role. Preliminary indications are that an interaction between the dietary protein and the steam pelleting process is a factor in SDS.

In cereal research, a better understanding of the complex of *Fusarium* spp. affecting wheat was achieved, including the determination of the effects of crop rotation and environmental conditions on infection levels and the elucidation of the interaction among various species in the development of toxins. Milling-quality potential was defined for the German cultivars Monopol, Absolvent, and Max grown in the region. Field management techniques, particularly for nitrogen application, were shown to be critical in the production of milling-quality wheats. The use of an effective seed fungicide produced a significant increase in barley production, by supressing foliar lesions caused by *Pyrenophora teres*, net blotch.

In forage crops research, significant advances were achieved in the development of biological controls for forage crop pests. The alfalfa blotch leafminer was successfully parasitized by the introduced parasite *Dacnusa dryas*; *Longitarsus jacobaeae*, an insect enemy of the tansy ragwort, was firmly established in Prince Edward Island. Annual ryegrasses have become an integral part of forage programs on many livestock enterprises in the region, mainly owing to developmental work done by Branch scientists.

Developments from the horticultural research program include the widespread commercial acceptance and superior performance of two recently released cultivars, Kent strawberry and Shepody potato. Kent has proven to be widely adaptable, and demands for planting stock have come from throughout North America. Producer and processor acceptance of Shepody indicate that it may replace Russet Burbank as the premier processing cultivar in Eastern Canada. Results of field surveys and studies on insect fauna from potato fields suggest there is a significant potential upon which to develop biological control techniques for use with this crop.

In processing research, a data base has been assembled on the heat-transfer characteristics of pouch-packaged foodstuffs processed in steam–air mixtures. Detailed studies designed to refine and define this technology are planned. Several new respiration-suppressing films have been identified for use on apples, blueberries, and peas. The development of a film derivative to replace artificial waxes currently used on apples is anticipated.

Significant staff changes in 1982 included the appointment of Dr. G. W. Wood as acting Superintendent of the Hervé J. Michaud Experimental Farm following the transfer of Mr. J. M. Wauthy to Normandin. Mr. Frank Calder returned from a CIDA assignment in Sri Lanka to resume his duties as Officer in Charge of the Nappan Experimental Farm.

Further information about our programs may be obtained by writing to the research establishment concerned or by addressing inquiries to Atlantic Region Headquarters, Research Branch, Agriculture Canada, 1888 Brunswick Street, Halifax, N.S. B3J 3J8.

E. E. Lister

# PRÉFACE

La région de l'Atlantique, dont l'administration centrale est située à Halifax, comporte quatre stations de recherche, deux fermes expérimentales et deux sous-stations qui desservent les collectivités agricoles du Nouveau-Brunswick, de l'Île-du-Prince-Édouard, de la Nouvelle-Écosse et de Terre-Neuve. En 1982, la région disposait d'un budget de 16,7 millions de dollars et d'un personnel de 92 professionnels pour mettre en oeuvre ses divers programmes.

La nouvelle ferme expérimentale Hervé J. Michaud a été inaugurée au cours de l'année. Toutes les stations de la région abritent maintenant sous un même toit les employés des deux paliers de gouvernement, solution qui favorise la collaboration dans l'étude des problèmes agricoles de la région. Les établissements collaborent régulièrement avec la Direction générale du développement régional à la planification et à l'exécution de projets régionaux de développement.

Les travaux de recherche menés sur le bétail et les aliments du bétail ont confirmé les avantages économiques de l'utilisation des aliments du bétail produits localement, en particulier des pommes de terre. L'utilisation de modèles informatisés pour déterminer les systèmes de gestion les plus rentables dans des circonstances bien définies s'est aussi avéré efficace. Comparativement à d'autres sources de protéines, l'emploi de poisson ensilé dans les rations pour porcs constitue une solution rentable en terme de conversion des aliments et de qualité de carcasse. En outre, les travaux ont démontré que l'aspirine n'est pas efficace pour remédier au syndrome de la mort subite (S.M.S.) chez les volailles et que les micro-éléments nutritifs et les graisses n'ont rien à voir avec l'incidence du S.M.S., alors que les protéines alimentaires auraient un rôle important à jouer. Les résultats préliminaires donnent en effet à penser qu'un facteur à considérer serait l'existence d'une interaction des protéines alimentaires et du procédé de pastillage à la vapeur.

Dans le domaine des céréales, les travaux de recherche ont permis de mieux comprendre le complexe de *Fusarium* spp. qui s'attaque au blé, de déterminer les effets de la rotation des cultures et des conditions de l'environnement sur le taux d'infection et d'élucider les interactions des diverses espèces dans la formation des toxines. On a également déterminé les qualités meunières des cultivars allemands Monopol, Absolvent et Max, cultivés dans la région. Les techniques d'exploitation des terres, en particulier l'épandage d'azote, sont critiques dans la production de blé de bonne qualité meunière. L'utilisation d'un fongicide efficace pour semences a donné une hausse significative de la production d'orge, en supprimant les lésions foliaires causées par la tache réticulée (*Pyrenophora teres*).

Du côté des cultures fourragères, des progrès importants ont été accomplis dans l'étude des agents de lutte biologique contre les ravageurs des cultures fourragères. L'agromyze de la luzerne a été parasitée avec succès par le parasite *Dacnusa dryas*; le *Longitarsus jacobaeae*, un ennemi naturel du séveçon jacobée, s'est très bien implanté dans l'Île-du-Prince-Édouard. L'ivraie annuel fait maintenant partie des programmes d'alimentation au fourrage de plusieurs entreprises de production de bovins de la région, en raison surtout de l'excellent travail effectué par les chercheurs de la Direction générale.

Dans le cadre des programmes de recherche en horticulture, on a réussi à imposer sur les marchés deux cultivars créés récemment et ayant un rendement supérieur: les fraises Kent et les pommes de terre Shepody. En raison de sa capacité d'adaptation, la variété de fraises Kent est en grande demande dans toute l'Amérique du Nord. D'autre part, l'accueil fait au cultivar Shepody par les producteurs et les transformateurs laisse penser que cette variété pourra remplacer la Russet Burbank comme première pomme de terre de transformation dans l'est du Canada. Les résultats des travaux sur le terrain et des études sur les insectes qui infestent les champs de pommes de terre laissent penser qu'il existe d'excellentes possibilités quant au développement de techniques de lutte biologique pour cette culture.

Dans le domaine de la transformation, on a constitué une base de données sur les caractéristiques de transfert de la chaleur des aliments mis en sacs hermétiques et traités par les mélanges vapeur-air. On prévoit effectuer des études détaillées destinées à améliorer et à décrire cette technique. On a trouvé plusieurs nouveaux films étanches qui peuvent être utilisés sur les pommes, les bleuets et les pois. On prévoit mettre au point un film qui remplacerait la cire artificielle utilisée actuellement sur les pommes.

Parmi les changements importants de personnel à signaler en 1982, on note la nomination de G.W. Wood au poste de surveillant par intérim à la ferme expérimentale Hervé J. Michaud à la suite de la mutation de J.M. Wauthy à Normandin; Frank Calder, qui avait été détaché pour un projet de l'A.C.D.I. au Sri Lanka, a repris ses fonctions d'agent responsable de la ferme expérimentale de Nappan.

Pour de plus amples renseignements sur nos programmes, s'adresser aux établissements de recherche ou à l'Administration centrale de la région de l'Atlantique, Direction générale de la recherche, Agriculture Canada, 1888, rue Brunswick, Halifax (N.-É.), B3J 3J8.

E.E. Lister

# Research Station
# St. John's West, Newfoundland

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### Entomology

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| R. F. Morris, B.S.A., M.Sc., F.E.S.C. | Head of Section; Vegetable insects |

### Horticulture

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| B. G. Penney, B.Sc., M.Sc. | Vegetable crops |

### Plant Breeding and Pathology

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| K. G. Proudfoot, B.Agr., M.Agr. | Head of Section; Potato breeding |
| M. C. Hampson, B.Sc., M.Sc., Ph.D. | Plant diseases |

### Agronomy

| | |
|---|---|
| A. F. Rayment, B.Sc., M.Sc. | Soil fertility and drainage |

# INTRODUCTION

The Research Station at St. John's West is the center for agricultural research in Newfoundland and Labrador. Multidisciplinary research is directed toward the control of potato wart and golden nematode diseases, clubroot disease of turnip, and economic crop insects, together with plant nutrition and vegetable adaptation trials. Considerable emphasis is being placed on increasing vegetable and forage production on peat soils, developing efficient drainage and cultivation techniques, and designing and adapting mechanical equipment for cultivating, fertilizing, seeding, and harvesting peat soil crops.

This report provides brief summaries of some of the results obtained in 1982. Further information, reprints of listed publications, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 7O98, St. John's West, Nfld. AlE 3Y3.

H. W. R. Chancey
Director

# ENTOMOLOGY

## Cabbage root maggot

*Rutabagas.* Previous indications of tolerance of cabbage root maggot to fensulfothion (Dasanit) and carbofuran (Furadan) at St. John's and Wooddale, were further investigated in field tests with rutabagas. Fensulfothion at the recommended rate, and at 0.5, 2, 4, and 8 times that amount was tested as a single application of granules at seeding and as a split application, half granular at seeding plus a drench at thinning. Fensulfothion was ineffective at recommended rates in St. John's, but it was 80% effective at Wooddale. Only eight times the recommended rate gave adequate control at St. John's. Split applications were more effective than equivalent single treatments at seeding. Carbofuran at recommended rates provided adequate control at St. John's (89%), and at Wooddale (78%). Results of year-to-year testing for root maggot resistance to fensulfothion and carbofuran have been conflicting and it is suspected that the effectiveness of the two insecticides is influenced by some factor in the soil or environment.

*Cultivar resistance.* Four rutabaga and three summer turnip cultivars were tested for resistance to root maggot attack in an area of high root maggot infestation. Results were similar to those obtained in 1981, in which Wilhelmsburger was the most resistant and Purple King the most susceptible of the rutabagas. Purple Top White Globe was the most resistant summer turnip and Tokyo Cross the most susceptible.

*Early cabbage.* Diazinon, fensulfothion (Dasanit), seaweed powder, and ocean salt water were tested for root maggot control in early cabbage, together with the pyrethroid insecticides permethrin (Ambush), cypermethrin (Cymbush), cypermethrin (Ripcord), deltamethrin (Decis), and Bay FCR 1272. In a moderate infestation, permethrin and Diazinon gave complete control, whereas all other treatments gave significant control at the 5% level.

*Blueberry leaf tier.* Eleven insecticide treatments and controls were established at Roaches Line on 10 June 1982. Larval counts were taken before spraying on 10 June and after spraying on 17, 22 June and 2, 7 July. The pyrethroids permethrin, cypermethrin (Cymbush), fenvalerate, cypermethrin (Ripcord), deltamethrin, and Bay FCR 1272 significantly reduced larval populations and were as effective as azinphosmethyl (Guthion).

# PLANT SCIENCE

## Field crops

*Limestone quality.* Early results from a 5-yr experiment started in 1981 to determine possible toxicity from use of local limestone relatively high in Cd (35 mg/kg) and Zn (8028 mg/kg) indicate that soil applications of 4–16 t/ha did not increase Cd levels in potato, carrot, or cabbage tissue compared

with low level Cd and Zn limestone control plots. Zn levels were increased slightly in plant tissue and considerably in the soil. Soil Cd levels were also increased, but analytical results were not consistent.

*Carrots.* Production on ridged rows at the Northern Arm Peat Bog in 1982 was only slightly better than on unridged rows. The mean marketable yield and root length were as follows: ridged 14.1 t/ha, 19.1 cm; unridged 13.3 t/ha, 17.2 cm. In a cultivar evaluation trial conducted at the same site, Pioneer and Spartan Classic produced the highest yield of marketable carrots on both ridged and unridged rows.

*Blueberries.* Blueberry plots treated with herbicides in 1981 were assessed for effect on production. Hexazinone with active ingredient (a.i.) at rates ranging from 0.5 to 2.0 kg/ha in combination with atrazine with a.i. at 5 kg/ha increased the number of branched stems, flower buds per stem, and ripe fruit yields by an average of 56%, 43%, and 166%, respectively. Hexazinone in combination with simazine produced similar results. Untreated control plots produced ripe fruit yields of 734–774 kg/ha and treated plots 1680–2062 kg/ha.

*Partridgeberries.* Yields of partridgeberries (*Vaccinium vitis-idaea*) were determined at several locations on the Avalon and Bonavista peninsulas. Mean yields in kilograms per hectare were as follows: Pouch Cove 889; Adams Cove 852; Riverhead 505; Little Catalina 1195; Newman's Cove 369; and Avondale 0. Except for Little Catalina, lower yields than in 1981 were probably due to poor pollinating conditions in 1982.

## SOIL SCIENCE

### Peat soils

*Fertility.* In trace nutrient studies on a mixture of red clover, reed canarygrass, and timothy, red clover on average accumulated three times the concentration of Mo as grasses. However, red clover levels in the generally accepted toxic range for livestock were obtained only where an initial rate of Mo at 0.04 kg/ha was applied, followed by half that rate in subsequent years. Mo levels were constant or slightly increased over the previous year when annual maintenance applications of one-half the initial rate were used. Under similar treatments, Mo levels of grass were slightly decreased. Based on these results, Mo-induced Cu deficiency probably occurred in some past grazing experiments, but is unlikely to be the only cause of ill-thrift observed in lambs.

*Peat drainage.* Water flow from a drainage experiment confirmed the advantage provided by supplementary slit drains, which increased outflow by 12.9% from primary drains during precipitation periods and reduced outflow during subsequent dry periods. This off-phasing of treatments in wet–dry cycles was a consequence of the greater take-down rate provided to the depth that the extra drainage was effective, and was also reflected in the generally lower water tables in the treated areas.

*Machinery.* Field tests of small hay stacks (500 kg dry weight) provided preliminary data on the use of a $CaCl_2$ desiccant as a drying aid and NaCl as a preservative. There were good indications of beneficial results from both treatments, either separately or combined, with total costs well within economic margins. The small, relatively weather-proof stacks can be left in the field for later removal, thereby providing a high-speed harvesting system at moderate labor and equipment cost.

## PLANT BREEDING AND PATHOLOGY

### Potato wart disease

*Disease control.* Further field tests for inhibiting effects of $NH_4NO_3$, lime, and urea on wart infection showed that increased levels of urea reduced infection by as much as 33% in the cultivar Arran Victory. With both $NH_4NO_3$ and lime treatments, disease control fell from 13% to 0% and then rose to approximately 10% with increasing dosage. These chemical effects will be examined further for possible roles in a cultural control strategy for reducing potato wart infection.

*Pathogenesis.* Greenhouse bench inoculations were done weekly, and seasonal fluctuations in infection were again noted; infection peaked particularly at about 4-wk intervals. Daily inoculations were done for 4 mo in a growth room and the overall pattern of infection resembled the typical cycles observed on greenhouse benches. Thus, minimal

interference with environmental conditions provides further evidence that infection intensity is mediated by virulence of the pathogen.

The presence of a lectinlike compound active in wart pathogenesis was indicated by inoculations in *N*-acetyl-D-glucosamine, in which infection increased. Inoculations using three states of inocula showed infection in the order whole wart > separated sporangia > homogenized wart. The apparent inhibition following washing and homogenization may be due to lectin involvement. Inoculation in the presence of potato extract resulted in reduced infection. Immersion inoculations indicated that zoospores were active for >1 h after removal of sporangia. Infection increased with immersion time and decreased as temperature deviated from a 12°C optimum.

*Sporangial examinations.* Zoospore release was examined using drop culture and many encysted zoospores were found. $H_2O_2$ caused sporangia to burst but did not induce synchronous zoospore release; freezing in $H_2O_2$ seemed to induce higher sporangial detachment.

Electron microscope examination at Memorial University of Newfoundland revealed viruslike particles in wart sporangia. Chitosomelike bodies appeared to be intimately linked to wall-building activities in the sporangium, and the molecular weight of the chief protein component of the wall was estimated to be 26 000. Work is in progress to estimate water and lipid components of sporangia with a view to determining longevity and viability characteristics. Successful application of biochemical techniques reveal several proteins in whole sporangia and the intention is to develop a pathotype differentiation system.

### Breeding potatoes for resistance to wart and potato cyst nematode

Growers trials of N647-24 (blue-skinned, wart resistant) and N664-127 (white-skinned, wart and nematode pathotype A resistant) were concluded during 1982. Application will be made for licensing and naming selection N647-24, which matures earlier and is more scab resistant than the cultivar Blue Mac. Selection N664-127 exhibited symptoms similar to infection by the potato leaf roll virus and will be further evaluated for frequency of this disorder.

Of 114 selections of the F79 series from the National potato breeding program, 104 developed symptoms of wart disease in the trial plots at Avondale. Cultivars Crystal and Oneida from the USA were highly susceptible to wart disease as was the prairie region cultivar Carlton. Conestoga from the Guelph program was only slightly infected and the Dutch cultivar Desiree was free from infection.

### Rutabaga breeding

Breeders seed of the cultivar Fortune was supplied to two seed growers in New Brunswick and Prince Edward Island, and samples of seed were distributed to growers throughout Eastern Canada for trial purposes. Fortune has been susceptible to clubroot in some areas of Newfoundland, but seems to be resistant in most other parts of the Atlantic Region.

Seeds produced in the greenhouse during the winter period from purple- and green-topped roots selected for showing the least amount of root maggot damage in 1981 were used for planting blocks in the field during July 1982. Plants of polycrossed green-topped roots (PXG) and polycrossed purple-topped roots (PXP) were compared for root maggot injury with plants of Wilhelmsburger and Laurentian. With severity of injury increasing from 0 to 4, the scoring was Wilhelmsburger 2.24, PXG 2.91, Laurentian 3.02, and PXP 3.04.

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### Research


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# Research Station
# Charlottetown, Prince Edward Island

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| D. A. Hutchinson | Administrative Officer |
| B. Stanfield,[1] B.S.A., M.S.A., M.L.S. | Librarian |
| M. B. Bourdon, D.Journ. | Information Officer |

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| J. A. MacLeod, B.Sc. (Agr.), M.Sc., Ph.D. | Head of Section; Forage and cereal nutrition |
| A. J. Campbell, B.Eng. | Agricultural engineering |
| L. M. Edwards, B.Sc., M.Sc., Ph.D. | Soil management |
| H. W. Johnston, B.Sc. (Agr.), M.Sc., Ph.D. | Cereal diseases |
| R. A. Martin, B.Sc., B.Sc. (Agr.), M.Sc., Ph.D. | Cereal diseases |
| H. G. Nass, B.S.A., M.Sc., Ph.D. | Wheat breeding, cereal physiology |
| J. D. E. Sterling, B.S.A., M.Sc. | Barley breeding |
| R. P. White, B.S. (Ed.), M.S., Ph.D. | Corn and potato nutrition and management, soil chemistry |

### Forage and Livestock

| | |
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| L. S. Thompson, B.Sc. (Agr.), Ph.D. | Head of Section; Forage, cereal, and potato insects |
| T. M. Choo, B.Sc., Ph.D. | Red clover breeding |
| H. T. Kunelius, B.Sc., M.Sc., Ph.D. | Forage physiology and management |
| P. R. Narasimhalu, B.Sc., B.V.Sc., M.S., Ph.D. | Forage quality and utilization |
| M. Suzuki, B.Sc., Ph.D. | Forage and cereal biochemistry and physiology |
| C. B. Willis, B.Sc. (Agr.), Ph.D. | Forage diseases |
| K. A. Winter, B.Sc. (Agr.), M.Sc., Ph.D. | Cattle nutrition |

### Horticulture and Tobacco

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| J. A. Cutcliffe, B.Sc. (Agr.), M.Sc. | Head of Section; Vegetable nutrition and management |
| W. J. Arsenault, B.Sc. (Agr.) | Tobacco management and nutrition |
| U. C. Gupta, B.Sc. (Agr.), M.Sc. (Agr.), Ph.D., F.C.S.S.S., F.A.S.A., F.S.S.S.A. | Soil and plant micronutrients |
| J. A. Ivany, B.Sc. (Agr.), M.S., Ph.D. | Vegetable, potato, and cereal weed control |
| J. Kimpinski, B.S.A., M.Sc., Ph.D. | Nematology |
| J. G. McDonald, B.Sc. (Agr.), M.Sc., Ph.D. | Potato virus diseases |
| H. W. Platt, B.Sc., Ph.D. | Potato diseases |
| D. C. Read, B.Sc. (Agr.), M.Sc., Ph.D. | Pesticide bioactivity, vegetable insects |
| J. B. Sanderson, B.Sc. (Agr.), M.Sc. | Potato management and nutrition |

### Departure

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|---|---|
| J. M. Sadler, B.Sc., M.Sc., Ph.D.<br>Transferred to Brandon Research Station, January 1982 | Soil management |

## VISITING SCIENTISTS

| | |
|---|---|
| K. Nishikawa, B.Sc., M.Sc., Ph.D.<br>Crop Science Department, Kobe University, Japan | Plant physiology |
| A. V. Sturz, B.Sc., Ph.D.<br>Natural Sciences and Engineering Research Council visiting fellow | Cereal diseases |

[1]Seconded from Libraries Division, Finance and Administration Branch.

# INTRODUCTION

The Research Station at Charlottetown has Atlantic Region responsibility for research on the production and utilization of livestock feed crops (forages, cereals, protein), tobacco, and certain vegetable crops (cole, peas) grown for processing. Emphasis on potato research is in the areas of nutrition and management for processing and table potatoes, but especially for small whole-seed potato production. Research is also conducted on disease evaluation and control and postharvest testing by enzyme-linked immunosorbent assay (ELISA) for virus content of potatoes destined for the domestic and export seed markets.

Dr. A. V. Sturz, a postdoctoral fellow, continued his research on the epidemiology of *Fusarium* diseases of cereals.

Dr. K. Nishikawa, Crop Science Department, Kobe University, Japan, was a visiting Research Scientist at the Station during July and August.

Several positions were staffed during the year: W. J. Arsenault as a biologist in tobacco research; M. B. Bourdon as an information officer; and Dr. L. M. Edwards as a research scientist in soil management.

This report includes brief summaries of some of the research completed in 1982. More detailed information may be obtained by referring to the Station's Research Summary, which is published annually, or by contacting the Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I. C1A 7M8.

L. B. MacLeod
Director

## CEREAL CROPS

### Breeding and testing

*Barley.* A license will be requested for the Charlottetown line AB53-4, which has been the highest yielding and earliest maturing two-row variety in trials in Eastern Canada for 3 yr. The six-row variety Leger and the two-row variety Birka, which were licensed recently with the support of data from Maritime trials, are now recommended in the Maritime Provinces and are expected to contribute significantly to the production capability of the region.

*Spring wheat.* A spring wheat variety developed in Quebec, SH 78-210, has good yield potential, good test weight, and a large kernel when grown in the Atlantic Region.

*Winter wheat.* The line CH 1B is a hardy winter feed wheat developed at the Charlottetown Research Station. It has tall straw, a well-filled head, and tolerance to most diseases. It has outyielded the check varieties consistently for 3 yr in Maritime trials. A license for CH 1B will be requested in 1983.

*Winter rye.* CHR 76-4, a winter rye line developed at the Charlottetown Research Station, has shown superior performance in Maritime trials for 4 yr. Seed supplies are being increased in anticipation of licensing.

### Management and nutrition

*Intensive management of spring wheat.* Management studies with spring wheat showed that a combination of disease control and supplementary nitrogen (N) application resulted in high yields. Intensity of management increased yields of all varieties studied and had little effect on the relative ranking of varieties. Supplementary N application increased the protein level remarkably in all varieties.

*Intensive management of spring barley.* A combination of disease and lodging control with supplementary N applications increased yields of barley substantially. Lodging control using the growth regulator ethephon prevented serious lodging at high fertility levels and improved yields slightly. Seed treatment, which enhanced initial growth rates of seedlings, had a beneficial effect in increasing yields.

*Intensive management of oats.* Use of the fungicide propiconazole to control Septoria speckled leaf blotch and black stem reduced both disease severity and lodging in oats

grown at high fertility. Use of the growth regulator ethephon to control lodging did not increase grain yields.

*Spring wheat response to herbicides.* Five commonly used herbicides applied at two rates of application on eight spring wheat varieties had no effect on dry plant weight at 20 days after treatment. Treatment with 2,4-D, dicamba, and a 2,4-D/mecoprop/dicamba mixture at the higher rate of application resulted in more deformed heads in all varieties in one of the 3 yr of the study. Only Neepawa and Dundas had more deformed heads than the control when treated with MCPA. No head deformation was noted on any variety treated with diclofop-methyl. Herbicide treatment that resulted in head deformation had no adverse effect on grain yield.

*Residual effect of boron on cereals.* Boron (B) at rates of up to 5 kg/ha applied to rutabagas did not cause B toxicity or yield reductions in subsequent cereal crops. However, B at 5 kg/ha applied directly to cereal crops reduced yield.

*Effect of Sea Crop 16 on crop yields.* Field and greenhouse experiments with Sea Crop 16, a liquid extract from a blend of seaweeds that has been promoted as a plant growth stimulant, showed that it had no effect on the yield or protein content of wheat and peas.

**Diseases**

*Fusarium.* Studies showed that in Prince Edward Island, *Fusarium graminearum* and *F. poae*, both toxigenic species, were the principal fusaria isolated from the heads of cereals. More fusaria were recovered from the heads of barley than from those of wheat. The levels of infection in cereals were in the order of Bonanza barley > Glenlea spring wheat > Lennox winter wheat.

*Seed quality.* Studies on barley and wheat illustrated that use of seed with low levels of pathogenic fungi such as *Bipolaris* and *Fusarium* spp. reduced severity of root diseases but did not reduce severity of leaf and head infections. High-quality seed performed best in soils with low levels of soil-borne fungal pathogens.

*Effects of seeding date and triadimefon on growth of winter wheat.* A study on the effects of seeding date and triadimefon on growth of winter wheat showed that September seedings resulted in a lower incidence of leaf rust and powdery mildew, less lodging, and higher yield than August seedings; September seedings resulted in larger plants in the fall and higher yield than the October seeding. The first half of September was the optimum seeding time for Lennox winter wheat in Prince Edward Island. The study also showed that the fungicide triadimefon controlled diseases but had no effect on lodging or grain yield.

*Nematode–fungus interactions.* The root lesion nematode *Pratylenchus crenatus* Loof and the stunt nematode *Tylenchorhynchus dubius* (Butschli) Filipjev were not associated with the root rot fungus *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. in a disease complex in wheat and barley.

## FORAGE CROPS

**Red clover breeding**

*Association between growth habit and persistence in red clover.* A red clover study showed that, not only did nonflowering plants survive the first winter better than flowering plants, they also persisted better into the 3rd yr. It showed further that nonflowering plants can be as productive as flowering plants in succeeding production years. Therefore, flowering response in the seedling year can be used as a selection criterion for persistent plants in red clover.

**Evaluation of varieties and species**

*Feed value of Barspectra.* Barspectra ryegrass was consistently higher in intake and digestibility than Barmultra, Lemtal, Aubade, Merwester, and Promenada ryegrasses or Climax timothy in feeding trials with sheep, using first- and second-cut silages.

*Legume–annual ryegrass mixtures.* Italian and Westerwolds ryegrasses, Persian clover, red clover, alfalfa, and bird's-foot trefoil were grown in monocultures and in ryegrass–legume mixtures as summer annual forages. The forage legumes in order of productivity were Persian clover > red clover > alfalfa > bird's-foot trefoil when grown in monocultures. Growing legumes in mixtures with ryegrass increased the dry matter (DM) yields by 15–52% compared to legumes grown in monocultures. The DM yields of mixtures, however, were lower than those of ryegrass

monocultures. Total N and in vitro digestibility of DM were lower for Westerwolds ryegrass–legume mixtures than for legume monocultures and Italian ryegrass–legume mixtures.

**Management and nutrition**

*Effect of plant age on cold resistance in red clover.* A coldroom study showed that 12-wk-old plants of Florex red clover survived –9°C much better than 8- , 4- , 2- , and 1-wk-old plants, suggesting that 12-wk-old plants can be used in screening for cold resistance in red clover.

*Rapid drying of red clover.* Red clover sprayed at cutting time with a 4% (wt/vol) aqueous solution of potassium carbonate at 222 L/ha reached 67% DM after a 27-h field-drying period under good weather conditions, whereas unsprayed red clover reached only 53% DM. Potassium carbonate, therefore, can be used to speed up the field-drying of red clover hay.

*Effect of harvest date on the yield and feed quality of corn silage.* Delaying the harvest of silage corn from 15 September to 16 November increased the DM content but decreased the DM yield. Corn silage intake and digestibility by sheep were highest for a crop harvested on the day when the first killing frost ( –2°C) occurred.

*Herbicides for no-till silage corn.* When adequate weed control was provided, corn seeded with a Buffalo no-till seeder equipped with slot-type shoes gave silage yields comparable to corn seeded conventionally into cereal stubble 15–20 cm tall. Best control of quack grass and dandelion and best crop yields were achieved with glyphosate and atrazine (1.5 + 2.5 kg/ha) or amitrole plus atrazine (3.4 + 2.5 kg/ha) applied preemergence after seeding but before corn emergence. Use of atrazine at 1.0 kg/ha in the above combinations did not provide adequate control.

*Mineral content of timothy.* Timothy samples taken from throughout Prince Edward Island were either barely adequate or deficient in trace-element content relative to the needs of cattle and sheep. Generally, the 4.5 μg/g level of copper (Cu) found in timothy samples is deficient for cattle but lack of Cu deficiency in Prince Edward Island is attributed to correspondingly low molybdenum and sulfur levels. Mean magnesium content at 0.1% was low relative to animals' requirements, which combined with low calcium (Ca) at 0.25% and potassium (K) at 2.1% can cause grass tetany in grazing animals. The need for adequate Ca and phosphorus supplementation and the use of a suitable trace-mineralized salt in formulating diets for dairy and beef cattle, and for sheep, was evident.

**Insects and diseases**

*Parasites reduce alfalfa blotch leafminer numbers.* Parasitism of third generation alfalfa blotch leafminers, *Agromyza frontella* (Rondani), by the introduced parasite *Dacnusa dryas* (Nixon) was greater than 50% in some areas of Prince Edward Island in 1982. This parasite, together with native parasites, should effect declines in numbers of *A. frontella* below any conceivable economic threshold. *D. dryas* was also recovered from New Brunswick in 1982, suggesting that the parasite has established in that province as well.

*Occurrence of alfalfa mosaic virus in forage legumes.* Alfalfa mosaic virus (AMV) was found at relatively low levels in Prince Edward Island. Four fields of 2-yr-old alfalfa averaged 5% infection and three fields of 3-yr-old alfalfa averaged 7%. AMV was not detected in red clover plants. Testing of several fields of bird's-foot trefoil revealed for the first time the natural susceptibility of this species. Two common wild legumes, *Trifolium repens* L. and *Vicia cracca* L., harbored significant levels of the virus.

*Influence of pesticides on nematode behavior.* Aldicarb was the most effective nematicide in reducing movement of *Pratylenchus penetrans* (Cobb) Filipjev & Sch.-Stek. and *P. crenatus*, followed in order by fenamiphos, carbofuran, and propoxur. Movement of fourth-stage juveniles and adult *P. crenatus* was inhibited more than the movement of second- or third-stage juveniles when aldicarb concentrations were 6 or 12 μg/mL. Propoxur did not have this effect. There was no significant difference in movement between the various stages of *P. penetrans* when treated with aldicarb or propoxur.

## HORTICULTURAL CROPS AND TOBACCO

### Potato management and pest control

*Greensprouting of Bintje seed potatoes.* Presprouting of Bintje whole-seed tubers in light at 20°C for 6 wk resulted in earlier (10 days) emergence and more rapid early growth in comparison to nonsprouted seed. When top killed 73 days after planting, yields of tubers <40 mm, 40–60 mm, and >60 mm were decreased 1.4 t/ha, increased 11.6 t/ha, and increased 1.3 t/ha, respectively, when greensprouted seed was used. When top killed 87 days after planting, yields of tubers were decreased 0.9 t/ha, increased 7.7 t/ha, and increased 2.7 t/ha, respectively. Greensprouting increased seed-size (40–60 mm) yield by 116% at the earlier top kill and by 40% at the later top kill.

*Spacing for Red Pontiac seed production.* A 2-yr comparison of three plant spacings (10, 15, and 20 cm) for small whole-seed production (under 60 mm) of Red Pontiac tubers showed that seed yields at the three plant spacings were 18.2, 14.9, and 12.6 t/ha, respectively, and yields of tubers over 60 mm were 18.8, 18.4, and 20.7 t/ha, respectively, when top killed 85 days after planting.

*ELISA postharvest testing.* Several modifications to the ELISA procedure were found to improve the detection of potato virus Y in primary- and secondary-infected tubers. Alkaline phosphatase, commercially available as a solution in 3 *M* NaCl, produced significantly more active immunoconjugates than did the more conventionally used suspension in 3.2 *M* $(NH_4)_2SO_4$. A crude grade of ovalbumin, when included in the enzyme buffer, produced a higher specific adsorption of the immunoconjugate to the microtitration plate than did a crystalline form. The optimal ovalbumin concentration was ca. 0.3% (wt/vol).

### Vegetables and tobacco

*Effects of lime and K on yield and storage losses of cabbage.* Field experiments conducted in Prince Edward Island for 3 yr showed that an application of lime at 6.7 t/ha increased cabbage yields by 13%. The addition of K at 224 kg/ha, compared to 56 kg/ha, increased yields by 7%. Weight loss and the percentage of marketable cabbage after 5 mo in storage at 1–2°C and 90–95% relative humidity were not affected by either the lime or K treatments.

*Effect of Cu on vegetables.* Fields studies in Prince Edward Island indicated that the addition of Cu to the soil did not affect the yield and quality of carrots, beets, onions, and rutabagas. Leaf-tissue Cu concentrations were found to be low and, therefore, the monitoring of Cu levels in vegetable crops at periodic intervals will be done to detect significant trends.

*Soil pesticides.* Fensulfothion and carbofuran, which have been used effectively for controlling root maggots and the carrot rust fly for about 15 yr, are now rapidly broken down by strains of microorganisms in some fields. Laboratory bioassay tests have shown that microorganisms capable of rapidly breaking down carbofuran are present in four areas of Prince Edward Island as well as at least one area in Nova Scotia and one in Ontario. Strains of microorganisms that break down fensulfothion rapidly have been discovered in soil from two areas in Prince Edward Island and two in Ontario. Alternative soil insecticides, chlorfenvinphos and terbufos, are not broken down quickly by the strains of microorganisms that degrade either carbofuran or fensulfothion.

*Effects of topping on yield and quality of tobacco.* Topping of tobacco at the stretch bud stage of floral development, as opposed to topping at first flower or full flower, increased yield and dollar return per hectare. Topping at stretch bud also increased total alkaloid content.

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## INTRODUCTION

This report highlights the principal research currently under conduct at the Kentville Research Station and the Nappan Experimental Farm for 1982. Both establishments are located in Nova Scotia, where Kentville serves as the Atlantic regional center for research on poultry, horticultural crops, and winter cereals, as well as the storage and processing of food crops. Research at Nappan is concentrated on the management of beef, sheep, and swine, and on their related feed crops requirements.

The region itself is characterized by a cool, humid climate. Soils are generally low in fertility and often imperfectly drained. The diverse agriculture that it sustains is predominantly a livestock base but has major concentrations of fruit and vegetable production in locally adapted areas.

Requests for further information or reprints of publications should be addressed to the Research Station, Research Branch, Agriculture Canada, Kentville, N.S. B4N 1J5.

G. M. Weaver
Director

## BREEDING, NUTRITION, AND CULTURE OF CROPS

### Lowbush blueberries

*Plant spacing and cultivar study with the cultivated lowbush blueberry.* Three spacing treatments were compared: (*1*) standard spacing of 1.0 m × 0.5 m requiring 20 000 plants per hectare; (*2*) double-row alternate spacing with 24 000 plants per hectare; and (*3*) triple-row alternate spacing with 28 500 plants per hectare. The cultivar Chignecto outyielded Augusta, Brunswick, and 510 at both the single and triple planting rates. The cultivar 510 outyielded Chignecto and the other clones at the double spacing. The yields for all clones were greater at the double spacing than for the single, and yields at the triple spacing exceeded those of the double. Two years after planting, the mean yield per hectare for all clones was as follows: at the single spacing 1.46 t, at the double spacing 2.25 t, and at the triple spacing 3.09 t.

*Production as related to certain weather data.* Production of lowbush blueberries significantly correlated with June rainfall in Newfoundland and with June sunshine and temperature in Nova Scotia. When the data were combined for the five most eastern provinces over 27 yr, no variables were of consistent value in predicting lowbush blueberry production.

*Pruning.* Results from pruning studies showed no significant differences in length of shoots and number of flower buds per shoot on plots burnt with oil, burnt with straw, mowed, mowed plus straw burning, and mowed plus oil burning.

*Rooting of cuttings.* During the past two winters some 50 000 plants have been propagated in the glasshouse as rooted cuttings with an overall success of 81% establishment. The six clones propagated plus the percentage for each cultivar or numbered selection are as follows: Augusta (60%), Blomidon (83%), Brunswick (82%), 69-1 (80%), 70-21 (90%), and 70-27 (71%).

*Cultivar performance.* Records on fruit yield from selections of the breeding program were taken from replicated blocks planted in 1978 and 1980. The 1978 planting had some 27 entries and the top six were 633, 315, 72-3, 4161, 69-1, and Chignecto, all of which yielded at least 10 t/ha. The 1980 planting had some 63 entries, five of which yielded better than 2 t/ha. Chignecto performed well also in this test, being 13th in yield, whereas Augusta and Brunswick were considerably lower at the 35th and 57th positions, respectively.

### Strawberries

*New cultivar release, Glooscap.* Selection K74-12 (Bounty × Micmac) has been named Glooscap. Local testing has verified the ability of this cultivar to produce crops of large, uniform, firm fruit. Glooscap caps easily and is suitable for both the fresh market and frozen pack. Plants are vigorous, produce

runners freely, and are tolerant to the common foliage diseases.

*Cultivar performance.* Kentville cultivars Bounty, Micmac, and Kent performed well in 1982. In the National Fruit Trial at Brogdale, England, Bounty had the highest class one fruit yield in both 1981 and 1982 compared with 20 European, American, and Australian cultivars. Kent exceeded all local yield records; it produced 45 023 kg of marketable fruit per hectare at Charlottetown and 31 890 kg/ha at Kentville.

*Management study with Bounty strawberry.* In 1982, trickle irrigation gave significant yield and size increases in the late and total season harvests. Black plastic mulching increased yields only in the early harvest. Trickle irrigation also significantly increased late harvest and total season size and yields in grades 1–3 of processing quality.

**Cereals**

*Winter wheat cultivar testing and licensing.* In 1982, two new winter wheat cultivars were exempted by Plant Products Division from general licensing requirements, allowing their adoption for the Maritimes. These are the West German medium-hard red cultivars Vuka and Monopol. Vuka is a feed (utility) type with superior yield and lodging resistance under intensive N management when compared to the principal feed cultivar Lennox. Its higher performance is best seen at high (ca. 500 kernels per square metre) seeding densities. Vuka, where it survives, has been somewhat uncompetitive because of weak tillering. Monopol is a European bread wheat with acceptable milling and baking qualities. Both cultivars exhibit greater winter susceptibility than Lennox and have therefore been especially recommended for the Annapolis Valley area.

*Vegetative and grain response of Lennox to spring N carrier.* A yield of 5.3 t/ha for Lennox winter wheat given N levels of 100 kg/ha at growth stage five (Feekes scale) was increased on average to 6.1 t/ha by various N carriers applied at N levels of 50 kg/ha on 1 April with the crop in the two- to three-leaf stage, lacking tillers. Early N also increased height an average 5.6 cm to 108.2 cm. Calcium nitrate generated 23% more vegetative and 14% more ear-bearing tillers than $NH_4NO_3$ with $(NH_2)_2CO$ least effective and $(NH_4)_2SO_4$ intermediate. The expected yield benefit of $NO_3$ over other N carriers was not realized this year because of reduced floret/spikelet fertility and decreased kernel size, probably reflecting moisture and heat stress in June and July 1982.

*Requirement for snow cover.* Removing snow cover from early January onward resulted in Lennox plots with enhanced spring vigor (14% more tillers, improved ear fertility (10% more grain per ear), and a 12% higher yield, although spring stand was slightly reduced (75% versus 86%). A hardy cultivar can benefit from lack of snow cover under Maritime weather conditions.

*Broad spectrum fungicide effects on Lennox.* Tilt effectively controlled ear diseases (80% control mildew plus *Septoria* symptoms), flag leaf mildew (80% control), and flag leaf *Septoria* (50% control), following multiple applications at bolting and heading. Next in symptom control was an application at heading, but there was some residual control of flag *Septoria* (37%) and ear diseases (38%) by the single early application. Tilt also increased ear numbers by up to 18% in the combined application. Yields were only modestly increased by a maximum of 4% to 6186 kg/ha. Reduced floret fertility with the fungicide indicates that the crop was under probable moisture and/or heat stress around anthesis, negating otherwise favorable early development of yield components.

*Dates of seeding.* A date of seeding trial was done with the Soils and Crops Branch of the Nova Scotia Department of Agriculture and Marketing at three locations, having eight dates of seeding, two winter wheat cultivars, and three fall rye cultivars. The earliest seeding dates produced the highest yields. At all locations, the later the crops were seeded, the later they headed and matured. Yields dropped off more dramatically with fall rye than with winter wheat.

**Forages**

*Birka bluegrass produces good animal gains.* Yearling steers were used to evaluate bluegrass with an average daily gain of 1.22 kg on Birka and 0.99 kg on Barkenta. Field production of grain was 922 kg/ha and 683 kg/ha, respectively.

*Fescue compared with timothy and bromegrass.* The 3rd yr of grazing Kenhy tall fescue, Basho timothy, and Deborah bromegrass was completed with excellent forage and

animal production. The average daily gain was 1.17, 1.14, and 1.06 kg, and the gain per hectare was 1052, 899, and 806 kg, respectively.

*Forage field peas.* Whole plant peas harvested as forage and mixed with grass on a 1:1 basis results in daily animal gains equal to a grass–legume high-quality silage, about 0.70 kg/head.

**Ornamentals**

*Potential use of fresh and composted sawdust media for chrysanthemum production.* Sawdust, used as the sole component of a growing medium, can produce commercially valuable plants of chrysanthemum cultivars Mountain Peak, Goldstar, and Cir Bronze, under regular nutrient irrigation. Sawdust used in the fresh (uncomposted) state or artificially composted for 7 wk with an admixture of $Ca(NO_3)_2$ produced plants that were equivalent in size and flower quality to those produced in a peat–lite mix. Concentration of N in the irrigation solution (150, 200, or 250 mg/kg) had no effect on harvest quality. Tissue levels of macronutrients (except K) increased linearly with increasing irrigation N concentration, but all levels were either at or above published optimal ranges. Tissue N, P, and K levels were highest in composted sawdust and peat–lite mixes, but were satisfactory in all media. High C:N ratios in fresh and partially composted sawdust may not preclude the use of these materials as growing media for chrysanthemums, provided that nutrient irrigation containing N at 150 mg/kg is supplied.

*Seasonal effects of high intensity supplementary lighting and split night temperatures on pot chrysanthemums.* Growth and flowering responses of the pot chrysanthemum cultivars Yellow Paragon and Copper Ann to combinations of supplementary lighting from high-pressure sodium lamps (190 $\mu$E $m^{-2}$ $s^{-1}$, approximately 9 klx) and split night temperatures (16°C, 1700–2400 h; 10°C, 2400–0800 h during short days) differed depending on date of shading (start of short day production cycle). In three crops starting short day on 28 January, 10 February, and 24 February, effects of supplementary lighting at normal night temperatures were relatively small; number of flowering breaks was increased by an average of two and there were small increases in flower and vegetative dry weights. Split night temperatures did not result in harvest delay or significant reduction in growth or flowering. By contrast, crops starting short day on 22 October, 5 November, and 19 November, and subjected to high-pressure sodium lighting, averaged more than five extra flowering breaks per 12 cm pot. Yellow Paragon grown under split night temperatures at this time of year was unacceptably delayed, whereas flower buds on Copper Ann failed to develop. Supplementary lighting partially offset these effects. The results suggest that improvement in market quality and reduction in production time may be achieved by supplementary lighting of pot chrysanthemums under fall light conditions at latitude 45°N. Furthermore, plant response to split night temperature regimes appears to be influenced by daily incident radiation. Successful use of this technique may only be possible for spring chrysanthemum crops.

*Reduced energy requirements for winter propagation of woody ornamentals.* Conventional propagation of evergreens with needlelike leaves is conducted in heated greenhouses under mist. Considerable energy savings are apparently achievable by propagating in copolymer-covered houses using covered, electrically heated ground beds. Cuttings of Pfitzer, Tamarix, Romlosa, and Mountbatten juniper, Woodword's Globe cedar, Threadleaf False cypress, and Hick's and Hills yew, were stuck in a peat–sand medium in early December in beds covered with either white copolymer or copolymer plus microfoam thermoblanket. Medium temperatures were thermostatically controlled and, except on the coldest days, were easily maintained at 25°C, under both coverings. Air temperatures in the vicinity of the cuttings remained well above the freezing point throughout the winter. Rooting had occurred on most cuttings by 16 February and electricity consumption on a kilowatt hour basis was approximately one-third higher in the copolymer-covered bed. The 1st yr of study of this technique has indicated the necessity to seal the ground beds below and above the cuttings with copolymer, even if microfoam is used, to prevent moisture loss.

**Vegetables**

*A fertilizer and placement with Cabot tomato.* Tomato plants receiving a 1-2-1 ratio (P banded) produced a total marketable yield that was equal to treatments with 1-2-2 and 2-2-2 (P banded). Yields for the first five

harvests were equal from plants receiving 2 units (160 kg/ha) of P banded at transplanting of treatments 1-2-2 and 2-2-2. The most economic treatment was the 1-2-1 ratio with P banded. This treatment gave total yields that were equal to those from higher rates of application and an equivalent, average fruit size of 126 g.

*Plastic row tunnels for tomatoes.* Tomato plants of the cultivar Springset in hand-ventilated row tunnels of clear, solid polyethylene yielded 42% more ripe fruit to mid-August than unprotected check plants, 7.5 versus 5.3 t/ha, respectively. Tunnels were opened and closed only five times as they were left open at night on successive sunny days. Row tunnels covered with perforated plastic (Xiro, ASB, clear plastic with 0.5%, 2.0%, or 3.5% perforation), with no additional ventilation, did not advance maturity. This was the result of the adverse effect of high temperature and humidity on fruit set. All tunnels in the study also had a surface mulch of black polyethylene.

*Unsupported perforated plastic covers for advancing maturity of broccoli and cabbage.* Various types of unsupported, or floating, perforated plastic films were of little value in advancing maturity of broccoli and cabbage. Films included clear polyethylene with 0.5%, 2.0%, or 3.5% perforation and the commercial materials Xiro and ASB. Plants were transplanted to the field on 6 and 7 May and films were removed at two times, either 1 and 2 June or 11 June. Broccoli cultivars differed in their response to the films. Films did not advance maturity of Improved Comet, but with Bravo all films except ASB gave higher early yields than uncovered check plots (75–175% higher). However, with Bravo, maturity was advanced by only a few days. None of the films advanced maturity of the cabbage cultivar Early Greenball. The earlier removal date generally gave higher early and total yields with both crops.

*Removal of terminal growth of young broccoli plants.* Hand pinching of the growing tips of young broccoli plants at the two- , three- , or five-leaf stage promoted early branching and production of several medium-sized terminal heads per plant. Of the 12 cultivars tested at a spacing of 45 × 90 cm, yields of terminal heads of pinched plants were higher than for unpinched plants in all cultivars except Skiff. Increased yields ranged from 20% to 120%. Cultivars differed somewhat in their response to pinching at the three stages of growth. This technique has promise for markedly increasing yields.

## PROTECTION OF CROPS AGAINST PESTS

### Plant pathology

*Control of twig and blossom blight of lowbush blueberry with fungicides.* One or two foliar sprays of triforine at a low rate, followed by two or three sprays of thiophanate-methyl and ferbam gave significant control of twig and blossom blight. Triforine followed by ferbam was effective and the most economic treatment for this disease.

*Control of black rot on Brassica crops.* Seed soaked in 0.05% chlortetracycline hydochloride for 1 h, followed by a rinse in tap water and a 30-min soak in 0.5% sodium hypochlorite, followed by a 2-min rinse in tap water, gave effective control of black rot and was safer to use than adding it to a hot-water treatment.

*Control of white mold on snap beans.* Foliar sprays of BAS 436F, benomyl, and improdione applied at 30% bloom gave control of white mold, *Sclerotinia sclerotiorum* (Lib.) de Bary.

*Tolerance to dodine of apple scab isolates from Nova Scotia and Quebec apple orchards.* Isolates of *Venturia inaequalis* (Cke.) Wint. from six Nova Scotia apple orchards in which dodine gave poor scab control showed a marked variation in sensitivity to dodine. Isolates from one orchard were more uniformly tolerant and isolates from another were more uniformly sensitive to dodine. Isolates from three Quebec orchards in which dodine was ineffective were markedly more tolerant to dodine than isolates from a non-dodine-sprayed orchard. There was little change in the sensitivity to dodine of isolates from a dodine-tolerant orchard 4 yr after use of the fungicide had been discontinued.

*Tolerance to benomyl of apple scab in Nova Scotia.* In Nova Scotia, tolerance of the apple scab fungus *Venturia inaequalis* (Cke.) Wint. to benomyl was evident for the first time in a commercial orchard in 1982. In apple scab fungicide plots where a full schedule of eight benomyl sprays was applied, 100% of the fruit was scabby, which is the

same as where no fungicide was used. A mixture of benomyl and mancozeb gave good control of scab in these benomyl-tolerant plots.

Studies on tolerance to the fungicide benomyl in the apple scab fungus show that benomyl screens out any susceptible isolates of apple scab from an orchard in which benomyl tolerance is present. Where benomyl is used in a tolerant orchard, apple scab isolates are almost uniformly tolerant to benomyl. In other orchards there appears to be either a mixture of tolerant and susceptible isolates or isolates all susceptible to benomyl.

**Insect pests**

*Migration of corn earworm and fall armyworm into Eastern Canada.* Light trap catches of corn earworm, *Heliothis zea* (Boddie), and fall armyworm, *Spodoptera frugiperda* (J. E. Smith), increased following the passage of weak surface and upper low-pressure atmospheric areas producing some rainfall. These low-pressure areas originate in troughs of low pressure crossing the southeastern United States' coastal plains during periods when moths are abundant and active, reaching Eastern Canada 24–48 h later. Low-level atmospheric instability in the source area carry moths to altitudes above 600 m, where stronger winds provide northeastward transport.

*The sudden appearance of the seven-spotted lady beetle in Eastern Canada.* The seven-spotted lady beetle, *Coccinella septempunetata* Linnaeus, was first reported established in North America in a tidal marsh waste disposal site near New York City in 1973. Two years later it was still confined to an area within 50 km of the original site, but by 1980 it had moved up the Hudson Valley and into southern Maine. In the summer of 1981, four adults were found at Moncton, N.B. The following spring an adult was taken in Kings County, N.S., on a strawberry nursery farm where plants had been imported from Massachusetts in April. In early August, adults were readily found in most areas of Nova Scotia, Prince Edward Island, and New Brunswick, particularly in grain fields where in Kings County, N.S., they outnumbered all other lady beetle species combined.

*Evaluations of pesticides on tree fruit Arthropods.* Insecticide and miticide evaluations were made against 14 species of pests and predators with 18 different chemicals. These included new products and also registered products to extend the label to additional species: low dosages and timing of applications were investigated as techniques to allow the use of broadly toxic compounds within integrated pest management practices. Synthetic pyrethroids were incorporated into the program without causing side effects by limiting the frequency of applications and monitoring to assess need. Dipel, *Bacillus thuringrensis*, was reevaluated in 1982 against the winter moth *Operophtera brumata* Linnaeus and other prebloom leaf feeders. It will be used to provide an alternate treatment for use in years following the application of a pyrethroid when pest pressures are low. Further tests against the apple leaf curling midge, *Dasineura mali* (Kieffer), in New Brunswick, verify that treatments against egg-laying adults are more effective than against hatching eggs. Pyrethroids were as effective as the phosphate diazinon, which is recommended for control.

Two further releases of the parasite *Platygaster* spp. (European form) were made in 1982. These were timed to coincide with the first and second generation of the apple leaf curling midge in New Brunswick. Previous releases were made in 1981. A few specimens were recovered indicating some establishment. This will be verified by identification of the parasites.

*Monitoring the apple maggot with Pherocon AM traps to determine spray need results in fewer sprays.* Fewer orchards were sprayed for apple maggot in 1981 than in previous years, and this was attributed to the more extensive use of Pherocon AM traps to determine the need for control treatments. Although these traps have been recommended for grower use since 1975, they have only been used extensively in the past 3 yr and have resulted in a substantial reduction in the use of insecticides. These findings were based on the spray records of 20 growers, which have been documented since 1971, to determine the effectiveness of the chemical control measures for apple maggot. In 1975, these growers monitored 64 of 643 ha and sprayed 609 ha, once (255 ha) or twice (354 ha) with lead arsenate or organophosphate insecticides. In 1981, these same growers monitored 531 of 699 ha and only sprayed 307 ha, once (239 ha) or twice (68 ha) with organophosphate insecticides. In 1981, there were no sprays of lead arsenate and considerably less use of the

organophosphates. Control was very good as maggot was only found at trace levels in 57 ha (ca. 9%) and 67 ha (ca. 10%) in 1975 and 1981, respectively.

*Predicting eclosion of overwintering eggs of the European red mite in Nova Scotia.* Eclosion of overwintering eggs of the European red mite, *Panonychus ulmi* (Koch), in Nova Scotia, was studied at four constant temperatures. Days to 50% hatch were 44.8, 23.1, 12.9, and 8.8, whereas the rates of development were 2.18%, 4.53%, 7.59%, and 11.34% per day at 8°, 12°, 16°, and 20°C, respectively. Nonlinear equations were developed to estimate the time to 50% hatch of overwintering eggs as a function of temperature. A weighted average of the daily extreme temperatures was used to improve the estimated time to 50% hatch for field data from the rates of development in the constant temperature studies.

*Sampling leaves to estimate brown mite.* In the first generation, brown mite, *Bryobia rubrioculus* (Scheuten), inhabits the wood as well as the leaves on apple. To eliminate sampling the wood, which is tedious and time-consuming, equations were developed to describe the total population of immature stages and adults from observation of the number of mites on the leaves alone.

*Effectiveness of pyrazophos on the leafminer of chrysanthemum.* Pyrazophos gave good control of the larvae of the leafminer of chrysanthemum, *Liriomyza trifolii*(Burgess). There was no evidence this chemical prevented the adults from causing injury to the foliage.

*Use of yellow sticky boards to control leafminer.* Trapping leafminer flies by yellow sticky boards in the greenhouse reduced the damage to chrysanthemum plants. These flies were equally attracted to the boards, whether hung horizontally or vertically above the plants. Although twice the number of flies were trapped per unit bench when the boards were hung vertically at 0.75 m spacing as compared with 1.5 m spacing, there was little difference in the level of damage done to the chrysanthemum plants.

### Herbicides

*The comparative behavior of simazine and terbacil in soils.* Adsorption of simazine (2-chloro-4,6-bisethylamino-1,3,5-triazine) was 2.2–4 times greater than that of terbacil (5-chloro-6-methyl-3-*t*-butyluracil) in the same soils, and adsorption of both herbicides was 2–4 times greater in topsoils than in subsoils. Adsorption was inversely correlated with herbicide movement in a thick-layer chromatography system. One year after application of 3 kg/ha to field plots, simazine residues were highest near the soil surface, whereas terbacil residues increased with soil depth in the sandy and sandy loam soils. Total residues recovered from the upper 25 cm of soils was 5%, or less, of the simazine originally applied, and 10%, or less, of the applied terbacil. In an oat seedling bioassay, the $GR_{50}$ values were generally 1.5–3 times higher for simazine than for terbacil in the same soils.

*Residues of atrazine and hexazinone in fruit of lowbush blueberries.* Field plots located in commercial blueberry fields in the four Atlantic Provinces were treated in the spring, following the pruning burn with atrazine at 4.5–8.0 kg/ha and hexazinone at 1.5–3.0 kg/ha. Fruit was harvested the following year and samples were analyzed by a gas–liquid chromatography system equipped with a N/P alkali flame ionization detector. Analytical techniques could accurately detect atrazine levels to 0.002 mg/kg and hexazinone and its four major metabolites to 0.04 and 0.08 mg/kg, respectively. No residues were found of either herbicide, nor of the hexazinone metabolites when the herbicides were applied in the burn year. These herbicides are extremely beneficial in this crop and efficacy, tolerance, and residue data supported their (1982) registration.

## ANIMAL SCIENCE

### Beef

*Effect of steam-treated grass silage on animal gain.* Four crops as unwilted silage were compared for weight gain with steers: (*a*) mixed grasses harvested 14–15 June at early head stage with 61% digestible dry matter in vitro; (*b*) similar grass, steamed while standing, with the Dutch thermal unit, harvested 14–15 June at early head stage with 63% digestible dry matter; (*c*) second harvest of grass from the same area as *a* but harvested 22–24 August at early head stage with 59% digestible dry matter; (*d*) grass–legume, second harvest on 22–24 August at early head–early bloom stage with 62% digestible

dry matter. One group of steers was fed each of the four silages alone, and another group of equal number was given 1 kg of ground barley with the silage. Animal gains when these silages only were offered were (*a*) 0.45, (*b*) 0.71, (*c*) 0.47, and (*d*) 0.71 kg/head per day. There was an increase of 57% in weight gain resulting from the steaming of the standing grass sward prior to ensiling. This was greater than the 30% increase in weight gain obtained by supplementing the conventional silage ration with barley at 1 kg/day.

**Hogs**

*Fish silage in swine rations as a source of protein.* Incorporation of fish silage into swine rations as a protein source was shown to be a viable alternative to other protein sources in terms of feed conversion and carcass quality. Palatability is still a problem that requires further study. Poor palatability of the silage resulted in decreased feed consumption and gain.

*Synthetic lysine a benefit in some pig rations.* Pigs fed a 12.8% crude protein ration supplemented with synthetic lysine to a level of 0.74% of the ration showed equally good performance in terms of rate of gain, feed conversion, and carcass quality, to pigs fed 16.1% crude protein and 0.94% natural lysine. Pigs fed 9.8% crude protein with synthetic lysine supplemented to provide a level of 0.60% of the ration showed significantly worse growth performance and carcass quality.

**Poultry**

*Effects of feeding vomitoxin-contaminated wheat on the performance of broiler chickens.* Two experiments were conducted to ascertain the effect of feeding vomitoxin to meat-type chickens. Chickens were fed diets containing 0%, 12%, 24%, 36%, 48%, and 60% of wheat containing a vomitoxin level of 3.00 mg/kg. Analysis indicated that the vomitoxin levels in the diets ranged from $<0.02$ (control) to 1.87 mg/kg. There was no evidence of feed refusal or emesis, nor were there any significant effects on mortality, body weight gain, live body weight, feed consumption, or feed conversion when these diets were fed. Subjecting the feeds to the pelleting crumbling process had no effect on the level of vomitoxin found in the finished feed. No organ damage from feeding vomitoxin was evident.

*Effect of sodium hypochlorite (Javex) on the performance of broiler chickens.* Studies were done with broiler chicks to determine the effects on mortality and biological performance of administering sodium hypochlorite (NaOCl) via the drinking water. Sodium hypochlorite was added to the drinking water to achieve the following treatment levels (milligrams per kilogram) of available chlorine: 0, 300, 600, and 1200 (experiment 1); 0, 37.5, 75.0, and 150 (experiment 2). Administration of available chlorine at 1200 mg/kg significantly increased mortality, lowered feed efficiency, reduced water consumption, and lowered heart, liver, kidney, and testes weights. Administration of 300 mg/kg, or more, resulted in significantly lower mean body weights. Overall, a significant effect on biological performance or practical benefit was not achieved from administering sodium hypochlorite to broiler chicks.

*Nutritive value of sorghum grain for broiler chickens.* The nutritive value of sorghum grain as a partial replacement for corn and wheat in practical poultry diets was evaluated. Starter (finisher) diets fed from 0 to 21 days (22–42 days) contained the following levels of sorghum grain: 15(19)%; 30(39)%; 45(58)%. The diets were isoenergic and isonitrogenous. The inclusion of up to 45% sorghum grain in the starter diet and up to 58% in the finisher diet had no significant effect on mortality, live body weight, feed conversion, or percentage of grade A carcasses.

*The effect of dietary energy regimens on the performance of two commercial chicken broiler genotypes reared to roaster weight.* Two commercial male genotypes were used to evaluate the optimal level of dietary energy for roasters at each stage of production using a three-stage (starter, grower, finisher) feeding system of 16-20-16% dietary protein, respectively. Of the regimens examined, a starter-grower-finisher regimen with a metabolizable energy of 12 552, 12 970, and 13 388 kJ/kg resulted in the heaviest body weights and best feed conversion and monetary returns. Although the incidence of slipped tendons tended to increase (significant for the highest energy regimen) with increasing levels of dietary energy, the incidence of total leg abnormalities (all types) was not altered significantly by dietary energy level per se.

*Performance of male broiler genotypes reared to roaster weight and females reared*

*to broiler weight on a low-protein dietary regimen.* Male and female broiler chickens representing four commercial genotypes were reared to roaster weight on a low-protein, three-stage (16-20-16) feeding program. The results indicate that this roaster program is not genotype specific and that males reached the marketable roaster weight by 70 days of age and yielded comparative monetary returns regardless of genotype used. The study also showed that the program supported good growth of females, which on average reached marketable broiler weight (1865 g) in 49 days. Thus, the results indicate that this feeding program could be used with a mixed sex population, with the males marketed as roasters at 70 days and the females marketed earlier as broilers.

*Effect of hatching-egg size from dwarf and normal meat parent genotypes on the performance of broiler chickens.* Hatching eggs were collected from two meat parent genotypes (normal and dwarf) between 200 and 210 days of age and sorted by weight into four quartiles. Eggs from the light and heavy quartiles were retained for a comparative testing of hatching quality and progeny performance. Maternal genotype had no significant effect on the body weights of broiler progeny at 49 days. Egg size had a significant effect on both male and female body weights at all ages, with broilers hatched from small eggs being lighter than those hatched from large eggs. Feed conversion was unaffected by genotype, but chickens hatched from large eggs exhibited better feed conversion compared with those hatched from small eggs. Egg size had a significant effect on monetary returns: broiler chickens hatched from the smaller eggs returned approximately seven cents less per bird compared with broilers hatched from the larger eggs. There was no significant difference between monetary returns from broiler chickens from either normal or dwarf maternal parentage.

*Effect of preincubation warming on the hatchability of hens eggs from normal and dwarf parental genotypes.* Eggs (9120) were collected from two maternal genotypes to estimate the effects on hatchability of preincubation exposure to 38°C for periods ranging from 0 to 7 h. Eggs from one genotype exhibited an increase in hatchability when exposed to 38°C for 5 h. In a second experiment, exposure of eggs from two genotypes to 38°C for 0, 5, 6, and 7 h resulted in a genotype × heat treatment interaction for hatchability.

*Effect of reduced feeding time using all-mash or crumble-pellet dietary regimes on chicken broiler performance, including the incidence of sudden death syndrome.* Commercial broiler chickens were used to estimate the effect of restricting feeding time to 8, 10, 12, 14, 16, or 24 h/day from 21 to 49 days of age (slaughter age) and the effect of using an all-mash versus a crumble-pellet feeding regimen. Restricting the feeding time had a significant effect on the body weights of both males and females at 28 and 49 days, with body weights being heavier as feeding time increased. Feeding crumble-pellet diets resulted in increased body weights at 21, 28, and 49 days, improved feed conversion, more grade A carcasses, and increased monetary returns. Mortality was also significantly higher for birds grown on the crumble-pellet feeding regimen. This higher mortality was attributed to deaths due to sudden death syndrome ("flip-over"), which was significantly higher among males on the crumble-pellet dietary regimen than on the all-mash dietary regimen.

*Feed texture effects on the performance of turkey broilers.* An experiment involving 2400 turkey broilers was conducted to compare feeding starter, grower, and finisher diets in the all-mash form or as crumbles and pellets. The effects of pelleted grower and finisher diets containing 0%, 7.5%, 15%, 30%, or 60% "fines" were also comparatively evaluated. Lower body weights and poorer feed conversion resulted when birds were fed the all-mash diets, but mortality, carcass grades, and monetary returns were not affected significantly ($P < 0.05$). Similarly, as levels of fines in pelleted grower and finisher diets increased, feed conversion was adversely affected and body weights tended to be lower, but mortality, carcass grades, and monetary returns were unaffected ($P < 0.05$).

*The effect of toe clipping and reduced feeding time on the performance of broiler chickens.* The performance of broiler chickens subjected to detoeing and restricting feeding time to 16 h/day commencing at 21, 28, 35, and 42 days was evaluated. No beneficial effects resulted from detoeing. Body weights were reduced for males at 21, 28, 35, 42, and 49 days; however, these differences were significant ($P < 0.05$) only at 21, 28, and 35

days. Female body weights were reduced ($P < 0.01$) only at 21 days. Detoeing had no significant effect ($P = 0.05$) on carcass grades, mortality, or monetary returns. Reducing feeding time to 16 h/day had no significant ($P = 0.05$) effect on mortality, body weights, feed conversion, percentage grade A carcasses, or monetary returns.

*The combined effect of a high-calcium prelay diet, a high-protein layer diet and supplemental oyster shell on egg specific gravity and other traits of Leghorn hens.* Three experiments were designed to study the combined effects of grower diet calcium level (3.26% versus 0.80%) fed from 105 to 147 days and the feeding of supplementary oyster shell and a high-protein diet (20.1% versus 15.1%) from 147 to 497 days of age, on shell strength (egg specific gravity) and other traits. The feeding of supplementary oyster shell during the laying period had little effect on mortality, egg production, egg weight, body weights, or feed consumed per dozen eggs produced. The high-protein layer diet coupled with supplementary oyster shell feeding resulted in improved eggshell strength.

*The effect of crumbled and pelleted feed on the incidence of sudden death syndrome among male chicken broilers.* The effect of feeding crumble-pellet diets on the incidence of sudden death syndrome was assessed. Mortality due to sudden death syndrome was significantly higher for birds fed a crumble-pellet regimen in its usual form or in a ground form compared with birds fed all-mash diets. Birds fed the crumble-pellet dietary regimen grew more rapidly than those fed either the ground crumble-pellet regimen or the all-mash regimen. There was no significant ($P = 0.05$) difference in the growth rate of the birds fed the ground crumble-pellet regimen compared with those fed the all-mash regimen. It was concluded that the higher incidence of sudden death syndrome was due to one or more factors in the pelleting process itself rather than the rapid growth resulting from the higher density of pelleted feeds.

*The effect of diets supplemented with Tower or Candle rapeseed meals on performance of meat chicken breeders.* The performance of four commercial meat-type parental genotypes and their progeny was significantly different when they were fed breeder diets supplemented with *Brassica napus* 'Tower' or *B. campestris* 'Candle' rapeseed meals, or both, compared with a commonly used commercial breeder diet supplemented with soybean meal. The egg production of birds on the rapeseed meal diets was equal to or better than that of birds fed the diets supplemented with soybean meal, and, although eggs from birds on rapeseed meal diets were smaller than those from birds fed soybean meal diets, the number of eggs weighing 47 g, or more, was not significantly different. There were more broiler chicks from breeders on the rapeseed meal diets than from those on soybean meal diets. Mortality, age at sexual maturity, feed efficiency, egg specific gravity, fertility, and hatchability were not affected by the dietary treatments. Although mortality among male broiler progeny from parent stocks on rapeseed meal breeder diets was higher than normal, monetary returns per bird started was greater than that from progeny of breeders on soybean meal diets.

*A comparison of the amino acid composition of two commercial oat groats.* The crude protein content of commercially available dehulled oats averaged 14.9% for the cultivar Oxford, grown in Eastern Canada, and 13.30% for the cultivar Sentinel, grown in Western Canada. Although the total lipid content (6.57%) and metabolizable energy (17.74 MJ/kg dry wt basis) of western grown oat groats differs considerably from eastern grown oat groats (3.7%, 16.91 MJ/kg dry wt basis), their crude fiber contents did not differ significantly and ranged from 3.4% to 3.7% of the elemental composition. Both commercial oat groats contained good-quality protein, with an amino acid profile superior to that of other cereals and an excellent balance of essential amino acids limited only in lysine.

**Sheep**

*Effect of sodium bicarbonate, cement kiln dust, and ammonium perchlorate on the growth of lambs.* Two experiments were conducted in which 20-kg feeder lambs were fed either diets supplemented with sodium bicarbonate, cement kiln dust, or ammonium perchlorate, or a control diet in combination with long timothy hay until they reached a market weight of 40 kg. Lambs fed sodium bicarbonate or cement kiln dust grew faster ($P < 0.05$) than the control group and showed equal or superior feed efficiency. Cement kiln dust in the diet produced a

higher fecal pH ($P < 0.01$), thus demonstrating a buffering effect in the lower digestive tract. Sodium bicarbonate or cement kiln dust had no effect on rumen pH. The control and ammonium perchlorate groups grew at the same rate but the control animals showed better feed efficiency.

## STORAGE AND PROCESSING

### Apples

*Controlled atmosphere storage of fresh apples used to maintain juice quality.* Storage of whole apples in air at 0°C resulted in rapid juice deterioration due to loss of soluble solids and titratable acids contents and increased alcoholic off-flavors, haze, and darkening components. Apple storage in conventional controlled atmospheres (5.0% $CO_2$ + 3.0% $O_2$, 2.8°C) retarded the loss of soluble solids and titratable acids in the juice and suppressed haze formation in the initial storage period. Low-oxygen storage (1.5% $CO_2$ + 1.0% $O_2$, 2.8°C) further suppressed titratable acids loss and haze formation during subsequent air storage. Both controlled atmosphere regimens suppressed the levels of ethanol, acetaldehyde, ethyl butyrate, and hexanal found in the headspace above juice. However, apples placed in an additional 90 days of air storage (0°C) after removal from either controlled atmosphere regimen, regenerated the measured headspace volatiles. Storage of whole apples in controlled atmosphere indicates potential for the production of high-quality apple juice over an extended processing season.

*Principal headspace volatile production of McIntosh apples stored in controlled atmospheres and air.* The production of ethanol and acetaldehyde by whole McIntosh apples was suppressed in 5% $CO_2$ + 3.0% $O_2$ (2.8°C) storage as compared to fruit from 0°C air storage. Acetaldehyde, ethanol, ethyl butyrate, and hexanal evolution from intact apples was further suppressed when the fruit was stored in 1.5% $CO_2$ + 1.0% $O_2$ at 2.8°C. Placement of fruit in 0°C air storage, following either one of the two controlled atmosphere regimens, caused regeneration of ethyl butyrate and hexanal in preference to ethanol and acetaldehyde. The capacity of the fruit to generate volatiles varied significantly from season to season, producing a tenfold difference in the levels of headspace volatiles detected.

### Sweet cherries

*Exposure of sweet cheeries to water aggravates the development of surface damage disorders.* Short immersions of 0.25 min in 0°C water increased the incidence of surface pitting as compared to undipped fruit. Immersions of damaged fruit either in 0°C water for extended durations of up to 30 min or in 20°C water did not increase the incidence of surface pitting or of bruising. Fruit immersed in 0°C water absorbed water and corresponded to the period of increased incidence of surface pitting. However, rapid initial water uptake by fruit immersed in 20°C water did not correspond to the development of surface disorders. Rapid temperature reduction of Van sweet cherries by hydrocooling renders fruit more susceptible to surface pitting and appears to be independent of water uptake.

### Tomatoes

*Extending storage life of tomatoes.* Mature green fruit of cultivars Cabot and Cal J were stored at 13°C either in air or in a modified atmosphere formed by sealing five fruit in a 1 mil (0.0254 mm) polyethylene bag. Modified atmospheres reduced rots and slowed fruit maturation. Cal J stored in a modified atmosphere kept for 10 wk compared to only about 3 wk for Cabot stored in air. The results suggest that with a proper choice of storage conditions, the storage life of tomatoes can be significantly extended. The sealed polyethylene bag method of creating a modified atmosphere is simple and economical.

### White beans

*Blanch process for dried white beans using the K-series blanching process.* The results of tests of the three sizes of the K-series of blanchers, 400 kg/h, 2400 kg/h, and 4800 kg/h, have indicated a definite advantage over conventional blanching processes in terms of both energy used and effluent generated. Preliminary studies indicate that these blanchers, with minor modifications, can also be used in processes that require rehydration. Beans soaked but not fully rehydrated and blanched in the K blancher did not pick up as much water during the blanching step as did beans blanched by immersion in water.

Steam-blanched beans that were subsequently immersed in the steam condensate from the heating section did rehydrate to approximately the same extent as beans blanched in water. Overall weight gains for the water-blanched product and the modified steam-blanched product were 115.5% and 116.9%, respectively, compared with a weight gain of 110.2% when a steam-blanch dry hold process was performed. Moisture gain after blanching with the modified steam blanch is equivalent to the water blanch and superior to the steam blanch with dry hold.

**Winter wheat**

*Baking and milling quality of Nova Scotia winter wheat.* Milling and baking test results have demonstrated that the following cultivars are unsuitable for milling purposes: Vuka, Karmoran, Clement, Lennox, Norstar, and Stephan. By contrast, both Monopol and Absolvent cultivars possess genetic quality characteristics, which produce proteins that result in good baking quality. Results further indicate that content of these proteins is highly dependent on the application of high levels of nitrogen fertilizer. The effects of Cyclocel are somewhat mixed.

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# INTRODUCTION

The Fredericton Research Station carries a comprehensive research program on potatoes, focusing a multidisciplinary effort on cultivar development, tuber processing quality, disease control, pest management, rapid multiplication techniques, dormancy manipulation, handling and storage procedures, and soil utilization. Recently, priority has been given to the seed potato sector of the industry, emphasizing the testing of Canadian genetic stocks in countries with import potential, and the aspects of phytosanitary quality.

The horticultural program also consists of research on the management of wild stands of blueberries, and contributes to the program at the Kentville Research Station on apple orchard management and strawberry cultivar evaluation. To this horticultural program is added the research at the Hervé J. Michaud Experimental Farm, established at Buctouche, N.B., in 1978. Its research summary appears in this report.

The livestock and livestock feeds program has, as its main thrust, the efficient utilization of forages by dairy and beef cattle, and by sheep. Herd and flock management aspects are also investigated. The research is pursued in close collaboration with the Nappan Experimental Farm.

The results herein reported are indicative of the outcome of the ongoing research programs. More complete information is available from the Research Station, Research Branch, Agriculture Canada, Box 20280, Fredericton, N.B. E3B 4Z7.

C. S. Bernard
Director

# ANIMAL NUTRITION AND LIVESTOCK FEEDS

## Forage quality forecast

This program advised farmers on current and predicted stages of growth and nutritional quality of forages. It was conducted from early June to mid-July. The areas covered in 1982 were expanded beyond those of 1981 to include more of New Brunswick and the Annapolis Valley in Nova Scotia. Predictions of nutritional quality were based on laboratory analyses of samples collected from selected sites and on data obtained in previous years on forages and the weather. Each forecast covered a 10-day period for two cultivars of timothy, red clover, and alfalfa, and was updated each week.

The information was available to farmers by weekly publication in newspapers and semiweekly broadcasts over local and regional radio networks. Observations by agricultural extension personnel and feed analysis laboratories indicate that farmers in the region are becoming more aware of the significance of forage quality and the management necessary to improve it.

## Mechanical processing of hay

An experiment was conducted with yearling Holstein heifers to measure the effects on feed intake of mechanically processing (grinding through a 0.5-cm screen) a low-quality grass hay and a form of crude protein supplementation (urea versus soybean meal). The predominantly timothy hay contained 6.9% crude protein and the dry matter digestibilities by sheep were 52.6% (chopped) and 48.2% (ground). Weight gains were significantly higher for the heifers fed the ground hay than for those fed chopped hay. The soybean supplement also resulted in higher weight gains, when compared to the urea supplement. Interactions between the form of hay and the type of protein supplement were not significant. The same relationship held true for dry matter intake. Even when adjustments were made for the lower dry matter digestibility of the ground hay, the intake of digestible dry matter was increased by grinding. These results support the hypothesis that there are two mechanisms controlling intake of low-quality forages by ruminants. One is the rate of passage of dry matter through the rumen and the other is the adequacy of absorbed amino acids.

**Silage moisture determination**

The traditional toluene distillation method for silage moisture determination was compared with oven drying, freeze-drying, and extraction with ethanol or methanol, followed by quantitation using gas–liquid chromatography (GLC). The objective was to compare accuracy versus time and number of samples processed, using toluene distillation as the theoretical standard.

Oven drying gave moisture values that were 2–3% greater than the toluene value. This was due to the removal of nonaqueous volatile compounds. Freeze-drying gave intermediate values because there were less volatile materials removed under those conditions, but the values were too variable to apply a simple correction factor. Methanol extraction for 24 h plus GLC analysis of the water extracted gave values almost identical to the toluene method. There was no improvement in the time requirement, but the number of samples that could be processed was much greater. Ethanol extraction for 24 h plus GLC analysis gave highly variable results that were 4–6% less than the toluene. Extending the time of extraction to 3–6 days decreased the variability but left the moisture value percentages lower by about 3%. Thus, methanol extraction for 24 h plus GLC analysis of the water appeared to be the only suitable alternative to toluene distillation, from those methods examined.

**White rot fungi to improve nutritional quality of straw**

The feasibility of using white rot fungi to increase the digestibility of wheat, barley, and oat straw for ruminants was studied on a laboratory scale. The fungal species included *Ganoderma applanatum* (GA), *Phanerochaete chrysosporium* (PC), and *Pleurotus ostreatus* (PO). They were chosen for their ability to degrade lignin while sparing cellulose and hemicellulose. Static, semisolid fermentations were set up in 500-mL jars with mixtures of 8–10 g of chopped straw and 4 mL of buffered pH 4.1 minimal media solution. The jars were then sterilized in an autoclave and inoculated with either GA or PO mycelia, or with PC conidia and incubated at 25°C. Uninoculated controls were treated in the same manner. Changes in chemical composition and in vitro rumen true digestibilities (IVTD) and cellulase degradability of the fermented mass were monitored for up to 12 wk. Lignin, neutral detergent, and acid detergent fiber contents of all straws decreased as the fungal fermentations proceeded. After 8 wk, lignin in barley, wheat, and oat straws by GA was reduced to 60%, 40%, and 66% of control samples. IVTD was increased by GA from 49.6% to 80.2% for barley straw, from 48.5% to 86.5% for wheat straw, and from 43.7% to 76.3% for oat straw.

Fermentation with PC improved digestibilities less than GA, whereas PO produced changes similar to GA. All fungi degraded some cellulose and hemicellulose as well as lignin. These laboratory-scale experiments indicate that white rot fungi can improve the nutritional quality of straw so that it is equivalent to good-quality hay.

**Cement kiln dust in the ruminant digestive tract**

Lambs fed 3% cement kiln dust (CKD) rations for 28 days and steers fed 2% CKD rations for 12 28-day periods were slaughtered, and the digestive tract contents were collected from the rumen, omasum, abomasum, duodenum, jejunum, ileum, caecum, and distal colon.

In both the lamb and steer digestive tracts, no differences in pH were observed from the rumen through the ileum. Lamb caecum and colon samples showed that the CKD diets elevated pH from 0.24 to 0.49 units when compared with the respective control diets. The steer caecum samples were not different, but the colon samples from the CKD group had their pH elevated by about 0.3 units over the control. Soluble carbohydrate was less throughout the digestive tract of the CKD steers when compared with the controls. These differences were greater and statistically significant ($P < 0.05$) in the ileum, caecum, and colon.

Thus, CKD appeared to express its effect in the lower digestive tract. This was shown as an elevated pH in the caecum and colon, where secondary fermentation processes were occurring. From the amount of soluble carbohydrate, it appeared that (*a*) more carbohydrate was being digested and absorbed in the CKD-fed animals, or (*b*) less soluble carbohydrate was being liberated from CDK rations so that a higher proportion appeared to be absorbed.

**Cement kiln dust in lamb rations**

Cement kiln dust (CKD), which is a by-product of the cement-making process, was added to finishing lamb rations at 0%, 1%, 2%, and 3% of the ration. Growth rate and feed consumption were monitored every 2 wk, for a total of 10 wk, on two groups of six lambs for each diet.

Lambs fed 1% and 2% CKD grew more rapidly than the 0% (control) group, with the differences increasing throughout the trial. The 1% group was superior to the 2% group. The 3% group grew more slowly than all others for 4 wk but accelerated to have total growth equivalent to the 1% group by week 10. Feed consumption for all CKD groups was greater than for the controls; however, only the 1% and 3% groups had superior feed efficiency.

CKD increased fecal pH in the 1% and 3% groups. Thus, CKD improved lamb growth by about 10% for the 1% and 3% groups, and fecal analysis showed that residual fecal protein, rather than fecal soluble carbohydrate, was decreased. The 2% group does not fit the pattern of the other CKD groups but this is probably a lamb-related cause such as subclinical infection, problems with water bowls, drafts in pens, or feeder placement.

**Potato by-products as feed**

By-products of potato production and processing in the Maritime Provinces are finding increasing uses in livestock feeding programs. Digestibility determinations done at Fredericton Research Station have shown that potato steam peel waste dry matter is 81% digested by pigs. Its crude protein content is about 16% and was 61% digestible. Feeding trials done on a farm indicate that pigs will readily consume diets containing up to 20% of the dry matter from potato steam peel waste without detrimental effects. Enough steam peel is produced in New Brunswick to replace 10% of all the grain fed to pigs in that province.

The 2nd yr of a steer-feeding experiment confirmed that growing–fattening cattle make more economic gains when fed on potatoes than on conventional silage–grain rations or even when on pasture part of the year. The potato-fed steers returned $50 per head of management compared with $32 per head for steers finished off pasture and a loss of $19 per head for cattle finished on barley and silage. Steers kept on a growing ration (gain of 0.5 kg/day) for 200 days and then finished on typical feedlot ration lost $60 per head. Enough cull potatoes and processing waste are produced in a typical year in New Brunswick and Prince Edward Island to fatten 50 000 beef cattle.

Ensiling programs have been developed to permit storing surplus potatoes on livestock farms for extended periods of time. A ratio of four parts pulped potato to one part chopped dry hay makes a satisfactory silage in upright silos. A preliminary trial indicates that potatoes can be satisfactorily preserved in a horizontal silo by alternating layers of wilted, chopped grass and whole potatoes.

Studies conducted over many years have shown that potato vines removed when they are still green contain a useful level of feed nutrients and can be utilized by ruminants after ensiling. The ensiling process results in a decrease in the content of toxic glycoalkaloids. Rumen microorganisms are also effective in hydrolyzing the glycoalkaloids. Although the products of the hydrolyzation remain in the silage, they are less soluble and thought to be less toxic. Analyses completed this year indicate that residues of some common pesticides used on potato foliage decline rapidly after application. However, because of potential pesticide residues, feeding of potato vines is not recommended at this time.

**Lignin analysis using ceramic fiber**

Ceramic fiber can replace asbestos fiber in the sulfuric acid (Klason) procedure for determining the lignin content of forages and other plant materials. Asbestos fiber has been used as a filtering aid for crude fiber and lignin assays, but its carcinogenic nature makes its replacement necessary. Ceramic fiber is used for high temperature insulation and is less hazardous than asbestos. Ceramic fiber was prepared by mixing it with water in a Waring blender. After treatment with 72% (wt/wt) sulfuric acid at 550°C in an ashing furnace, the recovery of ceramic fiber was higher and less variable than that of asbestos fiber. Thirty-two immature and mature forages and six samples of woody plants were analyzed for lignin by treating their acid detergent fiber fractions with sulfuric acid. Ceramic fiber was compared with asbestos fiber in the lignin analysis. Estimates of the samples' lignin content were lower when ceramic fiber was used. Expressed as a

percentage of sample dry matter, the average lignin contents using ceramic or asbestos fibers were, respectively, 3.00 and 3.24 for the 16 immature forages, 8.52 and 8.82 for the 16 mature forages, and 13.92 and 14.06 for the 6 woody materials. It is possible to correct lignin estimates obtained with ceramic fiber so that they correspond to those obtained with the traditional asbestos method.

### Malate dehydrogenase from bovine rumen epithelium

Malate dehydrogenase (MDH) was partially purified from both bovine rumen epithelium and heart. Most previous work on MDH has been conducted on the heart enzyme. When the physical characteristics of the heart and rumen epithelial enzymes were compared, they were similar. The $K_m$ values for all substrates (malate, oxaloacetate, NAD, and NADH) were similar, with a tendency toward lower values for the epithelium. The pH optimum for both was a relatively broad peak from 8.3 to 8.7 and the temperature optimum was 38–40°C. When crude extracts from bovine brain, rumen epithelium, heart, kidney, liver, and muscle were separated by electrophoresis and strained for MDH activity, two bands were observed that were indistinguishable among the tissues.

Adenine-containing compounds, AMP, ADP, and ATP, inhibited the activity of both MDH's. Others have suggested that this is a substrate competition with NAD. The volatile fatty acid, acetate, and the coenzyme A salts of all the volatile fatty acids inhibited MDH activity. The combination of volatile fatty acyl-CoA salts and ATP or ADP produced an additive inhibitory response suggesting that the mode of action for each inhibitor was different.

These findings are important because they show that volatile fatty acids, if they are being metabolized, can partially regulate the production of energy from the citric acid cycle and cause intracellular malate concentrations to increase. This is more important for the rumen epithelial MDH, because the rumen epithelium is constantly bathed in a solution of volatile fatty acids and is continually absorbing them. It was also found that acetate stimulated the activity of NADP-malate dehydrogenase (malic enzyme), whereas propionyl-CoA inhibited its activity. As malic enzyme is found in the cytoplasm, it should be more affected by acetate. Thus, malate accumulating as a result of MDH inhibition may be metabolized by malic enzyme-producing NADPH, a compound that is essential for cell growth. This may be the only source of NADPH in rumen epithelium.

## POTATOES

### Breeding

*Quantitative genetics of autotetraploids.* Potato, *Solanum tuberosum*, is an autotetraploid. Genetic and breeding research on quantitative traits such as yield are hampered by its complicated chromosomal behavior during meiosis. The "double reduction" phenomenon is particularly hard to deal with in a biometrical genetic model for polygenic variation. The fact that certain interspecific diploids in potato produce $2n$, unreduced gametes by either first or second division restitution during meiosis provides a new tool for quantitative genetic studies of autotetraploids. By using a diploid hybrid and its tetraploid in a series of crosses, it is possible to estimate double reduction and genetic parameters in an "additive-dominance" model for autotetraploids. The estimates of genetic parameters can then be used to answer many problems raised in potato genetic and breeding research, e.g., genetic mechanism of heterosis, cause of narrow genetic base, and suitable breeding scheme for utilizing germ plasms.

*Performance of first field generation seedlings under prairie conditions.* Two groups of first field generation seedlings obtained from the Fredericton breeding program were compared in Alberta. One group was composed of seedlings obtained at random and the other group was composed of seedlings obtained through the normal selection procedures used at Fredericton. Results of the study provide evidence that preselection in the first clonal generation at Fredericton significantly improves the maturity, yield, and tuber traits of these seedlings when grown in Alberta, yet does not cause a major reduction in the variability of traits.

*Sexual polyploidization and heterosis.* In order to broaden the relatively narrow genetic base of the cultivated potato, diploid germ plasm is being incorporated into Tuberosum breeding stocks. Diploid hybrids, which have been selected for $2n$ gametes, yield, and other horticultural traits, have been crossed with

tetraploid cultivars and breeding stocks. Several selected hybrids from these 4x–2x crosses were found to produce a marketable yield that is 15–30% higher than Kennebec. The observed heterosis appears not only to be the result of a broadened genetic base but also to confirm the need for a continued use of various germ plasm resources in the Canadian potato breeding program.

*Identification of superior Tuberosum and Andigena parents for the production of hybrid potato cultivars.* In a series of experiments, canonical analysis was used to study 60 $F_1$ Tuberosum × Andigena families and involved 21 Tuberosum parents and 18 long-day adapted Andigena parents. In each experiment, superior hybrid families were identified by their close similarity to the Tuberosum parental clones. Further, among all experiments, some parents were consistently involved in the superior families so that it was possible to identify superior parents; six Tuberosum parents and six Andigena parents were identified in this way. The Tuberosum parents generally had early initiation of tubers, produced large tubers, and matured early. The superior Andigena parents showed earlier sizing and reached a larger size and higher marketable yield than most other Andigena clones. These traits will permit the identification of further potentially superior parents and cross combinations.

**Entomology**

*Chemical control.* The relatively widespread use of systemic insecticides has increased concern about their environmental impact, so field plot studies were conducted to determine the lowest rates for satisfactory control of the major potato pests. Aldicarb, Disulfoton, and Phorate showed excellent control of the common potato aphid and the buckthorn aphid, and were effective with rates as low as 17 kg/ha. Carbofuran gave poor control of the common potato aphid but good control of the buckthorn aphid. Its effectiveness remained unchanged at the lower rate of 28 kg/ha, except against the green peach aphid. Because of the late arrival of this aphid in New Brunswick potato fields, only the most persistent systemic insecticides such as Aldicarb and Phorate can give some control. All the insecticides tested were excellent for control of adult Colorado potato beetles. Our data suggest that Aldicarb at a rate of 17 kg/ha is as effective as the recommended 22 kg/ha against both aphids and potato beetles. The lowest recommended rate for Disulfoton and Phorate (17 kg/ha) is satisfactory for aphids but not for Colorado potato beetles.

*Biological control.* A 3-yr faunal survey of potato fields throughout New Brunswick revealed a rich and diverse community of more than 565 species of arthropods. It is structured as a large group of rare and very rare species superposed over a smaller group of common and very common species. Less than 28% of the species could be identified as phytophagous. However, approximately 47% were specific or general parasites and predators, which suggests a potential for the use of native biological agents in the control of potato insect pests.

*Colorado potato beetle.* Adult Colorado potato beetles aggregated preferentially on potato plants infected with potato leaf roll virus in New Brunswick fields. Although laboratory tests have shown that female beetles actually prefer to feed on the infected potato leaves, they produce less eggs and do not live as long as females fed healthy potato leaves. However, this is not expected to have a significant effect on the abundance of beetles because of the relatively low percentage of infected potato plants in commercial fields. Future identification of the mechanisms responsible for feeding preference and decreased fecundity could be useful in the breeding and selection of cultivars resistant to the beetles.

**Pathology**

*Natural occurrence of necrotic systems in Kennebec potatoes with mixed infection of PSTV and PVY.* In 1981, a severe necrotic disease was observed on Kennebec potatoes grown in an experimental field plot. Symptoms consisted of necrotic rings and spots on the foliage near the top of the plant, severe drop of lower leaves, and very severe stunting of the entire plant. Identification of causal agents showed the presence of both potato spindle tuber viroid (PSTV) and potato virus Y (PVY) in infected plants. Virus- and viroid-free plants of Kennebec were mechanically inoculated with PSTV and PVY, used alone or in various combinations. The severe necrotic symptoms were only produced when the potato plants were infected with PSTV prior to the PVY infection. Very little necrosis

was observed following simultaneous inoculation with PSTV plus PVY, or inoculation with PVY prior to PSTV infection. Additional potato cultivars with different types of PVY resistance were tested for their reaction to PSTV plus PVY infection. The cultivars Keswick, Sebago, and Saco reacted similarly to Kennebec, whereas others did not show additional symptoms due to mixed infection. Tests indicate that concentration of PVY is higher in plants infected with PSTV plus PVY than in those infected with PVY alone.

*Temperature affects the storage of virus-infected leaves.* Storage of foliage infected with potato viruses A, S, X, Y, and leaf roll at temperatures of 25, 4, –20, and –70°C gave variable infectivity and serological values in enzyme-linked immunosorbent assay (ELISA) tests for all potato viruses tested. Similarly, infectivity of potato virus A or Y from tissues stored at –20°C showed that low yield of virus is obtained at –20°C, whereas high yield is obtained at –70°C. Pretreatment of leaves in solutions of 5% yeast extract, 5% bactotryptane, 5% bacto peptone, and 10% glycine, followed by storage at –20°C, partially maintained both serological and infectivity activity of viruses. The best temperature to store leaf samples for potato viruses is 4°C. At this temperature no reduction in serological or infectivity was apparent for up to a week.

*Indirect ELISA method for the assay of antibodies in the bacterial ring rot organism.* Based on preliminary results of an experimental procedure for the screening and detection of hybridomas specific for antibodies to an immunoreactive polysaccharide isolated from cultures of the ring rot pathogen, an ELISA test was developed to provide for routine analysis of antibody titer in sera prepared from rabbits immunized with the bacterium. Microtiter plates were coated with dilutions of the immunoreactive polysaccharide up to 1:3125, and twofold serial dilutions of the test antiserum adsorbed and reacted with horseradish peroxidase conjugates prepared from antirabbit immunoglobulin G. The suitability of this procedure for hybridoma screening is under evaluation.

*Concanavalin A and zoospore development in Phytophtora infestans (Mont.) DeBary.* Preliminary studies aimed at stabilizing membrane preparations from zoospores of the late blight fungus, in order to facilitate the isolation and separation of their constituent proteins, showed that the jack bean lectin, Concanavalin A, virtually curtailed zoospore development. When sporangia were suspended in aqueous solutions of this compound at 50 $\mu$g/mL in the presence of chloramphenicol at 5 $\mu$g/mL and incubated at 13°C for up to 4 h, encystment and subsequent growth and development of germ tubes were arrested. Ostensibly, Concanavalin A had no effect on indirect germination or zoospore release under these conditions, as reflected in counts made of sporangial casings in both test and control suspensions.

**Physiology and crop management**

*Abscisic acid and tuber dormancy.* Abscisic acid (ABA), sucrose, reducing sugars, and proline contents were monitored over an 11-mo period in tubers of three potato cultivars that exhibited considerable variation in tuber dormancy. ABA and proline levels increased after top-pulling the haulms and were not affected by harvest date. Proline did not change in either a storage temperature or a cultivar-specific manner. The highest concentrations of ABA were found in tubers stored at 2°C, whereas the lowest concentrations occurred in tubers stored at 20°C. At 10°C, the end of tuber dormancy in the cultivars Kennebec and Nooksack (but not Sebago) coincided with the decline in ABA content. There was no evidence of a threshold concentration of ABA below which sprouting would occur. Tuber samples of 10 different cultivars were removed from 10°C and placed in 20°C storage (in darkness). Initial ABA concentrations (i.e., at the time of removal from 10°C storage) were positively correlated with duration of dormancy and negatively correlated with subsequent rates of sprout elongation at 20°C. Sucrose content was negatively correlated with duration of dormancy. Reducing sugars responded primarily to storage temperature and did not appear to be related to dormancy or sprouting.

*Breaking potato tuber dormancy with bromoethane.* Large-scale, dormancy-breaking experiments with bromoethane were done in the fall of 1982 using seed tubers of 14 potato cultivars. Bromoethane was applied as a vapor at a concentration of 0.2 mL/L, for 72 h and at room temperature, to 50-kg bags of dormant tubers in a 52-$m^3$ fumigation room. Subsequent greenhouse evaluation of treated, whole tubers indicated a significant reduction

in duration of dormancy, increased sprout growth rate, and increased sprout number when compared with untreated tubers. Fumigation of the tubers for 6 days led to tuber necrosis. Further large-scale experiments are necessary to evaluate the effects of 1- or 2-day fumigations on dormancy and sprout development.

*Oxidative transformation of deoxynivaleno (vomitoxin) for quantitative and chemical confirmatory purposes.* Although mass spectrometry is the ideal technique for confirming the identity of a suspected toxin, its use is often limited by availability. To help alleviate matters, a rapid and sensitive chemical confirmatory test for the presence of the tricothacene toxin, deoxynivalenol (vomitoxin), has been developed. The test involves oxidation (5 min at room temperature) with a dilute sodium metaperiodate solution. With deoxynivalenol, the 7-hydroxy-8-keto functions undergo oxidative cleavage to yield an aldehyde and a carboxcyclic acid group, respectively. Cyclization of the latter with the C-15-hydroxyl yields a stable seven-membered ring lactone. This derivative can be measured directly by high-performance liquid chromatography or rapidly per-trifluoroacetyled for electron capture gas–liquid chromatographic quantitation. The derivative has been formed and detected from as little as 0.1 $\mu$g of vomitoxin isolated from grain.

*Hollow heart in Russet Burbank.* The incidence of hollow heart in some experimental plots of Russet Burbank was extremely severe this season, reaching up to 74% of the yield (in number of tubers). Observations showed a relationship with low soil temperature at the time of tuber initiation. Fields planted on different dates and exposed to low soil temperatures (approximately 15°C) for 12, 9, and 3 days after tuber initiation resulted in 74%, 54%, and 12% hollow heart, respectively. The data support recent findings of researchers in Washington. It should be noted that prolonged low soil temperatures in late June and early July are uncommon in New Brunswick, as evidenced by records back to 1974. No major incidence of hollow heart was reported during those years.

*Development of a prototype potato harvester.* A mechanical potato harvester for minimizing cost and tuber damage was designed, constructed, and evaluated. Its key features include vibrating shares, brush separator, light-weight construction, hydraulic drives, and two-point hitch arrangement. The harvester performance indicated that it was capable of operating at speeds up to 3.0 km/h. The optimal brush-gap setting minimizing potato tuber loss while maximizing stone separation efficiency was 7 mm. The vibrating share was an effective means of initial soil–potato separation. The upper limit of field-moisture content for satisfactory harvester performance was 29% dry basis.

The necessary components for the harvester have been identified and developed. However, three items need additional research and development: (*a*) improved soil–potato separation by use of additional brushes, (*b*) improved transition from the horizontal to the inclined elevator, and (*c*) deviner chain rearrangement to reduce tuber skinning.

*Potato planters—uniformity of spacing.* The effect of seed piece size and type on potato planter performance was measured during field evaluations. Uniformity of seed piece spacing was quantified by determining the number of skips and doubles, and the coefficient of variation of spacing produced during the planting operations. Three types of planters included in the study were the pick type, cup type, and tuber unit type. The results from the study indicate that the planters responded differently to seed size and type, although all planters performed best when planting whole seed.

Seed size was an important parameter affecting uniformity of seed piece spacing with the cup-type planter. For good performance from these machines, as measured by uniformity of spacing, the larger seed pieces or the use of whole seed appears to be advantageous.

With the pick-type planter, performance was less sensitive to seed size. The pick-type planter was as capable of handling whole seed as the cup-type planter.

The tuber unit-type planter, which was equipped with seed cutters, gave an even seed piece spacing. The uniformity of spacing decreased when large tubers were planted. The tuber unit-type planter, like the other planters, performed best when planting whole seed.

## SOILS

### Soil erosion

In 1981, runoff-erosion plots (11 × 33 m) equipped with monitoring devices were established on Holmesville soil at slopes of 11% (four plots) and 8% (three plots), in the Upper Saint John River Valley. The Holmesville soil is the most extensively farmed soil type for potato production and is subjected to severe erosion.

Very little, if any, soil losses occurred during the snowmelt period of 1982. This exceptional phenomenon may be attributed to the relatively thick snow cover during the winter, which reduced the depth of frozen soil. The relatively dry and mild weather during the spring also reduced the melting rate of snow and, therefore, decreased the amount of water available for surface runoff and sediment transportation. Wheat and potatoes (up and down slope) were planted in the summer of 1982 on five of the seven plots, with the remaining two plots as fallow. Runoff and sediment were measured after each major rainfall. Sediment yield of the potato plots was 3.3 and 7.5 times higher than that of fallow fields for slopes of 11% and 8%, respectively. The results also showed that sediment yield from plots planted with wheat were 6 and 2.2 times less than in fallow fields for slopes of 11% and 8%, respectively. Although the runoff volumes were considerably higher in plots of 8% slope than in plots of 11% slope, no significant increase in sediment yield was found in the 8%-slope plots. On the other hand, the sediment yield from plots planted with potatoes was approximately 50% less in fields of 8% slope than in those of 11% slope. The higher runoff volume of the 8%-slope field was due to the much lower water infiltration rate of the soil (0.3 versus 0.8 cm/h).

### Influence of organic amendments on subsoil properties and forage crop production

In 1980, manure, peat, and sawdust were incorporated individually into compact basal till. The following year, subsoil bulk densities measured with gamma-attenuation devices at depths of 20–60 cm showed reductions of 7%, 11%, 15%, and 22%, respectively, over the control where no organic matter, manure, peat, and sawdust had been added. The readings for 1982 showed that, over the previous 2 yr, the loosened subsoil without added organic matter had reverted to its original condition, whereas the bulk densities of the modified subsoils were still approximately 5% less than the control. Subsurface storm flows measured at a depth of 20 cm showed that the subsurface discharges from the control and the loosened subsoil without added amendment were approximately 1.5–3 times more than the discharge from fields where organic matter had been added. Because of the decreased subsurface discharge, resulting from the higher moisture-storage capacity, more water was available for plant growth during periods of inadequate rainfall, and the average surface (0–5 cm) moisture content of the treated soils was 16–28% higher than the control. In 1982, data from amended fields also showed crop yield increases of 32–86% and 53–124% over the controls, for corn and alfalfa, respectively.

### Influence of compaction on hydrologic characteristics of sphagnum peat soil

Detailed laboratory compaction tests were conducted on cultivated sphagnum peat materials by using the Ottawa Texture Measuring System. The results indicated that the compaction of peat was relatively unaffected by its moisture content at stress less than 13 kPa. However, at higher stresses, compaction increased with increasing moisture content until it reached a maximum bulk density, near saturation. The optimum moisture content for achieving maximum compaction decreased with increasing stress. In response to the increase in bulk density, saturated hydraulic conductivity of the peat material was reduced more than a thousandfold as bulk density increased from 0.1 to 0.25 g/cm$^3$. In addition, the compacted peat (0.25 g/cm$^3$) retained over 50% more water (volumetric basis) than the loose peat (0.12 g/cm$^3$), at a matric water potential of –150 mbar.

Similar compaction tests were also done in the field, where various compaction stresses were achieved by wooden roller, metal roller, and metal roller filled with different amounts of water. The results showed that bulk density correlated well with logarithm of stress ($R^2 >$ 0.9). Significant linear relationships were also found between average surface field moisture content and logarithm of stress with $R^2 >$ 0.9).

### Carrot production on sphagnum peat soil

Low yield resulting from poor germination has always been a problem of carrot production on organic soil. The low germination is largely due to the combination of a relatively late growing season and the traditional method of preparing the seedbed, whereby the surface peat is loosened before seeding. The loose peat not only causes inadequate soil moisture regimes, due to a discontinuity in capillary pores, but it also increases the daily maximum temperature at seeding depth, because of lower thermal conductivity and specific heat capacity. Based on 3 yr of field experiments, it was concluded that increased surface-moisture content of peat either by compacting the seedbed (rolling) or by rising the groundwater table to an optimum level resulted in marked increase (as much as 100%) in germination. Another beneficial effect of these operations was the reduction of the daily maximum temperature at soil surface, which is another cause of poor germination if it exceeds 26°C. Temperature differences as great as 3°C were recorded between the treatments and the control. The studies also showed that the highest germination occurred at average-surface moisture content of approximately 0.6 $cm^3/cm^3$. This moisture content corresponds to a groundwater table of approximately 60 cm from the soil surface for peat compacted with stresses of less than 3 kPa. Due to the gigantic reduction in the peat's ability to drain properly, compaction stress $>3$ kPa is not recommended for germination improvement. Over-compaction, in general, has an adverse effect on yield because of poor aeration.

## SENATOR HERVÉ J. MICHAUD EXPERIMENTAL FARM BUCTOUCHE, N.B.

### Vegetables

*Clear plastic mulches with sweet corn.* Experiments conducted in 1982 on the use of clear plastic mulches with sweet corn have given earlier mature sweet corn as well as higher marketable yields.

Three varieties, North Star, Aztec, and Harmony, were tested under three different treatments: the seeding method ordinarily used by growers; seeding in a 15-cm trench and then covering with a clear plastic mulch; seeding and then covering with a clear, slit mulch, which allows the plants to grow through.

Seeding in a 15-cm trench and then covering with a clear plastic mulch proved to be especially beneficial. Mature corn was obtained 16 days earlier with this treatment and 50% more marketable ears of corn were produced. The other mulch treatment reduced the growth period by about 10 days, compared to the control, and gave 23% more marketable ears.

*Black plastic mulch with pickling cucumbers.* Using black plastic mulch with pickling cucumbers, we obtained 61% higher early yield and 48% total yield compared to the controls. Vines grew more vigorously, and fruit appearance was also slightly better in mulched plots. There were differences between cultivars in response to the black plastic mulch treatment; the cultivar Lucky Strike showed favorable response, whereas the cultivar Multipick did not show significant improvement.

### Fruits

*Strawberry cultivar trial.* For the third consecutive year of testing, the recently released cultivar, Kent, has outyielded all other cultivars and selections on trial. These included the two standard recommended cultivars, Redcoat and Micmac.

*Sour cherry cultivar trial.* Four cultivars of sour cherries were planted in 1981. One cultivar, Hansen's Bush Cherry, was harvested in 1982. The cherries were reddish purple and very tart. Exposure to wind delayed harvest and reduced yields on some bushes.

*Raspberry cultivar trial.* Four raspberry cultivars planted in 1981 were harvested in 1982. Except for the cultivar Carnival, all overwintered fairly well. Although Boyne was the highest yielder in terms of quality, appearance, and flavor, Festival was the best.

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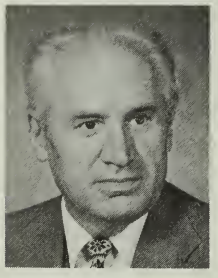

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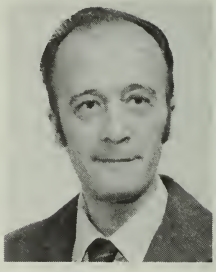

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# PRÉFACE

La région du Québec, dont l'administration centrale se trouve à Montréal, compte trois stations de recherche, trois fermes expérimentales et cinq sous-stations expérimentales. En 1982, le budget de la région était de 17,6 millions de dollars avec un personnel de 94 chercheurs et un effectif total de 352 années/personnes.

Les différents établissements de la région du Québec poursuivent des programmes de recherche axés sur les priorités du Ministère tout en répondant aux exigences régionales.

La station de Lennoxville oriente ses travaux sur les productions animales, en particulier le troupeau laitier, le bovin de boucherie, le porc et le mouton. Plusieurs nouveaux chercheurs ont été embauchés durant l'année et quelques-uns bénéficient de congés d'étude dans le but de compléter leurs connaissances et de s'orienter dans les domaines prioritaires. Les autres domaines qui intéressent cette station sont la production de fourrages pour ruminants et l'utilisation de fumiers qui ne pollueraient pas l'environnement. Les fermes de Normandin et de La Pocatière supportent respectivement une partie du programme laitier et du programme sur le mouton.

La station de Sainte-Foy, située à proximité de la Faculté d'agriculture de l'université Laval, oriente sa recherche principalement sur les sols, les céréales et les fourrages. Des équipes de recherche font un travail en profondeur sur la résistance des plantes au froid ainsi que sur les microorganismes tels que les rhizobiums et les mycorhizes qui vivent en étroite collaboration avec les plantes. Les fermes expérimentales dépendantes administrativement de cette station sont celles de Normandin et de La Pocatière et une nouvelle sous-station expérimentale à Saint-David a été acquise cette année et a été inaugurée sous le nom de ferme expérimentale Jean-Charles Chapais. La proximité de cette ferme de la station de recherche en fait un site idéal pour les travaux en plein champ. Elle remplira principalement cette fonction en plus d'être un centre de rassemblement pour les producteurs de la région de Québec.

La ferme expérimentale de Normandin, en plus de participer au projet national de génétique des bovins laitiers, évalue la rusticité et la productivité des espèces et des cultivars de céréales et de plantes fourragères dans les conditions du Lac Saint-Jean. Ses travaux s'étendent également au bleuet, à la gourgane horticole, aux fines herbes pour ne nommer que quelques-uns de ses projets.

La ferme expérimentale de La Pocatière, en plus de participer au programme de génétique et de nutrition des moutons, évalue la rusticité et la productivité des espèces et des cultivars de céréales et de plantes fourragères dans les conditions du Bas Saint-Laurent. Ses travaux s'étendent également à la pomme de terre, à la malherbologie et à la protection des cultures en général.

La station de recherche de Saint-Jean est orientée vers les cultures horticoles et les grandes cultures. Ses travaux portent sur la production et la protection de ces cultures et tout principalement, dans le domaine des fruits, sur la pomme, le bleuet, la fraise, la framboise, la poire et la prune; dans le domaine des légumes, sur le chou et les membres de cette famille, la carotte, l'oignon, le maïs, la laitue, le céleri et l'ail; des travaux viennent de commencer dans le domaine des fines herbes, des huiles essentielles et des plantes médicinales.

La ferme expérimentale de L'Assomption, qui avec sa sous-station expérimentale de Lavaltrie étudie les tabacs à cigare et à cigarette, a un programme de recherche sur les arbres et arbustes d'ornementation et collabore avec la station de Saint-Jean dans la création de lignées de maïs–grain résistant aux insectes et aux maladies.

Les sous-stations expérimentales de Frelighsburg, Sainte-Clothilde et L'Acadie sont les champs expérimentaux de la station pour ses travaux dans les domaines respectifs des fruits, du maraîchage et des productions légumières.

Les programmes de recherche réalisés à nos diverses stations sont intégrés aux programmes de recherche à contrat qui soutiennent l'effort régional. La recherche à contrat permet à l'industrie agricole et para-agricole de s'engager dans le secteur de la recherche et du développement, et de prendre en main la solution de leurs problèmes technologiques.

En 1982, le bureau régional s'est assuré les services de R. Boulanger comme coordonnateur régional, administration, et de P.P. Lukosevicius comme spécialiste en programmes.

Il est possible d'obtenir de plus amples renseignements sur les programmes en écrivant à ces établissements ou en communiquant avec l'administration centrale de la région du Québec, Direction générale de la recherche, Agriculture Canada, Complexe Guy Favreau, boul. Dorchester ouest, Suite 1002, Montréal (Québéc) H2Z 1X4.

J.-J. Jasmin

# PREFACE

The Quebec Region, with headquarters in Montreal, comprises three research stations, three experimental farms, and five experimental substations. In 1982 the Region had a budget of $17.6 million and a staff of 352, of which 94 were research scientists.

The research programs conducted by the various establishments are designed to meet Departmental priorities and the Region's needs.

The work of the Lennoxville station focuses on livestock production, particularly that of dairy and beef cattle, swine, and sheep. Several new scientists were hired during the year, and others were granted educational leave to further their knowledge and prepare themselves for work in priority areas. The station is also involved in forage production for ruminants and methods of utilizing fertilizers without undue pollution of the environment. The experimental farms at Normandin and La Pocatière, which are administered by the Sainte-Foy station, provide support for the dairy program and the sheep program, respectively, of the Lennoxville station.

The Sainte-Foy station, which is close to the agricultural faculty at Laval University, is mainly concerned with soils, cereals, and forage crops. Its research teams are doing intensive studies on the winter survival of plants and on microorganisms such as rhizobium and mycorrhiza that live in close association with plants. In addition to the experimental farms at Normandin and La Pocatière, the station administers a new experimental substation at Saint-David, acquired this year. Called the Jean-Charles Chapais experimental farm, its proximity to the research station makes it ideal for field work. It will also be used as a meeting place for producers from the Quebec Region.

Besides contributing to the national dairy cattle genetic project, the experimental farm at Normandin assesses the hardiness and yield of cereal and forage species and cultivars under the conditions prevailing in the Lac Saint-Jean region. It also does work on blueberries and on garden varieties of horse beans and herbs, among other things.

The experimental farm at La Pocatière, in addition to contributing to the genetics and nutrition program on sheep, assesses the hardiness and yield of cereal and forage species and cultivars under the conditions found in the Lower St. Lawrence region. It also does work on potatoes and weed control, and on crop protection in general.

The research station at Saint-Jean concentrates on horticultural and field crops. Its work focuses on the production and protection of fruits, especially apples, blueberries, strawberries, raspberries, pears, and plums; and vegetables, especially cabbages and other members of the cabbage family, carrots, onions, corn, lettuce, celery, and garlic. Work has also been started on herbs, essential oils, and medicinal plants.

The experimental farm at L'Assomption and its substation at Lavaltrie study cigar and cigarette tobaccos. Research on ornamental trees and shrubs is also conducted at L'Assomption, and the farm collaborates with the Saint-Jean station in the production of insect- and disease-resistant strains of corn grown for grain.

The Frelighsburgh, Sainte-Clothilde, and L'Acadie experimental substations provide the Saint-Jean station with facilities for field work on fruit, market-garden crops, and legumes, respectively.

The research programs carried out at our various establishments are integrated with contract research programs that contribute to the regional effort. The contracting of research allows the agricultural and para-agricultural industry to become involved in the research and development needed to find solutions to their technological problems.

During 1982, Mr. D. R. Boulanger joined the regional office as regional administration coordinator, and Dr. P. P. Lukosevicius, as program specialist.

Further information on programs can be obtained by writing directly to the establishments concerned, or by contacting the Quebec Region's headquarters at the following address: Agriculture Canada, Research Branch, Guy Favreau Complex, Dorchester Boulevard West, Suite 1002, Montreal, Que. H2Z 1X4.

J.-J. Jasmin

# Station de recherche
# Lennoxville, Québec

## CADRES PROFESSIONNELS

### Administration

| | |
|---|---|
| Y. Martel, B.A., B.Sc. (Agr.), Ph.D. | Directeur |
| J. de Léséleuc | Services administratifs |

### Soutien scientifique

| | |
|---|---|
| S. Gagné-Giguère,[1] B.A., M.A., M.Bibl. | Bibliothèque |
| A. Belleau | Programmeur analyste |

### Production de viande

| | |
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| M.H. Fahmy, B.Sc. (Agr.), M.Sc., Ph.D. | Chef d'objectifs; génétique—mouton |
| A.M.B. de Passillé, B.Sc., M.Sc. | Éthologie—porcs |
| J.J. Dufour, B.Sc. (Agr.), M.Sc., Ph.D. | Physiologie de la reproduction—porcs |
| Paul Flipot,[2] B.Sc. (Agr.), M.Sc., Ph.D. | Nutrition—bovins de boucherie |

### Production laitière

| | |
|---|---|
| G.L. Roy, B.S.A., M.Sc., Ph.D. | Chef d'objectifs; génétique |
| B. Lachance, B.Sc. (Agr.), M.Sc. | Régie—jeunes ruminants |
| G. Pelletier, B.Sc. (Agr.), M.Sc., Ph.D. | Physiologie de la digestion |

### Production fourragère et sols

| | |
|---|---|
| J.-L. Dionne, B.A., B.Sc. (Agr.), Ph.D. | Chef d'objectifs; fertilité des sols |
| G.M. Barnett, B.Sc. (Agr.), M.Sc. | Régie—environnement |
| W. Mason, B.Sc. (Agr.), M.Sc., Ph.D. | Régie—plantes fourragères |
| A.R. Pesant, B.Sc. (Agr.), M.Sc. | Physique des sols |
| C. Fernet, B.Sc. | Amélioration des plantes |

*Étudiants*

| | |
|---|---|
| J. Bernier, B.Sc. (Agr.) | Régie—boeufs |
| J. Chiquette,[3] B.Sc. (Agr.), M.Sc. | Microbiologie du rumen |
| C. Farmer, B.Sc. (Agr.), M.Sc. | Régie—porcs |
| C. Girard, B.Sc. (Agr.), M.Sc. | Nutrition—jeunes ruminants |
| L. Guilbault, B.Sc., M.Sc. | Physiologie de la reproduction |
| J. Matte, B.Sc. (Agr.), M.Sc. | Nutrition—porcs |
| D. Petitclerc, B.Sc., B.Sc. (Agr.), M.Sc. | Physiologie de la lactation |
| S. Pommier, B.Sc., M.Sc. | Spécialiste en viande |
| N. St-Pierre, B.Sc. (Agr.), M.Sc. | Analyse de systèmes |
| C. Vinet, B.Sc. (Agr.), M.Sc. | Nutrition—bovins laitiers |

[1]Détaché de la Direction générale des affaires financières et administratives, Division des bibliothèques.
[2]Détaché à la Direction de l'imputabilité gestionnaire, de septembre 1982 à mars 1983.
[3]Se joint au personnel 1982.

# INTRODUCTION

La station de recherche de Lennoxville et sa ferme expérimentale forment un tout visant à solutionner les problèmes importants au Québec dans les domaines des productions animales et ceux des plantes fourragères et des sols qui s'y rattachent de près. Les programmes de recherches sont placés sous trois objectifs: la production de viande incluant les travaux sur les bovins de boucherie, les porcs et les ovins, la production laitière et la production fourragère et les sols. En 1982, les priorités de recherches ont porté sur la reproduction des truies, l'élevage de veaux lourds et la régie des fumiers. D'autre part, les travaux portant sur les produits laitiers, le boeuf et le mouton ont été maintenus pour répondre aux besoins du Québec.

On peut obtenir des renseignements plus complets en écrivant directement aux chercheurs à l'adresse suivante: Station de recherche, Agriculture Canada, C.P. 90, Lennoxville, Québec, J1M 1Z3.

Yvon Martel
Directeur

## PRODUCTIONS ANIMALES

### Bovins laitiers

*L'hétérosis pour la production laitière.* Les croisements chez les bovins laitiers sont plutôt rares. La supériorité des croisements par rapport à la moyenne des races pures qui les forment est qualifiée comme étant le pourcentage d'hétérosis.

C'est à partir du projet national d'amélioration génétique de la vache laitière qu'on a déterminé, pour les lactations 1 et 2, l'hétérosis pour les rendements en lait, en protéine et en gras ainsi que le pourcentage de gras et de protéine.

À la première lactation, l'hétérosis pour les caractères de rendement est de 4% tandis qu'à la deuxième lactation, il est diminué de moitié. Il ne semble pas exister d'hétérosis pour le pourcentage de gras et de protéine.

Les rendements des vaches croisées HA (père de la lignée H par mère de la lignée A) sont plus grands que ceux de leurs co-soeurs réciproques, les AH. Cette différence peut être attribuable à un effet du côté maternel qui persiste. Les rendements des vaches HA sont équivalents à ceux de la meilleure lignée, c'est-à-dire la lignée H.

Il est évident qu'il existe de l'hétérosis pour le rendement en lait, en protéine et en gras, mais non pour le pourcentage de protéine et de gras. L'hétérosis semble disparaître à mesure que l'animal vieillit.

*Valeur nutritive du maïs fourrager produit au Québec pour les bovins.* La composition chimique et la digestibilité in vitro de la matière sèche (D.I.V.M.S.) ont été déterminées à partir de 160 échantillons de plants de maïs provenant de trois endroits au Québec. Parmi les 50 variétés étudiées, 24 se retrouvaient aux trois endroits. Les valeurs moyennes de la protéine brute, du phosphore, du potassium, du calcium et du magnésium étaient respectivement de 8,61, 0,27, 1,54, 0,28 et 0,13% pour le plant entier, 10,11, 0,39, 0,72, 0,03 et 0,15% pour l'épis et 8,34, 0,21, 2,14, 0,45 et 0,12% pour les tiges et les feuilles. Le pourcentage de matière sèche, le rendement et la D.I.V.M.S. pour le plant entier étaient respectivement de 27,4%, 3880 kg/ha et 63,3%. L'épis représentait 46,2 ± 7% du rendement moyen. La protéine brute, le potassium, le calcium et le phosphore étaient respectivement de 0,6, 0,49, 0,01 et 0,07% plus élevés que les valeurs du N.R.C. (1978) et le magnésium était de 0,15% moins élevé. La meilleure prédiction de D.I.V.M.S. pour le plant entier a été obtenue avec le contenu en potassium dans l'équation linéaire: D.I.V.M.S. (%) = 83,48 – 13,12K (%), $r$ = 0,78. La valeur de prédiction augmente en ajoutant à l'équation la matière sèche (M.S.) et le calcium (Ca): D.I.V.M.S. (%) = 35,54 – 14,55K (%) + 0,82 DM (%) – 35,17 Ca (%), $r$ = 0,91. D'autres données portant sur le maïs ensilé et/ou le maïs récolté après le gel sous les conditions climatiques du Québec sont nécessaires pour évaluer la valeur nutritive du maïs fourrager et pour formuler des équations de prédiction de la digestibilité.

*L'utilisation d'aliments d'allaitement acides dans la production de veaux de grain.* Les

fromageries font face encore de nos jours à des problèmes relatifs à l'utilisation économique du lactosérum. Le séchage est devenu prohibitif depuis l'augmentation du coût de l'énergie. Une façon de valoriser le lactosérum est d'en extraire les protéines et le lactose. Le sous-produit acide (pH 3,4) qui en résulte contient environ de 25 à 30% de matière sèche. Sur une base de matière sèche, ce sous-produit contient environ 10% de protéines brutes, 17% de minéraux et 73% de lactose. Ce sous-produit du lactosérum peut être utilisé dans la fabrication des aliments d'allaitement acides.

Cent douze veaux mâles Holstein pesant au départ 49 kg ont été nourris jusqu'au poids de 190 kg avec sept régimes utilisant du lait acide (pH 5,2). Le lactoremplaceur acide a été servi aux veaux soit pendant 6 semaines, soit pendant 12 semaines ou jusqu'à l'abattage. Après la sixième semaine, les veaux recevant du lait étaient limités à 0,75 kg d'aliment d'allaitement par jour. L'aliment d'allaitement servi au cours des quatre premières semaines contenait 23% de protéines brutes et 15% de gras tandis que celui servi par la suite, fabriqué surtout à base de sous-produit, contenait 11% de protéines brutes et 10% de gras. Tous les veaux ont reçu à volonté du concentré contenant 16% de protéines brutes dès la première semaine.

Le fait de servir du lait pendant 6 semaines, 12 semaines ou jusqu'à l'abattage n'a pas influencé le gain quotidien qui a été respectivement de 0,98, 1,00 et 0,99 kg. La consommation totale de matière sèche provenant du lait, du concentré et l'efficacité alimentaire des trois groupes de veaux mentionnés précédemment a été respectivement de 17 kg, 351 kg, 2,64; 54 kg, 305 kg, 2,54; 98 kg, 245 kg, 2,43. Les veaux recevant du lait pendant 12 semaines ont consommé 37 kg de lactoremplaceur de plus et 46 kg de concentré de moins que les veaux sevrés à 6 semaines, tandis que les veaux recevant du lait jusqu'à l'abattage ont consommé 80 kg de lactoremplaceur de plus et 105 kg de concentré de moins que les veaux recevant du lait pendant 6 semaines. Il en résulte que pour les veaux recevant du lait jusqu'à 12 semaines ou jusqu'à l'abattage, il y a eu une économie de 1,25 à 1,30 kg de concentré pour chaque kilogramme additionnel d'aliment d'allaitement.

Les quantités totales de lait servi n'ont pas eu d'effets significatifs ($P < 0,05$) sur le niveau d'hémoglobine et le pourcentage d'hématocrite dans le sang, le rendement et le classement des carcasses, l'âge à l'abattage, le poids du ris et la couleur du muscle au niveau de la douxième côte ou au niveau de la poitrine.

Il est donc possible de valoriser ce sous-produit du lactosérum en l'utilisant dans la fabrication des aliments acides. Ce type de lactoremplaceur acide peut être utilisé dans la production du veau de grain après 6 semaines en autant que son coût ne soit pas supérieur à 1,30 fois le coût des concentrés.

**Bovins de boucherie**

*Qualité de viande de bouvillons Holstein et de bouvillons croisés abattus à trois poids vifs.* Deux expériences, qui ont duré plus de 2 ans, ont porté sur l'étude de la qualité de cuisson et de gustation de la viande de bouvillons abattus à 454, 544 et 635 kg de poids vif. La première année, on a étudié les croisements Maine-Anjou × Holstein (MH), Limousin × Holstein (LH) et la race Holstein pure (H1); tandis que la deuxième année, les groupes génétiques étaient le Chianina × Holstein (KH), le Blond d'Aquitaine × Holstein (BH) et le Holstein pur (H2). Au cours de ces deux années, pour chaque poids d'abattage, il n'y a pas eu de différence entre les groupes génétiques dans le taux de cuisson ou de la perte pendant la cuisson. Par contre, c'est au poids de 635 kg que les bouvillons H1 ont produit la viande la plus savoureuse, alors que les H2 l'ont produite à 454 kg. Les deux années, les bouvillons Holstein ont obtenu la viande la plus tendre au poids de 635 kg.

Au cours des 2 années, on n'a pas noté de différence dans la jutosité aux différents poids. Les bouvillons LH ont produit une viande significativement plus tendre et plus juteuse au poids de 635 kg qu'à celui de 454 kg, alors que les bouvillons BH l'ont produite au poids de 544 kg plutôt qu'à 635 kg. Les bouvillons KH ont produit leur viande la plus tendre et la plus juteuse au poids de 454 kg. Les bouvillons MH ont obtenu, aux trois poids d'abattage, des cotes semblables pour la saveur, la tendreté et la jutosité. Au poids de 454 kg, la viande des Holstein fut significativement supérieure à celle des MH et des LH pour la saveur, à celle des MH pour la tendreté et à celle des LH, BH et KH pour la jutosité. La seule différence significative entre les Holstein et les croisés, au poids de 544 kg, fut dans la jutosité des bouvillons BH. Au poids de 635 kg, la viande des Holstein fut

significativement plus juteuse et moins tendre que celle des BH. Toutes les différences entre les croisements furent non significatives, excepté au poids de 544 kg où la viande des KH fut plus savoureuse que celle des bouvillons BH.

*Valeur alimentaire de l'ensilage de maïs–luzerne pour l'alimentation des bouvillons.* Le maïs contient plus d'hydrates de carbone fermentescibles que les légumineuses, ce qui le rend plus facile à conserver sous forme d'ensilage. Le haut contenu protéique de la luzerne la rend intéressante à utiliser en combinaison avec l'ensilage de maïs, lequel est faible en protéine. Une expérience a été réalisée dans le but de vérifier: (*a*) si l'ensilage de luzerne peut remplacer le tourteau de soya dans une ration à base d'ensilage de maïs; (*b*) si le fait de mélanger le maïs fourrager à la luzerne lors de la mise en silo améliore la qualité de cet ensilage.

On a utilisé 66 bouvillons Hereford, d'un poids moyen de 213 kg, divisés en trois groupes de 11 bouvillons chacun. Chaque traitement était répété deux fois. Les bouvillons étaient répartis de façon à ce que le poids des groupes soit uniforme. Le groupe I recevait de l'ensilage de maïs. Le groupe II recevait de l'ensilage de maïs auquel on ajoutait 400 g tête$^{-1}$ jour$^{-1}$ de tourteau de soya. Le groupe III recevait un mélange de maïs fourrager et de luzerne ensilés (rapport 1:1 sur une base humide lors de la mise en silo). Durant la période expérimentale de 84 jours, les bouvillons avaient libre accès à l'ensilage, à l'eau et à un mélange commercial de minéraux. Tous les bouvillons ont été pesés deux jours consécutifs, au début et à la fin de l'expérience, après un jeûne de 16 h.

Les résultats obtenus démontrent que la luzerne peut remplacer partiellement le tourteau de soya, comme supplément protéique à l'ensilage de maïs. Il semble aussi que le fait de mélanger de la luzerne au maïs fourrager, au moment de la mise en silo, améliore la conservation de cet ensilage. L'ensilage de maïs seul serait à déconseiller dans un programme d'engraissement de bovins d'abattage.

**Porc**

*La durée de la mise bas des truies et son effet sur la mortalité et la croissance des porcelets.* Nous avons étudié la durée des mises bas de 19 truies Landrace, ainsi que l'ordre de naissance et le rang de tétée sur les performances pré-sevrage des porcelets. La durée des mises bas était inférieure à 3 h dans 74% des cas, 10% entre 3 et 4 h et 16% de 4 à 5 h. La moyenne et le mode de la durée de la mise bas étaient, respectivement, de 140,5 ± 14,0 et 137 min ou 15,7 et 8 min par porcelet. La durée de la mise bas était plus courte chez les truies avec des portées moyennes que chez celles avec des petites ou grosses portées.

La corrélation entre l'ordre de naissance et le poids à la naissance était de –0,22. Les porcelets nés les premiers étaient les plus lourds. La survie des porcelets à la naissance était en étroite relation avec le poids à la naissance et l'ordre de naissance. Les porcelets les plus agressifs et les plus dominants s'appropriaient les mamelles antérieures et faisaient les meilleurs gains pré-sevrage peu importe leur poids à la naissance.

*Changements de poids et de composition du pancréas au cours de la gestation chez la truie primipare.* Des truies primipares ont été abattues à différentes périodes au cours d'un cycle de reproduction afin de mesurer les changements de poids et les changements biochimiques du pancréas. On a tué 42 truies témoins et 42 truies accouplées après 30, 70 et 110 jours de gestation, après 7, 14 et 28 jours de lactation et 11 jours après le sevrage. On a excisé et pesé leur pancréas, puis on a homogénéisé des fragments afin de mesurer leur teneur en protéines, en amylase, en chymotrypsine, en acide ribonucléique (A.R.N.) et en acide désoxyribonucléique (A.D.N.). Les résultats indiquent que tous ces paramètres avaient diminué à la fin de la période de gestation chez les truies accouplées, comparativement aux truies témoins. Pendant la période de lactation, on a observé des augmentations graduelles et régulières des poids pancréatiques et des teneurs en A.R.N., en protéines et en enzymes digestives. Après le sevrage, on a noté une hausse significative des teneurs en A.D.N., indice d'une hyperplasie pancréatique. Le retour aux valeurs témoins, pour la plupart des paramètres, n'a pas été atteint 11 jours après le sevrage. Ces modifications pancréatiques peuvent être le résultat soit d'un apport alimentaire accrû pendant la lactation ou soit des changements d'hormones qui se produisent au cours d'un cycle de reproduction et qui auraient un effet synergique sur les hormones gastro-intestinales. L'influence de ces changements physiologiques sur la digestibilité des rations et la

productivité des truies est présentement étudiée.

**Mouton**

*La performance des moutons Romanov au Canada.* Huit brebis Romanov et quatre béliers de 2 ans, ainsi que six brebis et un bélier de 3 ans ont été importés de France en octobre 1980. En France, le nombre d'agneaux par portée variait selon l'âge de la brebis: 2,15, 2,77 et 3,33 agneaux à 1,2 et 3 ans d'âge respectivement. Quatre brebis ont agnelé au cours de la quarantaine au Canada et elles ont produit 13 agneaux (les portées variaient entre deux et cinq agneaux). De ces agneaux, 12 ont été sevrés (92%). Les poids moyens à la naissance et au sevrage étaient de 2,7 ± 0,6 et 18,9 ± 3,7 kg respectivement. Les brebis ont été accouplées en septembre et 12 ont agnelé entre le 20 janvier et le 10 février 1982. À la naissance, la taille de la portée était de 2,83 agneaux dont seulement 2,08 étaient vivants (73%). Le poids de la portée était de 6,6 ± 1,5 kg en moyenne. Le poids à la naissance des jumeaux, des triplés et des quadruplés était de 2,5, 2,6 et 1,5 kg respectivement. Les cinq brebis qui sont nées pendant la quarantaine furent accouplées à 8 mois d'âge alors qu'elles pesaient 45 kg. Après l'agnelage de 1982, le troupeau a maintenant atteint le nombre de 75 têtes.

*Les paramètres génétiques de la date d'agnelage chez les moutons D.L.S.* Depuis 1965, des croisements de Dorset d'Australie, de Leicester et de Suffolk canadiens ont été faits pour produire la race D.L.S. L'objectif est de développer une nouvelle race possédant une saison d'accouplement plus longue et qui peut reproduire toute l'année. Le seul critère de sélection est un index basé sur la date d'agnelage des deux premières mises bas survenues après accouplement pendant l'été (de juin à novembre).

La sélection est directe pour les mâles: les mâles issus des meilleures brebis sont gardés pour l'accouplement. Chez les femelles, la sélection est indirecte: les meilleurs 50% de la population sont gardés pour un troisième agnelage. La date d'agnelage de 1300 brebis représentant quatre générations de sélection a été utilisée afin de calculer l'héritabilité et la répétabilité de la date d'agnelage et ce, en utilisant différentes méthodes. Les corrélations entre le premier et le deuxième agnelage, le premier et le troisième, et le deuxième et le troisième ont été de 0,33, 0,25 et 0,13 respectivement.

Les coefficients d'héritabilité obtenus par la méthode des demi-frères paternels et des demi-frères maternels étaient de 0,14 et de 0,43 respectivement. La méthode de régression entre mères-filles a donné une valeur de 0,4.

Les paramètres génétiques calculés à partir de ces données ont indiqué que la date d'agnelage est modérément héritable. Conséquemment, la sélection peut être efficace.

*Durée de la saison d'accouplement de brebis sélectionnées pour agnelage en tout temps de l'année.* Dans un projet, qui a duré 18 mois, on a utilisé 29 brebis D.L.S. (moitié Dorset, quart Leicester, quart Suffolk) afin d'étudier la longueur de la saison d'accouplement de ces brebis. Par rapport à leur date moyenne d'agnelage, située au premier janvier, 15 brebis ont obtenu un indice d'agnelage élevé, alors que l'indice des autres fut plutôt bas, la différence étant de 33 jours. La moitié des brebis furent assignées au hasard et sont demeurées non gestantes durant toute l'étude, alors que les autres ont été accouplées en juillet et en août. Vingt brebis (69%) ont cyclé entre le 1er mai et le 15 juillet. Quatre-vingt-un pour cent d'entre elles appartenaient au groupe à indice élevé et 54% à l'autre groupe. Deux brebis ont continué de cycler pendant tout l'été. Les 18 autres n'ont pas eu de chaleur durant cette saison, qui a commencé le 27 mai (±3,5 jours) pour se prolonger pendant une moyenne de 63 jours (±2,6). C'est le 29 juillet (±2,6 jours) que nous avons observé la première ovulation. Elle n'était pas accompagnée de chaleur. La seconde ovulation, cette fois accompagnée de chaleur, a été perçue 20 jours plus tard. La saison d'accouplement des brebis non gestantes a duré 194 jours (±3,2 jours) et s'est terminée le 1er mars (±7,3 jours). La date moyenne d'agnelage des 15 brebis gestantes s'est située le 8 janvier (±2,8 jours). Sept d'entre elles ont eu au moins une ovulation post-partum, mais seulement deux accompagnées de chaleur. En introduisant le bélier marqueur tous les jours, on s'est aperçu qu'il ne détectait que 88% des brebis en chaleur. On a observé 66% des fausses chaleurs avant la reprise du cycle régulier de l'oestrus.

*Les performances des femelles des races de moutons Oxford et Suffolk et des croisements issus de ces races.* On a étudié chez 326

brebis le pourcentage de brebis qui ont agnelé comparativement à celles qui ont été exposées au bélier, la taille des portées, le poids à la naissance et au sevrage, la mortalité pré-sevrage des agneaux et les changements de poids des brebis durant la période d'allaitement. Les groupes génétiques étudiés étaient les races Oxford et Suffolk et quatre croisements: Oxford♂ × Suffolk♀, Suffolk ♂ × Oxford♀, North Country Cheviot♂ × Oxford♀, et Cheviot♂ × Suffolk♀. Les brebis étaient accouplées avec des béliers de races pures et croisées pendant 9 années. Le pourcentage de fertilité des races Oxford et Suffolk (0,82 et 0,85 respectivement) fut plus faible que celui des brebis Suffolk × Oxford (0,93) Oxford × Suffolk (0,94), Cheviot × Oxford (0,88) et Cheviot × Suffolk (0,88). La taille des portées à la naissance et au sevrage des brebis Suffolk fut 1,6 et 1,3 agneau, comparativement à 1,3 et 1,0 agneau pour les brebis Oxford respectivement. Les différences entre les deux races, quant au poids des portées à la naissance et au sevrage, étaient de 1,29 et 11,8 kg respectivement. Chez les brebis Oxford, le poids corporel a diminué de 10% durant l'allaitement comparativement à 14% chez les Suffolk et les deux croisements réciproques. L'hétérosis de la taille et du poids de la portée à la naissance était de 8,5 et 8,2%, et de 13 et 18% au sevrage respectivement.

Les résultats démontrent que les croisements Oxford donnaient de meilleures performances que les Oxford purs et que les performances des croisements Suffolk équivalaient à celles des Suffolk purs. Cependant, le pourcentage des femelles agnelant comparativement à celui des femelles qui avaient été exposées au bélier était plus élevé et le pourcentage de mortalité pré-sevrage était inférieur à celui des Suffolk purs.

## PRODUCTION FOURRAGÈRE ET SOLS

### Doses et méthodes d'application du fumier de bovins en vue de la production d'ensilage de maïs

Le fumier de bovins contenant de la litière a été appliqué à des doses variant de 0 à 400 t/ha. On a appliqué le fumier à l'automne et au printemps. Il a été, soit laissé en surface, soit incorporé au sol. On a répété les traitements une deuxième année sur les mêmes parcelles et, la troisième année, on n'a fait aucune application de fumier.

La première année de récolte, on a observé très peu d'effets consécutifs aux applications de fumier, si ce n'est que les applications de printemps ont accru légèrement les rendements. La deuxième année, il y eut encore peu d'effets si ce n'est une légère tendance à une réduction des rendements. La teneur en matière sèche des plants (moins les épis) a diminué à cause de l'accroissement des doses de fumier, et cela même la troisième année où on mesure l'effet résiduel du fumier. Le contenu en humidité du grain n'a pas été influencé.

Bien que le rendement de maïs ait été peu influencé par les applications de fumier, les paramètres de qualité, eux, l'ont été. Ni les doses ni les méthodes d'application de fumier n'ont fait varier la teneur en azote du plant et du grain de maïs lors de la première année de récolte, mais cette teneur s'est accrue, grâce aux traitements lors de la deuxième année. Le contenu en phosphore du maïs, plants et grains, a été augmenté par les doses de fumier surtout lors des applications automnales. Le pourcentage de potassium des plants, moins les épis, a été accru par les doses de fumier, et ce, surtout au printemps, ceci étant accompagné d'une diminution de la teneur en calcium et en magnésium. La proportion de grain dans l'ensilage de maïs a augmenté au même rythme que les doses d'application du fumier. Il en fut de même pour la dimension des racines de maïs. La grosseur des grains s'est également accrue avec les doses de fumier, même l'année de l'effet résiduel. Généralement, les doses croissantes d'application de fumier ont diminué la population des plants de maïs, surtout lors des applications de printemps. Ceci a été vrai même pour l'année d'effet résiduel.

Tous les éléments P, K, Ca, Mg dans le sol se sont accrus sensiblement grâce à l'application de fumier à des doses croissantes. Il en fut de même pour l'humidité du sol que l'application de fumier a augmenté assez pour prévenir le flétrissement du maïs lors d'une année sèche.

On a détecté donc peu d'effets des doses et des modes d'application de fumier sur les rendements de maïs. On a noté des effets plus marqués sur les paramètres de qualité des plants et sur le sol. Les effets des méthodes d'application ont été souvent peu significatifs et dépendant du paramètre considéré. Par exemple, les applications de fumier au printemps ont donné de meilleurs rendements,

mais ont diminué la population des plants de maïs. Les doses d'application de fumier ont influencé le plus souvent les divers paramètres de qualité du maïs.

**Les motoneiges affectent la végétation au Québec**

On a étudié l'effet de la motoneige sur le rendement et la composition botanique des plantes fourragères cultivées au Québec. Une première expérience a été réalisée en faisant circuler la motoneige, à raison de 150 passages par semaine, sur deux sites expérimentaux durant 2 années. La motoneige n'a pas influencé significativement le rendement et la composition botanique des mélanges de fléole en association avec la luzerne, le trèfle rouge et le trèfle ladino. Dans une deuxième expérience, on a évalué les dommages causés aux plantes fourragères sur des pistes de clubs de motoneige. Au cours de trois hivers consécutifs, sur 30 années-sites, des échantillonnages printaniers ont démontré que le rendement et la proportion de légumineuses dans les mélanges ont diminué significativement. Les graminées n'ont pas été endommagées tandis que les mauvaises herbes étaient beaucoup plus compétitives sur les pistes. L'analyse de régression multiple par étapes a montré que d'abord la pluie, ensuite l'épaisseur de neige et enfin le pourcentage d'argile des sols ont le plus influencé le rendement, la proportion de légumineuses et les mauvaises herbes. La circulation excessive des motoneiges (plus de 150 passages par semaine) a été dommageable aux plantes pérennes. Suite à ces expériences, nous suggérons que les sentiers de motoneige devraient éviter plus particulièrement les champs de légumineuses et sillonner plutôt les terres incultes, même si cela exige des tracés plus longs.

**Effets des doses de manganèse, d'aluminium, des régimes hydriques et du pH des sols sur les rendements de luzerne et sur l'assimilabilité du manganèse et de l'aluminium**

On a cultivé en serre de la luzerne (*Medicago sativa* L. 'Saranac') sur de l'argile Sainte-Rosalie, du loam Greensboro et du sable Saint-Jude, afin de déterminer les changements de réponse et d'assimilabilité du manganèse et de l'aluminium causés par des variations de pH et de régimes hydriques imposées aux sols. Les doses de manganèse choisies étaient 0 et 200 kg/ha et celles d'aluminium, 0 et 100 kg/ha. Le pH des sols a été ajusté autour de 5,0, 6,5 et 7,5. Trois régimes hydriques ont été imposés aux sols: (*1*) optimum (OPT.), pourcentage d'humidité du sol variant de capacité au champ (C.A.C.) à 70% de cette valeur; (*2*) saturé (SAT.), humidité du sol variant de la capacité au champ au point de saturation (P.S.); (*3*) sursaturé, humidité du sol variant du point de saturation à une valeur située à mi-chemin entre P.S. et C.A.C. L'apport de manganèse dans les sols acides (pH 5,2) a été moins nocif en régime hydrique optimum qu'en régimes plus humides. L'application de Mn en régime optimum a même augmenté les rendements de 50% sur l'argile Sainte-Rosalie. Dans les deux autres types de sol, elle a au contraire diminué la productivité de la luzerne de 58% en moyenne. Cette diminution a été encore plus grande en régimes hydriques saturés et sursaturés: elle s'est chiffrée à 66%. Ceci était dû à des quantités excessives de Mn trouvées dans les sols humides et acides. On a également enregistré de grandes quantités d'aluminium dans les sols acides et la productivité de la luzerne a été réduite de 54% par les applications d'aluminium. Le chaulage des sols aux environs de 6,7 ou de 7,6 a réduit les quantités de Mn et Al dans les sols et la luzerne est revenue à une bonne productivité. On conseille de chauler les sols autour de pH 7,0 afin de permettre à la luzerne de survivre aux niveaux élevés de Mn et Al observés fréquemment dans les sols acides et très humides.

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# Station de recherche
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# INTRODUCTION

Les programmes de recherche de la station de Sainte-Foy sont orientés de façon à résoudre des problèmes agricoles tout en évitant de doubler les travaux faits par d'autres organisations.

Des efforts particuliers ont été faits en vue d'accroître nos effectifs et nos réalisations dans le programme sur l'énergie. L'acquisition de la ferme expérimentale Jean-Charles Chapais va aider grandement à faire connaître davantage la station dans la région de Québec. Un nouveau surintendant, monsieur Jean-Marie Wauthy, a été engagé à la ferme expérimentale de Normandin.

Pour obtenir de plus amples renseignements, veuillez vous adresser à: Station de recherche, Agriculture Canada, 2560 boulevard Hochelaga, Sainte-Foy, (Québec) G1V 2J3.

S.J. Bourget
Directeur

## LES PLANTES

### L'énergie: fixation d'azote et endomycorhizes

*Métabolisme.* L'application de la méthode isotopique pour quantifier l'attachement des cellules du *Rhizobium* aux racines de luzerne nous a permis d'évaluer l'effet des ions $NO_3$ et $NH_4$ sur le degré d'attachement. L'action négative du nitrate se situe au niveau du métabolisme de la plante plutôt que dans la nature physico-chimique de l'adsorption; le nitrate agit dès la première étape du processus symbiotique et il pourrait régulariser la nodulation chez la luzerne par le biais de l'adsorption du *R. meliloti* aux sites infectieux. En nous servant de l'azote isotopique à courte vie, le $^{13}N$, nous avons évalué les effets du $NO_3$ et de $NH_4$ sur l'expression de la nitrogénase avec les plantules de luzerne; à des concentrations de 30 mg/kg, après 5 min d'exposition, l'ammonium et le nitrate provoquent la même inhibition (46%) de l'enzyme, tandis qu'après 24 h, l'ammonium inhibe beaucoup plus (48%) que le nitrate (13%); à des concentrations élevées de 70 mg/kg, les inhibitions sont sensiblement les mêmes pour les deux ions pour les mêmes temps d'exposition, soit de 32 à 43% pour l'ammonium, et de 48 à 36% pour le nitrate, pour 5 min et 24 h d'exposition respectivement. Dans l'étude de l'assimilation de l'azote chez les formes bactéroïdes et bactérie libre du *R. meliloti*, nous avons démontré que l'espèce contient deux glutamines synthétases (G.S.I. et G.S.II) distinctes qui peuvent être séparées par centrifugation sur gradient de densité, que la G.S.I adénylable est plus thermostable que la G.S.II et est beaucoup plus active dans les extraits du *R. meliloti* cultivés sur des milieux contenant du $NH_4$ ou du glutamate. Le passage d'un milieu glutamate à un milieu $NH_4$ entraîne une répression du niveau de G.S. dans la souche sauvage, mais pas dans le mutant nitrate réductase négatif. Les résultats indiquent l'existence d'un lien de régulation entre le nitrate réductase et la G.S. chez le *R. meliloti*.

*Technologie des inoculants.* Notre collaboration avec la Direction générale de la production et de l'inspection des aliments, division des fertilisants, portant sur la qualité des inoculants des légumineuses s'est maintenue; plus de 80 échantillons ont été analysés pour fins de contrôle et de recherche; nous avons préparé trois rapports techniques et avons participé à la réunion annuelle de planification de travail avec cette direction. Dans nos études sur la survie du *Rhizobium*, nous avons démontré que le stress hydrique affecte plus la survie que les limites nutritionnelles en carbone, en phosphore ou en potassium. De plus, le conditionnement des cellules, par des composés à haut poids moléculaire tels les polyvinylpropilones et les polyéthylglycols, prévient les dommages à la paroi cellulaire; lorsque le lactose est en excès dans le milieu de culture, il y a une forte synthèse des polysaccharides par les *Rhizobium*, et les cellules sont alors plus résistantes au stress hydrique, car les pertes cellulaires sont moindres. Pour s'assurer de l'identité des souches du *R. meliloti*, nous avons établi les patrons de résistance intrinsèque aux antibiotiques et caractérisé les

souches par leur utilisation des intermédiaires du cycle de Kubs.

*Fixation d'azote à basse température.* L'étude de la fixation symbiotique d'azote dans l'Arctique, durant l'été 1982, nous a permis d'effectuer plusieurs mesures de la nitrogénase in situ chez trois légumineuses arctiques: *Oxytropis maydelliana, Oxytropis arctobia* et *Astragalus alpinus*. Les plus fortes activités de fixation d'azote, par plante, représentent environ 20% de celles rapportées pour les légumineuses domestiquées des régions tempérées; ces valeurs ont été obtenues de façon constante quand les températures du sol étaient basses (5 ou 6°C). De plus, des essais sur des nodules détachés nous ont révélé une activité de la nitrogénase à des températures aussi basses que −5°C. Nous avons compilé des données climatiques et collectionné des plantes, des nodules, des sols et des graines pour les études en laboratoire. Une trentaine de souches de *Rhizobium* arctiques ont été isolées et font l'objet de caractérisations physiologique et biochimique.

*Endomycorhizes.* Des recherches fondamentales et appliquées ont été commencées sur les endomycorhizes à vésicules et arbuscules associées à des plantes agricoles. Des plants de poireau ont été inoculés avec trois espèces de champignons endomycorhizateurs pour la production d'inoculum. Des échantillons de sols et de racines de luzerne, de céréales et de plantes sauvages ont été analysés pour isoler de nouvelles espèces de champignons endomycorhizateurs et constituer une collection.

**Les plantes fourragères**

Dans la perspective d'une plus grande rentabilité des cultures fourragères, le programme de recherche vise à établir les meilleurs cultivars disponibles, à en développer de nouveaux spécialement pour les espèces de graminées et de légumineuses les plus susceptibles de répondre aux besoins de l'agriculture du Québec, à déterminer les meilleures régies de production, de récolte et de conservation des fourrages.

*Graminées.* La descendance de 45 plants-mères de fléole des prés sélectionnés pour leur haute valeur protéique et leur grande digestibilité est en évaluation. Une étude de la variabilité génétique de la fléole pour des propriétés physiques est en cours en vue de développer un cultivar ayant une meilleure ingestibilité et une plus grande digestibilité. De la semence Syn-1 de dactyle a été produite comme résultat du croisement de 13 clones sélectionnés pour leur rendement et leur résistance au froid.

Pour la production de semence de fléole, il appert que les semis de printemps sont les meilleurs et qu'un taux de semis de 3,0 kg/ha est suffisant. Par ailleurs, les modes de semis et la fertilisation ont des effets variables. La brûlure de l'épi ou blanchissure est la principale maladie qui semble pouvoir affecter sérieusement la production de semence.

*Légumineuses.* Le cultivar de luzerne Apica a été homologué en 1982. Quatre nouvelles populations expérimentales de luzerne ont été inclues dans les essais du Québec; elles sont également évaluées à Charlottetown, Î.P.É., et à Beaverlodge, Alb.

Quelque 170 plants de luzerne ont été sélectionnés pour leur persistance après un test de congélation mené sur des plants qui ont survécu sous la glace pendant au moins une semaine. Une population de luzerne a été sélectionnée pour la double résistance au gel et aux fusariums des racines, et a subi avec succès l'épreuve de descendance. La comparaison de quatre cultivars de luzerne soumis en serre et au champ à deux cycles de sélection pour la résistance à diverses pourritures des racines indique un progrès certain sur les populations originales. Des plants de luzerne sélectionnés pour la résistance au nématode cécidogène ont été croisés pour évaluation de leurs descendances.

Les expériences sur les interactions de la mineuse virgule et la résistance au froid de la luzerne nous montrent que l'insecte a un effet très marqué sur la croissance des plantes et un effet minime sur la résistance au gel. L'application d'un fongicide endothérapique (bénomyl) augmente la survie et le rendement de la luzerne par une réduction des pourritures des racines et des collets.

Plusieurs bactéries ont été isolées à l'intérieur des graines de luzerne et des tissus internes des racines de plantes durant la première saison de croissance, mais leur rôle demeure obscur. Cependant, les bactéries isolées de la rhizosphère montrent un antagonisme envers les champignons pathogènes de la luzerne. Il semble que ce soit un antagonisme de compétition nutritive du milieu.

Le classement des cultivars de luzerne recommandé par le Conseil des productions végétales du Québec a été fait en ce qui a trait

à leur sensibilité à la tige noire. Un deuxième cycle de sélection pour la résistance à cette infection a permis de constituer une population de 89 plants résistants.

La sélection pour la résistance de la luzerne à un fusarium semble horizontale puisque les plantes sélectionnées avec un fusarium ont acquis un certain niveau de résistance à un autre. Ceci est à vérifier à cause de certains résultats contradictoires.

*Mélanges fourragers.* Des parcelles établies à quatre sites au Québec en 1979 pour étudier le comportement de différentes espèces fourragères établies en monoculture ou en mélanges bispécifiques ont servi à évaluer l'effet de différentes doses d'azote sur la productivité, la persistance et la contribution de la fléole au rendement; la qualité nutritive du fourrage sera également déterminée.

*Mauvaises herbes.* Environ 200 prairies et pâturages ont été inventoriés en 1982 dans les comtés d'Abitibi-est, d'Abitibi-ouest et du Témiscamingue. Une liste des mauvaises herbes et de leur importance de même qu'une enquête agronomique ont été dressées pour chaque champ visité. Suite à un examen sommaire des données, le chiendent, le plantain, le pissenlit, la marguerite blanche, l'achillée millefeuille et la vesce jargeau constituent les principales mauvaises herbes des jeunes prairies et pâturages. Les épervières, le fraisier sauvage, la renoncule âcre, la prunelle et les verges d'or caractérisent les sites plus âgés. L'aspect descriptif des mauvaises herbes des prairies et des pâturages par région est en préparation. La plupart des tableaux sont terminés. L'analyse des relations entre les variables botaniques et agronomiques est à entreprendre.

Des études sur les seuils de nuisibilité et sur la période critique d'interférence de l'ortie royale, du chénopode blanc et de la spargoute des champs ont été poursuivies au champ. L'expérience avec la spargoute a dû être abandonnée à cause d'un mauvais établissement de la luzerne. La réduction du rendement de la luzerne a été directement proportionnelle à l'augmentation de la densité de l'ortie royale. Une densité de l'ortie royale de 100 plantes/m$^2$ a provoqué une réduction de 50% du rendement de la luzerne. De plus, l'effet de la mauvaise herbe est surtout évident entre la deuxième et la quatrième semaine après le semis. Les données sur le chénopode blanc n'ont pas encore été analysées.

Les travaux sur le cycle de croissance de l'ortie royale, de la spargoute des champs et de la sétaire glauque sont presque terminés. Ils portaient essentiellement sur la levée, la mortalité et la reproduction en fonction de la densité. Des travaux similaires avec le chénopode blanc sont en cours. Ils serviront à la rédaction d'une thèse de deuxième cycle. En résumé, les stratégies de ces quatre espèces sont différentes. La levée de l'ortie royale est la plus hâtive tandis que celle de la sétaire et du chénopode est la plus tardive. Les cohorts tardifs de chénopode subiraient plus de mortalité que ceux des autres espèces lesquelles manifestent surtout des caractères de plasticité. La structure de hauteur varie selon les espèces, spécialement entre l'ortie et le chénopode.

**La survivance à l'hiver**

*Influence du climat.* Les conditions climatiques qui ont prévalu à l'automne 1981 et l'hiver 1982 ont favorisé un endurcissement au gel continu, sans réchauffement, des six espèces cultivées à La Pocatière et Saint-Hyacinthe. Les maximums de résistance au gel atteints par les trois espèces fourragères et les trois espèces céréalières à La Pocatière, ont été sensiblement les mêmes que ceux de l'automne et de l'hiver précédents, soit une $TL_{50}$ (température pour 50% de mortalité) de −34 à −35°C pour la fléole des prés Engmo, de −30 à −32°C pour le seigle Cougar, de −29°C pour le brome Saratoga, de −27°C pour le blé Kharkov et le triticale Winbri, et de −25 à −26°C pour la luzerne Rambler. À Saint-Hyacinthe, le maximum de résistance au gel a été inférieur de 3 à 5°C pour les six espèces et a été atteint vers le milieu de décembre. À La Pocatière le maximum de résistance se produisait en janvier 1982, à l'exception de la luzerne qui atteignait sa résistance maximale en février. Comme pour la saison précédente, l'acquisition de la résistance au gel a offert une corrélation très étroite avec l'abaissement des températures de l'air et du sol, les coefficients de corrélation étant voisins de l'unité ($r$ = 0,95 à 1,00). Le calcul de l'équation de cette corrélation pour la période de septembre au début de décembre a permis de prédire la résistance au gel des six espèces non seulement pour La Pocatière, mais aussi pour Saint-Hyacinthe avec des écarts de 0,1 à 3,0°C. Si ces résultats se confirmaient dans

l'avenir, nous aurions là un outil qui nous permettrait d'évaluer la résistance au gel d'un cultivar à partir des températures de l'air et du sol, et de développer un modèle pour la prédiction de la survie à l'hiver des cultivars.

Des six espèces étudiées, la fléole des prés est celle qui a conservé le plus longtemps sa résistance au gel, la $TL_{50}$ étant encore de −30°C au début d'avril, à La Pocatière, comparativement à −19°C pour la luzerne. Par contre, c'est le brome qui a perdu le plus rapidement sa résistance au gel au printemps.

Les résultats des années précédentes sur les effets du drainage, de l'irrigation et de la glace sur la survie à l'hiver de la luzerne Vernol ont été confirmés. L'irrigation a eu peu d'effet sur la résistance au gel au cours de l'automne, mais la formation de glace au début de décembre a été mortelle pour la luzerne. L'accumulation hâtive de la neige grâce à une barrière a aidé la luzerne à survivre même sous une couche de glace de 10 à 15 cm. La formation de glace en février n'a pas causé de dommage. La mortalité hivernale serait attribuable à une combinaison du gel des racines avec la durée. En présence de la glace fortement conductrice du froid, la température du sol a atteint −15 et −17°C. Si la luzerne peut endurer un gel de −20 à −25°C pendant quelques heures, elle ne peut tolérer une température de −10°C durant plus de 2 à 3 jours. La mortalité hivernale semble donc attribuable surtout au gel des racines. De plus, suivant des résultats obtenus en laboratoire, la luzerne perdrait rapidement sa résistance sous la glace.

*Mécanismes de la résistance au froid.* La mise au point d'une méthode de culture de jeunes pousses de luzerne dans des conditions d'asepsie et la détermination des conditions d'absorption d'un précurseur radioactif tel que le tritium ($^3H$) ont permis d'analyser les protéines synthétisées par la plante au cours de son endurcissement au froid. C'est ainsi qu'on a pu démontrer que la luzerne contient des inhibiteurs qui ralentissent la dégradation des protéines chez la plante endurcie. On peut supposer que ces inhibiteurs pourraient avoir un rôle important dans le maintien de la résistance au froid, surtout au niveau des membranes.

À l'aide des techniques de l'histochimie, on a pu démontrer, dans les cellules de racines de luzerne, la présence d'organites (sphérosomes) qui pourraient être impliqués dans les lipoprotéines membranaires. Le contenu de ces sphérosomes serait enveloppé par deux membranes unitaires. Ces organites seraient très sensibles au gel et leur enveloppe serait facilement brisée par des températures sous le point de congélation, dispersant ainsi le contenu lipoprotéique.

Lors d'une étude visant à cultiver aseptiquement des jeunes pousses de luzerne en endurcissement, les critères suivants ont été retenus: conductivité et densité de la sève, couleur et degré d'ouverture des cotylédons, rigidité et transparence des parties aériennes, turgescence des racines et détermination de la résistance au gel ($TL_{50}$). La meilleure corrélation a été obtenue entre la couleur des cotylédons et la résistance au gel.

Les basses températures perturbent le transport de la proline chez le blé d'hiver et son accumulation dans les collets coïncide avec l'acquisition de la résistance au gel de cette céréale. Les résultats obtenus avec le blé d'hiver sont, à peu de chose près, identiques à ceux obtenus avec la luzerne.

Chez les six espèces cultivées à La Pocatière et Saint-Hyacinthe, la teneur maximale en proline des collets n'a pas coïncidé nécessairement avec le maximum de résistance au gel. La fléole des prés, la plus résistante au gel des six espèces n'a accumulé que 44 micromoles de proline par gramme de matière sèche (44 $\mu$mol/g m.s.) comparativement à 105 pour le brome et 66 $\mu$mol/g m.s. pour la luzerne. À Saint-Hyacinthe, la teneur maximale en proline a varié beaucoup moins, soit de 50 $\mu$mol/g m.s. pour le triticale à 74 pour le brome. Cependant, c'est chez le brome que la teneur en proline a diminué le plus rapidement, ce qui coïncide avec la perte hâtive de sa résistance au gel. Le brome a accumulé également le plus de sucres totaux et le triticale le moins. D'autre part, la fléole des prés a accumulé plus de sucrose que les cinq autres espèces et le triticale le moins, au cours de l'hiver 1982.

## Les céréales

Le programme des céréales continue à desservir la communauté scientifique nationale et internationale par la publication d'articles scientifiques et l'évaluation de pépinières scientifiques [Centro internacional par a la mayoration de mais y de trigo (CIMMYT), International Center for Agricultural research in the dry areas (ICARDA)], le Groupe du Québec par l'évaluation de cultivars et l'agriculteur par les recommandations

de cultivars et l'homologation d'une nouvelle avoine.

*Amélioration.* Quelque 45% de tous les efforts québécois en amélioration et évaluation des céréales à paille sont fournis par la station de Sainte-Foy. En 1982, un nouveau cultivar, l'avoine Kamouraska, a été homologué. Le Kamouraska représente une amélioration notable pour la province de Québec, car il combine le haut potentiel de rendement du Lamar, les gros grains du Manic et est presque aussi hâtif que l'Alma. De plus, sa paille est forte et les qualités de son grain sont supérieures avec un poids de 3 à 5 kg de plus par hectolitre et 1% de protéine plus élevé que les autres cultivars ensemencés.

En plus de l'avoine et de l'orge, le projet d'amélioration comprend maintenant le blé et le triticale. Chez le blé, étendre l'aire d'adaptation aux régions périphériques de la province, raccourcir le cycle vital et obtenir un blé à qualité boulangère intermédiaire sont les trois objectifs principaux tandis que chez le triticale, l'adaptation générale à nos conditions québécoises est l'objectif principal, car aucune amélioration n'a été faite au Québec dans cette espèce.

*Pathologie.* Systématiquement, dans les essais coopératifs de l'est et dans les essais régionaux, les cultivars sont notés pour leur réaction aux diverses maladies présentes au Québec. Ces notations servent d'information de base pour déterminer ou non l'homologation et la recommandation de cultures des cultivars.

Dans un effort de création de cultivars résistants aux maladies et adaptés aux conditions de croissance du Québec, les croisements réalisés dans le projet d'amélioration étaient inoculés au charbon nu et cinq populations de blé, au *Fusarium* spp. et une population d'orge, au *Bipolaris sorokiniana* en plus de la recherche de parents potentiels. L'évaluation des ressources phytogénétiques pour la résistance au virus de la jaunisse nanisante de l'orge (V.J.N.O.) continue avec le semis annuel des pépinières du CYMMIT et de l'ICARDA (niveau international) et avec le semis des lignées québécoises et canadiennes (niveau national) dans les quatre espèces de céréales à paille. Les résultats sont expédiés sur demande et les recommandations faites aux améliorateurs concernés. En Tunisie et sur la côte méditerranéenne de la Turquie, on trouve de l'*Avena sterilis* résistante au V.J.N.O.

*Malherbologie.* Les inventaires des mauvaises herbes dans les champs de céréales se sont poursuivis en Abitibi (est et ouest) et au Témiscamingue. Les principales mauvaises herbes étant le chiendent, le laiteron des champs, l'ortie royale, la marguerite blanche, la vesce jargeau, les renouées et la moutarde des champs.

Les travaux sur le cycle vital de croissance de l'ortie royale, de la spargoute et de la sétaire glauque sont terminés. Les stratégies sont très différentes avec une levée hâtive pour l'ortie royale et tardive pour les deux autres. Les structures de hauteur sont aussi très différentes avec l'ortie et le chénopode.

## LES SOLS

### La fertilité

*Matière organique et azote.* Une étude sur 10 sols du Québec avec une teneur en matière organique variant de 2,96 à 9,67% a été réalisée en serre en vue d'établir si une préincubation des sols est nécessaire avant de déterminer la capacité des sols à fournir de l'azote minéral aux plantes par la méthode de "l'azote exporté" (azote contenu dans la partie aérienne des plantes). Deux traitements, avec et sans préincubation, ont été comparés en utilisant l'avoine comme plante-test. La meilleure corrélation entre l'azote exporté et la matière organique a été obtenu dans le traitement avec incubation ($r = 0{,}91^{**}$). Dans le traitement sans incubation, la corrélation de l'azote exporté avec la matière organique ($r = 0{,}74^{*}$) a été plus faible, mais significativement lié à l'azote nitrique initial des sols ($r = 0{,}64^{*}$). Comme cet azote n'était pas en concordance avec la teneur en matière organique ($r = 0{,}33$), il a négativement influencé la relation entre celle-ci et l'azote exporté. Par contre, la teneur en azote nitrique des sols après incubation était significativement corrélée tant avec la matière organique ($r = 0{,}74^{*}$) qu'avec l'azote exporté par la culture qui avait suivi l'incubation ($r = 0{,}80^{**}$). Ces résultats démontrent que pour une meilleure détermination de la capacité des sols à fournir de l'azote minéral (par la méthode de l'azote exporté), une préincubation est nécessaire en vue d'amener les sols à

un certain équilibre au point de vue azote organique – azote minéral.

*Azote fractionné chez l'avoine.* Une expérience en serre a été réalisée en vue de déterminer l'influence de l'engrais azoté administré en reprises sur les composantes du rendement et sur l'utilisation de l'azote. Les rendements les plus élevés ont été enregistrés chez la variété Cascade suivie de Scott, Lamar et Elgin. Le rendement et le gain maxima dus à l'azote ont été observés à la dose maximale chez la Cascade et à des doses plus faibles chez les variétés moins productives. Chez les variétés plus productives, moins susceptibles au tallage, c'est la fertilisation au semis qui a été la plus efficace, tandis que chez les autres, les deux applications ont eu un effet semblable au point de vue rendement. L'application fractionnée (au semis plus en fin de tallage) a eu plus d'impact sur le rendement des épis principaux chez les variétés plus productives et sur le rendement des talles chez les variétés moins productives. Le nombre de graines par épis a été déterminé surtout par la fertilisation au semis. Une corrélation positive a été enregistrée entre le nombre de graines des épis principaux et le rendement total. La teneur en azote a été plus élevée dans les graines des épis secondaires, au deuxième apport et chez les variétés moins productives. Ce sont les variétés Cascade et Scott qui ont absorbé le plus d'azote, à cause de leurs rendements plus élevés.

*Amendements organiques.* L'étude portant sur les amendements organiques a révélé une augmentation de la teneur en matière organique du sol qui est passée, après une première saison de croissance, de 1,36% de M.O. pour le témoin à 2,32% pour la plus haute dose de compost. Il y a eu peu d'effet résiduel du compost et de la mousse de tourbe sur les rendements de l'avoine de la deuxième saison tandis que la plus haute dose de fumier a donné un gain de rendement de 10,3 g/ha par rapport au témoin. Les amendements étudiés ont eu peu d'effet sur les rendements de l'orge.

**La pédogénèse**

*Physique du sol.* Vingt-et-un sols de texture variant entre le limon sableux et l'argile, et contenant de 1,6 à 11,9% de matière organique ont été traités à différents taux d'humidité et soumis à des forces de tassement et de compaction. Les essais de compaction avaient pour but de déterminer les teneurs en eau qui permettaient de réduire au minimum l'espace poreux tandis que par le tassement, on cherchait la teneur en eau qui assurait une résistance maximale des agrégats. À faible tension, la matière organique est le facteur prépondérant pour déterminer la rétention d'eau. Il devient dès lors hasardeux de se baser seulement sur l'humidité du sol pour évaluer les conditions optimales de travail au champ.

On a procédé à une réévaluation de la méthode en laboratoire pour la détermination de $K_{sat}$. Une solution de bleu de méthylène est utilisée pour évaluer le niveau d'adhésion de la paraffine au sol et détecter les fuites qui se produisent entre le sol et la paraffine. L'emploi d'une pellicule de silicone avant l'enrobage a permis de diminuer l'écoulement latéral à moins de 20% pour la plupart des échantillons ce qui se traduisait par une diminution des valeurs de $K_{sat}$ de 400 à 900% par rapport aux valeurs initialement mesurées.

*Chimie et minéralogie.* Afin de permettre une identification par rayons-X des minéraux argileux, des traitements successifs doivent être appliqués pour enlever les ciments qui lient les particules minérales des sols. Une modification de la méthode dithionite-citrate-bicarbonate (D.C.B.) a été suggérée, qui permet une extraction plus poussée des oxydes de Fe, Al et Si à un coût réduit et une identification précise des minéraux.

Le traitement avec un plasma d'oxygène a permis d'éliminer complètement la matière organique de la fraction argileuse de deux sols. Ce traitement affecte quelque peu la solubilité de Si et Al, mais permet une identification plus complète des minéraux.

*Géochimie et génèse.* Une étude a été effectuée sur des sols développés à partir de matériaux stratifiés ou varvés dans la région de Saint-Hyacinthe. La chlorite et l'illite dominent dans la fraction argileuse, associés au quartz, feldspath et hornblende. Le faible niveau d'évolution dans ces profils se manifestait par la présence de peu de minéraux 2:1 gonflants et par des basses teneurs en oxydes de Fe et Al. L'altération chimique des anorthosites est intense par rapport à la désagrégation physique. La composition minéralogique de la fraction fine montre une séquence dépendant du site et influencée par le drainage. À la base du profil, des minéraux 2:1 de type smectite et vermiculite sont accompagnés de kaolinite. Au sommet du profil, on constate une augmentation marquée du pourcentage de kaolinite alors que la quantité de minéraux

gonflants tend à diminuer. L'influence du site a aussi été confirmée comme jouant le plus sur l'évolution de matériaux acides et basiques (granites et gabbros). L'altération de ces roches donne des arènes d'épaisseur variable. Il a été démontré que l'incidence de la roche-mère sur le processus de l'altération pouvait s'estomper devant celle du drainage: kaolinite et gibbsite dans les arènes granitiques et gabbroïques en zone de drainage accéléré, smectite et vermiculite en zone de drainage plus lent.

## FERME EXPÉRIMENTALE LA POCATIÈRE

### Les céréales

*Régie.* Les sols argileux peuvent être hersés à l'automne au lieu d'au printemps sans perte de rendement ou de qualité s'ils sont semés tôt. Lorsque le semis est retardé, un léger hersage devient beaucoup plus important pour la répression des mauvaises herbes. Les rendements et la qualité de l'orge diminuent très rapidement avec le retard du semis. Cet effet est beaucoup moins important sur les sols graveleux où les semis peuvent être retardés plus longtemps sans perte de rendements. Les sols non travaillés produisent des rendements plus bas, ont plus de mauvaises herbes, sont plus humides et plus froids en surface que tous les sols ayant subis d'autres méthodes de préparations.

### Les plantes fourragères

*Chiendent.* Dans des fourragères de luzerne, l'année de l'établissement, la digestibilité in vitro a diminué de 41,6% à 32,2% et la protéine de 18,1 à 12,8% avec une augmentation du contenu en chiendent de 0 à 47%. Pour chaque augmentation de 1% du contenu en chiendent, il y a une baisse de 0,07 point dans le pourcentage du contenu en protéines et de 0,18 point dans le pourcentage de digestibilité. Dans une luzernière de 3 ans coupée au stade 5% de floraison, le chiendent avait une digestibilité de 31% et la luzerne de 47%. La teneur en protéines du chiendent a varié de 8,5% à 10,3% et celle de la luzerne de 14,4% à 18,6%. Les herbicides Bas9052 et TF1169 ont diminué la teneur en protéines des deux plantes sans affecter la digestibilité.

*Production de semence du trèfle rouge.* La production de semence du trèfle rouge est influencée par la régie de coupe de la partie aérienne. Pour obtenir un rendement valable en semence, la récolte de la partie végétative devrait être faite au plus tard au stade 50% de la floraison. Le type de sol semble être un facteur déterminant. En effet, pour les mêmes traitements, nous avons obtenu un rendement en semence sur le loam graveleux Saint-André jusqu'à trois fois plus élevé que sur l'argile Kamouraska. Les cultivars semblent, eux aussi, jouer un rôle important, mais la différence entre eux est généralement moins marquée qu'entre les types de sol.

*Régie du semis.* L'utilisation en semis direct de semence enrobée n'a pas semblé utile l'année du semis, mais l'année suivant le semis, on a noté un léger effet positif de l'enrobage. Les semis directs de trèfle rouge ont encore bien réussi.

*Besoins en azote.* Le rendement en matière sèche de la fléole montre un effet bénéfique de sa culture en présence de la luzerne. En plus de l'effet positif sur le rendement, la luzerne améliore aussi le contenu en protéine brute de la fléole. Cet effet bénéfique de la luzerne sur la teneur en protéines brutes de la fléole semble plus important sur le loam graveleux Saint-André que sur l'argile Kamouraska.

### Les pommes de terre

*Irrigation.* Après 85 jours de croissance, l'irrigation a augmenté le rendement du cultivar Superior de 18,6 t/ha et celui du Kennebec de 15,3 t/ha. La proportion des tubercules de calibre compris entre 48 et 70 mm est de 42,3% à 61,3% avec le cultivar Superior et de 49,6 à 56,7 avec le Kennebec.

Après 120 jours de croissance, l'irrigation a augmenté le rendement du cultivar Russet Burbank de 9,0 t/ha et celui du Kennebec de 15,4 t/ha. La proportion des tubercules de calibre compris entre 48 et 70 mm est passée de 35,8 à 49,3% avec le cultivar Russet Burbank et de 48,1 à 66,8 avec le Kennebec. La proportion des tubercules supérieurs à 70 mm était de 5,2% pour le cultivar Russet Burbank et de 39,8% pour le Kennebec.

*Maladies et pucerons.* Une étude a été faite pour la deuxième fois en 1982. Le *Macrosyphum* a encore été le plus important dans les pièges et sur les feuilles. Deux envols ont eu lieu entre le 19 et 30 juillet. Les producteurs de semence ont toujours eu moins de pucerons sur 100 feuilles. Deux cas isolés

ont permis de démontrer que les vents dominants favorisaient la dissémination des pucerons et entravaient leur répression chez les producteurs de semence. Les classes de semences sont distinctes lors des tests sérologiques et la lecture des maladies sur le feuillage. Les plus affectés sont ceux dont la semence est d'origine domestique. Dans tous les cas, les producteurs pour la consommation ont plus de problèmes phytosanitaires.

*Sélection des lignées.* Les 1079 nouvelles lignées provenant de Frédéricton (N.B.) et sélectionnées au stade quatre buttes ont été plantées sur deux sols. Après l'évaluation en laboratoire, 73 lignées ont été sélectionnées. Des 630 évaluées en 1981, 17 ont été sélectionnées. Des 1579 lignées évaluées en 1980, 36, 25 et 8 ont été réévaluées respectivement dans l'essai d'adaptation de La Pocatière, ainsi que dans les essais d'adaptation et dans les essais avancés d'adaptation du réseau d'essai. De plus, des 1098 lignées de 1979, 4 et 8 ont été évaluées respectivement dans les essais hâtifs et avancés d'adaptation. Finalement, 102 lignées et variétés ont été évaluées dans les divers essais de variétés et 89 lignées homologuées au Canada et ailleurs ont été évaluées en collaboration avec le bureau de la Quarantaine des plantes de La Pocatière.

*Inoculation: Jambe Noire.* Après la quatrième année d'évaluation, trois lignées ont été classées comme étant aussi sensibles que la Sebago: F72090, F72068 et F75111.

### Les arbres fruitiers

D'autres pommiers tels le Golden Delicious et le Delicious, et des pruniers tels le Valor, le Lanark et le Farmingdage sont morts des suites de l'hiver doux de 1981. Les rendements des pommiers ont été faibles à cause d'une mauvaise pollinisation et du manque d'eau pendant la saison. Les pruniers plantés en 1975 tels le Bradshaw à prune bleue, le Reine Claude, le V33028 et le Damas à prune bleue ont produit respectivement 42,0, 25,3, 20,1 et 13,5 kg. De plus, presque toutes les variétés ont produit dans les deux plantations de 1977; les rendements du V33028, du Victoria et du Stanley ont été respectivement de 5,3, 4,6 et 3,1 kg. Les poiriers Miney et Phileson plantés en 1944 ont produit respectivement 189,5 et 117,1 kg.

## FERME EXPÉRIMENTALE NORMANDIN

### Les plantes fourragères

Plusieurs lignées et variétés de différentes espèces fourragères sont évaluées à chaque année sous un régime de deux coupes, afin de connaître leurs performances et en même temps, par l'entremise du Conseil des productions végétales du Québec, de servir aux recommandations. Sous nos conditions, le trèfle rouge Tristan a été légèrement supérieur aux témoins Prosper et Arlington sur une moyenne de 4 années-station. Le cultivar de luzerne 532, pour une moyenne de 6 années-station, a surpassé la moyenne de ces trois témoins par 390 kg/ha. Pour la fléole, le nouveau cultivar Hokuo a produit, pour une moyenne de 5 années-station, un rendement semblable au Climax et légèrement inférieur au Champ. Les cultivars de dactyle Orion et Sumas ont fourni respectivement 607 et 79 kg/ha de plus que le Frode sur une moyenne de 7 années-station.

### Les céréales

*Blé de printemps.* Une sélection locale a été promue en troisième année dans l'essai coopératif Québec–Maritimes. Son rendement a permis de la classer deuxième sur une moyenne de deux années d'essai dans les 15 stations. Plus de 100 lignées ont été sélectionnées en pré-observation et seront réévaluées dans le réseau des essais. De plus, environ 3500 sélections de blé de printemps ont été retenues.

*Gourgane.* Sur une moyenne de 7 années de production, les souches locales de gourgane évaluées sous les appellations GI-N et TR-N ont produit respectivement 15 561 et 16 401 kg/ha de gousses vertes par comparaison au meilleur témoin Baie Saint-Paul avec 16 927 kg/ha. La production du grain vert pour le GI-N, le TR-N et le Baie Saint-Paul a été respectivement de 6395, 6145 et 6453 kg/ha tandis que le pourcentage moyen occupé par le grain dans la gousse, sur une base de poids frais, s'est situé respectivement à 41,2, 37,4 et 38,0%.

*Fraises.* Les résultats moyens de deux années de production d'une fraisière implantée

en 1980 révèlent la supériorité des cultivars Kent (K74-10) et K72-8 avec des rendements respectifs de 13 867 et 10 129 kg/ha sur les témoins Bounty, Red Coat et Veestar qui ont produit respectivement 8721, 8328 et 6847 kg/ha.

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# Station de recherche
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# INTRODUCTION

La station de recherche de Saint-Jean-sur-Richelieu est située au sud de Montréal où les conditions sont favorables à la production de plantes horticoles et de maïs grain. Les programmes de recherche sont orientés vers la production et la protection de plantes maraîchères, de fruits, de petits fruits ainsi que de plantes aromatiques et de maïs grain qui contribuent au développement économique du Québec. De plus, la ferme expérimentale de L'Assomption s'occupe de tabac à cigarettes et à cigare ainsi que de plantes ornementales.

Plusieurs chercheurs ont été engagés pour compléter les programmes déjà existants et deux entomologistes ont pris leur retraite. De plus, les travaux de construction du nouvel édifice laboratoire-bureau ont commencé le 28 septembre.

Ce rapport donne un bref aperçu des résultats de recherche obtenus en 1982. Pour de plus amples informations sur nos réalisations, vous pouvez communiquer avec la station de recherche, Direction générale de la recherche, Agriculture Canada, Saint-Jean-sur-Richelieu, C.P. 457, Québec J3B 6Z8.

Claude B. Aubé
Directeur

## LÉGUMES

### Production du brocoli

Des essais de fertilisation supplémentaire combinée azote–molybdène ont été effectués sur sol argileux durant deux années consécutives à deux pH, soit, 6,5 et 7,3 ainsi que 5,1 et 6,5, afin d'en déterminer l'effet sur le rendement, la précocité de la récolte et la récupération de l'azote par le brocoli. L'urée de type à moulée (feed-grade) a été appliquée à raison de 60 kg d'azote par hectare en bandes et 13,5 kg d'azote par hectare en solutions foliaires alors que le molybdène a été appliqué en solutions foliaires à raison de 0,2 kg/ha. Durant ces essais, les traitements d'urée ont augmenté le rendement de 4% en 1981 et de 9% en 1982, alors que les meilleurs rendements ont été obtenus en 1982 à pH 6,5 avec 20% plus de rendement avec l'urée en bandes ou foliaire. Cependant, les applications de molybdène ont diminué la récolte hâtive de 19% en moyenne, sans réduire la récolte totale et semblerait avoir augmenté la teneur en nitrates des feuilles lors de l'essai à pH 6,5 en 1981. Cependant l'application de molybdène ne semble pas avoir augmenté la récupération d'engrais par la plante bien que la récupération de l'urée foliaire soit nettement supérieure à celle de l'urée en bandes, d'où une certaine économie d'engrais avec l'application d'urée foliaire.

### Lutte intégrée dans la carotte et l'oignon

Un programme de lutte intégrée a été mis sur pied dans les cultures de carottes et d'oignons. Ce réseau couvrait les insectes et les maladies de ces cultures. Une superficie de 500 ha de carottes et 200 ha d'oignons dans les régions de Sainte-Clotilde, Sherrington et Napierville a été couverte par deux éclaireurs. L'utilisation de techniques de dépistage et de seuil temporaire d'intervention a permis d'abaisser à moins de 1% les dommages causés par le charançon de la carotte et la mouche de l'oignon, et de retarder l'application de fongicides contre les maladies foliaires de ces cultures.

Un piège efficace et sélectif a été mis au point pour les adultes du charançon de la carotte. Ce piège est composé de plaques de bois et utilise une carotte comme appât. Les adultes viennent se nourrir sur la carotte et y demeurent pour être à l'abri du soleil, de la pluie et du vent. Ce piège devrait être utilisé dans les programmes de dépistage contre cet insecte.

## PETITS FRUITS

### Bleuetiers en corymbe

Dans un essai de cultivars et de gestion de sol commencé à la ferme expérimentale de Frelighsburg en 1976, le cultivar Northland a

rapporté des rendements significativement plus élevés que ceux de Blueray, Berkeley et Rubel. Le bran de scie s'est avéré un meilleur amendement de sol que la mousse de tourbe lorsqu'il est incorporé au sol avant la plantation. L'irrigation goutte à goutte a été plus efficace que le paillis de bran de scie comme moyen d'assurer un taux d'humidité adéquat. Les apports de soufre et les doses les plus fortes d'azote ont donné les meilleurs rendements.

**Fraisiers**

Des nombreux cultivars et sélections à l'essai, le Honeoye et le Canoga de l'État de New York ainsi que le Kent de la Nouvelle-Écosse sont les plus prometteurs tant pour la qualité de leurs fruits que pour leur rendement. Les résultats préliminaires d'une plantation sur billons dont les 72 000 plants par hectare ont produit dès la première année laissent entrevoir la possibilité d'exploiter rentablement ce type de plantation et cette pratique culturale. L'utilisation de gros plants de haute qualité et d'un système d'irrigation goutte à goutte sont des impératifs pour assurer le succès de cette nouvelle pratique culturale.

## ARBRES FRUITIERS

**L'intervention en éradication pour la répression de la tavelure du pommier**

Contrairement à la méthode d'intervention en protection qui est coûteuse en temps et en argent, la mise en place d'interventions pour l'éradication de la tavelure permet de réduire le nombre des applications de fongicides de 12 à 7 ou 8 au cours des saisons où on dénombre de 12 à 13 infections primaires. Les pomiculteurs d'avant-garde, munis de l'équipement météorologique approprié, ont commencé à pratiquer avec succès cette façon d'intervenir, mise au point dans le verger expérimental de Frelighsburg. Cette méthode de répression, rattachée à la lutte dirigée, est une étape positive vers la lutte intégrée et permet de réduire de beaucoup le coût de la protection et l'apport des fongicides dans l'environnement.

**Amélioration du pommier**

L'évaluation des lignées à lambourdes des cultivars de pommier McIntosh a permis, au cours des 10 dernières années, d'établir la supériorité de ces lignées sur la lignée standard Imperial All Red. En effet, les lignées étudiées, soit Lussier Spur, MacSpur, MorSpur, Starkspur et Starkspur UltraMac (Dewar), sont toutes plus précoces et productives que la lignée standard. Parmi les lignées à lambourdes, la MacSpur et la MorSpur s'avèrent supérieures quant à la couleur du fruit, la résistance au froid, la compacité, la précocité et la productivité. Cependant, leurs fruits sont légèrement plus petits et leur maturité est avancée de 1 à 2 jours. Pour l'ensemble des caractéristiques étudiées, les autres lignées se classent dans l'ordre suivant: Starkspur, Lussier Spur et Starkspur UltraMac (Dewar). Aucune différence significative n'a été observée entre les lignées étudiées quant à la durée de vie en entrepôt, la pression des fruits et leur contenu en solides solubles.

Par ailleurs, dans le cadre de l'amélioration du pommier pour la résistance à la tavelure, plus de 15 000 pépins hybrides ont été obtenus en 1982, ce qui porte à 179 336 le total obtenu dans 340 croisements réalisés depuis 1971. Grâce à une sélection intensive en bas âge, seulement 15% des plantules ont été conservées pour une évaluation primaire de la productivité et des autres caractéristiques de l'arbre et du fruit. Parmi les quelques 5000 arbres évalués à ce stade, environ 100 ont été sélectionnés pour une évaluation secondaire.

## MAÏS

**Amélioration**

Trois lignées autofécondées précoces ont été développées à compter d'une lignée européenne, appelée 'Synthétique A', résistante à la pyrale du maïs, *Ostrinia nubilalis* (Hbn.). Cette lignée synthétique origine du croisement de neuf différents hybrides autofécondés et possédant le caractère de résistance à la pyrale. Les trois lignées résultent de trois cycles d'intercroisement et de trois cycles d'autofécondation réalisés en condition d'infestation artificielle de l'insecte. Elles se sont classées parmi les plus productives dans un essai de tamisage conduit à deux sites en 1980. De type semi-denté, elles requièrent de

70 à 74 jours entre le semis et l'apparition des soies.

## TABAC

### Amélioration du tabac à cigare

La lignée L64-99 est issue du croisement Pennbel 69 × Havana L'Assomption réalisé en 1964. Elle s'est révélée supérieure à des cultivars connus en production et en qualité au cours des cinq dernières années. Par rapport au cultivar commercial 'Resistant Havana 211', son rendement et son indice de prix ont été de 20% plus élevés et son degré d'acceptation par les fumeurs lui a été comparable.

### Physiologie du tabac gris

*Morphologie de la plante.* Les feuilles basales sont jaunes ou bronzées sur toute leur surface alors que les feuilles de tête et médianes ont une teinte cendrée ou vert-gris. Les feuilles de tête sont érigées et forment un angle aigu par rapport à la tige. Le pourtour des feuilles inférieures est moins cireux et la surface foliaire est plus lisse que celle du tabac sain. Les feuilles supérieures sont légèrement retombantes, peu développées et incurvées vers la nervure centrale. Dans certains cas, les feuilles forment une coupe inversée vers le bas du plant.

*Développement.* En même temps que l'apparition de la teinte bronzée apparaissent des tachetures sur la face abaxiale des feuilles basales. Avec le temps, ces taches progressent au point d'envahir les feuilles supérieures. Sur une feuille donnée, les tachetures apparaissent d'abord à l'extrémité, puis se distribuent sur le pourtour vers la nervure centrale pour finalement couvrir toute la surface. Il n'y a pas évidence de nécrose. Un examen stéréoscopique des cellules du mésophylle a révélé que le tissu vasculaire secondaire, ainsi que le tissu proximal, sont de couleur brun foncé.

*Étude isotopique.* Par la technique d'autoradiographie, il a été démontré que l'isotope $Fe^{55}$, lorsqu'utilisé pour la nutrition de plants infectés de tabac gris, effectue une translocation vers les tachetures qui se trouvent sur la face abaxiale des feuilles. L'isotope s'est retrouvé en plus forte concentration dans les feuilles basales et en faible proportion dans les feuilles supérieures, tel que mesuré par le compteur à scintillation. Dans la feuille, la concentration moyenne de $Fe^{55}$ était plus élevée à l'extrémité qu'à la base.

*Analyses spectrométriques.* Les analyses par rayon-X des feuilles de tabac gris et sain cultivé au champ ont confirmé que les tissus atteints contiennent moins de K, Ca et S, mais plus de Fe que les tissus sains. La teneur en Mn était identique dans les deux cas.

### Dispositif expérimental

Une étude statistique, entreprise pour déterminer la dimension optimale des parcelles et des blocs pour la culture du tabac à cigare, a indiqué que dix plants inter-compétitifs constituaient la plus petite unité acceptable. Quand la courbe estimée de la relation linéaire entre le logarithme de la variance du rendement et de la dimension de la parcelle était de 0,5 le gain de précision a été estimé à 10 et 20% pour les blocs constitués de 20 et 5 parcelles respectivement. Quand l'espace de terrain est le facteur critique, la plus petite dimension pratique de parcelle peut être choisie, du moins initialement. Cependant, si plus de précision est requise, il faudrait accroître le nombre de répétitions sans augmenter la taille des parcelles.

### Fertilisation du tabac jaune

La valeur fertilisante de divers engrais simples a été évaluée et différents taux de ces engrais ont été comparés durant trois ans sur un loam sableux Soulanges et sur un sable Uplands. Les sources de fertilisants azotés ont eu un effet significativement positif sur le rendement des deux types de sol, particulièrement le sulfate d'ammonium. Sur sol Uplands cependant, l'indice de qualité et le revenu brut ont subi une diminution significative par l'apport de nitrate de potasse. Les sources de phosphore ont favorisé l'indice de qualité sur sol Soulanges, le rendement et la qualité sur sol Uplands. Le rendement s'est accru et l'indice de qualité a été plus faible par l'apport de superphosphate; le superphosphate triple a produit l'effet inverse. Les taux les plus élevés des divers fertilisants utilisés ont contribué à l'augmentation du rendement, mais ont diminué la qualité du tabac.

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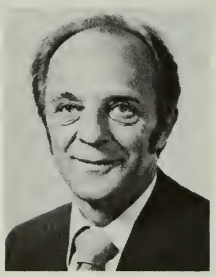
# ONTARIO REGION
# RÉGION DE L'ONTARIO

Dr. J. J. Cartier



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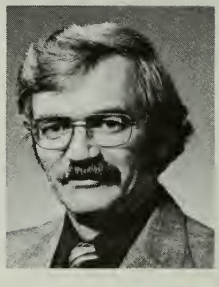

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## EXECUTIVE OF THE ONTARIO REGION
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# PREFACE

The Ontario Region comprises nine responsibility centers: the research stations of Harrow, Delhi, Vineland Station, and Ottawa; the London and the Animal research centres; and the experimental farms at Smithfield, Kapuskasing, and Thunder Bay. Each has a specific mandate to carry out mission-oriented research in support of particular components of the agricultural industry or of a particular area. The regional staff totals about 880, of which about 180 are professionals. The total regional budget is approximately $35 million.

The Harrow Research Station has one of the most diverse research programs in the Region. Its program features field crops such as corn, soybeans, winter wheat, field beans, and burley tobacco, as well as horticultural crops such as tree fruits and vegetables. Most of these programs involve developing improved cultivars and superior production technologies. Emphasis is placed on improving integrated pest management technologies for the control of weeds, diseases, and insects.

The Delhi Research Station provides research support to the flue-cured tobacco industry in Ontario, Quebec, and the Maritimes. Improved cultivars and production technologies are being developed. A research program on alternative crops for tobacco soils is also under way.

Integrated pest management for orchard and vegetable crops, grapes, ornamentals, and some forage crops is the focus of research at the Vineland Research Station, to reduce the use of chemical pesticides while maintaining crop productivity and produce quality. The Station also maintains a virus-free nuclear stock repository of strawberries, raspberries, and tree fruits.

The Ottawa Research Station conducts breeding programs in cereals, forages, soybeans, and some ornamentals, supported with research in plant pathology, physiology, entomology, cytogenetics, and grain quality. A center of excellence has been established in biotechnology to support plant-improvement programs of the future.

The Animal Research Centre conducts research in nutrition, physiology, and management of beef cattle; breeding, nutrition, and management of dairy cattle; nutrition, physiology, meat quality, and management of swine; breeding, nutrition, egg and carcass quality, disease resistance, and management of poultry; genetics, reproductive physiology, nutrition, and management of sheep; animal waste management; and food safety and nutrition. Vomitoxin contamination in winter wheat led to detailed research to establish contamination tolerance in feeds.

The London Research Centre concentrates on integrated pest management (protection), including biological control, and environmental quality. Research is directed toward reducing the dependence of the agri-food industry on chemical pesticides and toward assuring that human health and environmental safety are not adversely affected by pesticide use.

The Smithfield Experimental Farm program features plant breeding of apples and tomatoes, orchard and vegetable crop management (including integrated pest management), and some processing research.

The Kapuskasing Experimental Farm works with the Animal Research Centre and the Ottawa Research Station. Animal research aims at improving beef production systems for northern Ontario and western Quebec. Crop research attempts to improve crop production technology.

The Thunder Bay Experimental Farm evaluates adaptation of forage, grain, and horticultural crops to the area.

Detailed information on the various programs may be obtained by writing to the establishments concerned or by addressing inquiries to Ontario Region Headquarters, Research Branch, Agriculture Canada, Central Experimental Farm, Ottawa, Ont. K1A 0C6.

J. J. Cartier

# PRÉFACE

La région de l'Ontario compte neuf centres de responsabilité: les stations de recherche d'Harrow, de Delhi, de Vineland et d'Ottawa, le Centre de recherche de London, le Centre de recherche zootechnique et les fermes expérimentales de Smithfield, Kapuskasing et Thunder Bay. Chacun de ces établissements a un mandat propre qui consiste à poursuivre des recherches thématiques pour le bénéfice de composantes données du secteur agricole ou d'une région donnée. Le personnel de la région comprend environ 800 employés dont 180 professionnels et le budget se chiffre à peu près à 35 millions de dollars.

Le programme de la station de recherche d'Harrow est l'un des plus diversifiés de la région. Ses recherches portent sur les grandes cultures comme le maïs, le soja, le blé d'hiver, les haricots de grande culture et le tabac Burley ainsi que sur des cultures horticoles comme les arbres fruitiers et les légumes. La plupart de ces travaux visent entre autres à produire des cultivars améliorés et à mettre au point des techniques de production plus efficaces. Les chercheurs mettent l'accent sur le perfectionnement des méthodes de lutte intégrée contre les mauvaises herbes, les maladies et les insectes.

La station de Delhi effectue des recherches sur le tabac jaune qui profitent à l'industrie du tabac de l'Ontario, du Québec et des Maritimes. Les objectifs sont la production de cultivars améliorés et la mise au point de meilleures techniques de production. La station poursuit un programme de recherche sur les cultures de rechange pour les terres à tabac.

Le programme de la station de recherche de Vineland met surtout l'accent sur les méthodes de lutte intégrée contre les parasites des vergers, des cultures maraîchères, des vignobles, des plantes ornementales et de certaines cultures fourragères. Il vise à réduire l'emploi de pesticides chimiques tout en maintenant la productivité et la qualité du produit. La station conserve aussi un stock de matériel-souche de fraises, de framboises et d'arbres fruitiers exempts de virus.

La station de recherche d'Ottawa s'occupe de l'amélioration des céréales et des cultures fourragères du soja et de certaines plantes ornementales. La recherche y englobe des domaines comme la pathologie et la physiologie végétales, l'entomologie, la cytogénétique et la qualité des grains. Un centre de recherche de haut calibre en biotechnologie a été mis sur pied pour appuyer les futurs programmes d'amélioration des végétaux.

Le Centre de recherche zootechnique effectue des travaux sur l'élevage, la nutrition et la physiologie des bovins de boucherie; l'élevage, la nutrition et l'amélioration des bovins laitiers; l'élevage, la nutrition, la physiologie et la qualité de la viande des porcs; l'élevage, l'amélioration, la nutrition, la qualité des oeufs et des carcasses, et la résistance aux maladies des volailles; l'élevage, la génétique, la physiologie de la reproduction et la nutrition des moutons; la valorisation et l'élimination des déchets d'origine animale, et l'innocuité et la valeur nutritive des aliments. La contamination du blé d'hiver par les vomitoxines a incité les chercheurs à entreprendre des études méthodiques afin d'établir les niveaux de tolérance dans les aliments du bétail.

Les principaux objectifs poursuivis par le Centre de recherche de London sont la lutte intégrée contre les parasites, en particulier la lutte biologique, et la qualité de l'environnement. Les recherches visent à réduire l'utilisation des pesticides chimiques dans le secteur agro-alimentaire et à veiller à ce que l'organisme humain et l'environnement ne soient pas menacés par ces pesticides.

Le programme de la ferme expérimentale de Smithfield porte sur l'amélioration de végétaux comme les pommes et les tomates, et sur la conduite de cultures de vergers et de cultures maraîchères (y compris la lutte intégrée contre les parasites). Les chercheurs poursuivent également des travaux sur la transformation.

La ferme expérimentale de Kapuskasing travaille en collaboration avec le Centre de recherche zootechnique et la station de recherche d'Ottawa. Les recherches zootechniques visent à améliorer les systèmes de production de boeuf dans le nord de l'Ontario et l'ouest du Québec. Les recherches sur les cultures se concentrent sur l'amélioration des techniques de production.

La ferme expérimentale de Thunder Bay évalue la capacité d'adaptation des cultures fourragères, céréalières et horticoles dans la région.

Pour de plus amples renseignements sur les programmes, écrire à ces établissements ou communiquer avec l'administration centrale de la région de l'Ontario, Direction générale de la recherche, Agriculture Canada, Ferme expérimentale centrale, Ottawa (Ont.), K1A 0C6.

J.J. Cartier

# Animal Research Centre

# Ottawa, Ontario

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| R. M. G. Hamilton, B.Sc. (Agr.), M.Sc., Ph.D. | Program Chairman; Nutrition and physiology, eggshell quality |
| N. A. G. Cave, B.Sc., M.Sc., Ph.D. | Amino acids and proteins, broiler breeder nutrition and management |
| I. R. Sibbald, B.Sc. (Agr.), M.Sc., Ph.D., D.Sc. | Avian energetics and feedingstuff evaluation |

## Sheep Production

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|---|---|
| L. Ainsworth, B.Sc., M.Sc., Ph.D. | Program Chairman; Female reproductive physiology |
| P. S. Fiser, B.Sc., M.Sc., Ph.D. | Male reproductive physiology |
| D. P. Heaney, B.S., M.S., Ph.D. | Nutrition and intensive management |
| G. A. Langford, B.Sc., M.Sc., Ph.D. | Male reproductive physiology |
| J. N. B. Shrestha, B.V.Sc.A.H., M.S., Ph.D. | Breeding and intensive management |

## Animal Feed Safety and Nutrition

| | |
|---|---|
| H. L. Trenholm, B.Sc., Ph.D. | Program Chairman; Mycotoxins, toxicology |
| M. H. Akhtar, B.Sc., M.Sc., Ph.D. | Pesticide metabolism and residues |
| L. M. Cote,[12] B.Sc., M.Sc. | Biochemical toxicology, mycotoxins |
| E. R. Farnworth, B.Sc., M.Sc., Ph.D. | Nutrition and biochemistry—lipids and mycotoxins |
| J. K. G. Kramer, B.Sc., M.Sc., Ph.D. | Lipid chemistry and biochemistry |

## VISITING SCIENTISTS

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|---|---|
| M. J. Schang, Ing., M.Sc.<br>Instituto Nacional de Tecnologia Agropecuraria, Pergamino, Argentina | Feedingstuff evaluation |

*Natural Sciences and Engineering Research Council postdoctorate fellows*

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|---|---|
| M. K. Akbar, B.Sc., M.Sc., Ph.D.<br>1981–1983 | Poultry breeding |
| L. M. Connor, B.Sc. (Agr.), M.Sc., Ph.D.<br>1981–1982 | Reproductive physiology |
| D. W. Fitzpatrick, B.A., B.Sc., M.Sc., Ph.D.<br>1981–1982 | Toxicology |
| P. M. Hocking, B.Agr., Ph.D.<br>1980–1982 | Dairy cattle crossbreeding |

*Graduate students*

| | |
|---|---|
| F. Levine, B.Sc. | Reproductive physiology |
| J. C. Segura, C. Ing. | Poultry genetics |

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[1]On management leave, 1 June 1981–28 February 1982.
[2]Acting Director, 1 June 1981–28 February 1982; seconded to Research Branch, Program Coordination Directorate, 1 July 1982, for an indefinite period.
[3]Acting Deputy Director, 28 June 1982–31 January 1983.
[4]On French language training, 30 March 1981–12 March 1982.
[5]11 May 1981–31 March 1982.
[6]Seconded from Systems and Consulting Division, Finance and Administration Branch.
[7]Seconded from Libraries Division, Finance and Administration Branch.
[8]Seconded to Research Branch, Program Coordination Directorate, 15 May 1982–1 October 1982.
[9]Seconded to Management Accountability Directorate, 8 September 1981–31 September 1982; on French language training, 4 October 1982–30 May 1983.
[10]On transfer of work at Animal Production and Health Section, Joint FAO/IAEA Division, International Atomic Energy Agency, Vienna, Austria, 1 October 1981–30 August 1982.
[11]Appointed 15 October 1982.
[12]Appointed 1 May 1981. On education leave at the University of Illinois, Urbana, IL, as of 21 May 1982 for an indefinite period.

# INTRODUCTION

The Animal Research Centre (ARC) is the main Canadian location for breeding and genetics research with dairy cattle, sheep, and poultry; it also has major research programs in the nutrition of dairy and beef cattle, sheep, swine, and poultry. ARC has research under way in animal waste utilization and management, reproductive physiology, trace mineral requirements, carcass evaluation, ruminant digestive physiology, and pesticides and other contaminants in animal feeds. The nine research program teams are multidisciplinary and are composed of scientists with a broad range of scientific knowledge. Both applied research and basic research that is directly related to the solution of the problem are carried out by these teams.

ARC continues to devote a large effort to studying the problems of intensively housed and managed livestock and poultry. Scientists in several disciplines, in particular genetics, nutrition, animal behavior, and reproductive physiology, are involved in studies to effectively resolve the numerous problems associated with improving the productivity of intensively housed animals.

In 1982, considerable emphasis was placed on research on feedingstuff contaminants, in response to identified, high-priority needs in this area. Nutritionists, toxicologists, and biochemists from the swine, poultry, and dairy cattle programs are now conducting major studies on the effects of feeding various mycotoxins to farm livestock and poultry.

The application of biotechnology in Canadian agricultural production is becoming increasingly important. Work at ARC is already under way to use sophisticated genetic manipulation techniques to improve the ability of rumen bacteria to synthesize essential amino acids. In 1982, an additional research scientist was added to the ARC staff to explore other promising biotechnology techniques.

This annual report highlights research progress in 1982. The following are some advances that are particularly noteworthy: contrary to popular belief, the chelation of zinc and manganese does not improve their utilization in sheep; beef steers in a northern climate gain weight faster in a totally enclosed barn than an open-fronted one; hormonally treated cows effectively detect estrus in a herd; preliminary results from the national breeding experiment show definite advantages of crossbreeding over pure breeds for some dairy cattle traits; formaldehyde treatment imparts good bypass properties to soybean meal, increasing its utilization by cattle; electronic probes streamline the hog-grading process; safe levels of feeding mycotoxin-contaminated wheat to various species were established.

The poultry breeding research associated with disease resistance selection and heterosis, and the poultry nutrition programs in feed evaluation, eggshell strength, and broiler management have been extensively and internationally recognized this past year. Scientists in the poultry programs organized the bilingual Canadian Poultry Breeders' Workshop in May, to which all principal members of the Canadian primary poultry breeding industry were invited.

The transfer of research results from the laboratory to the farmer–user remains a high priority. Efforts in this regard were exemplified by the quantity of high-quality research data being published in the scientific and popular press. In 1982 a publication was released entitled *The economics of intensive sheep production*, ARC Technical Bulletin Series No. 4. It is a comprehensive analysis of the economics of a total confinement sheep production system and compares it with lesser degrees of intensification as production alternatives. In cooperation with Communications Branch, a major-length (26-min) color sound film entitled "Research to increase lamb production in Canada" was produced. In 1982, ARC was also heavily involved in international cooperative research and development programs in Venezuela, Brazil, and Cuba in the areas of dairy cattle and poultry breeding and dairy cattle production research.

The staff at ARC act as the scientific authorities for a number of contract research programs and projects with private companies and universities. Contract research, together with government in-house research, plays an important role in solving problems of Canadian agriculture. ARC supervised 17 contract research programs valued at $1.3 million in the areas of livestock feed from animal waste, reproductive physiology of sheep and cattle, poultry

breeding and feeding, and disease resistance genetics. Some of this work terminated in 1982 and is described in this report.

Development at the ARC Research Farm continued with the completion of an outdoor paddock for cattle and a double horizontal silo to augment this type of storage for research on the feeding of high-moisture silages. Construction of a barn for storage of large round hay bales was also finished.

Detailed information on the research accomplishments, methodology, and results can be obtained from the publications listed at the end of this report. Reprints of the publications, copies of this report, and the 1982 edition of the ARC staff and program booklet are available on request from the Animal Research Centre, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R. S. Gowe
Director

## ANIMAL WASTE UTILIZATION

### Changes in nutrient content and properties of farm animal wastes during storage

Changes in nutrient content, composition, and physical properties of dairy cattle wastes during undisturbed, 5- and 9-mo storage in large (12.3 × 7.2 × 3.0 m deep) covered concrete tanks were determined. Specific gravity, pH, specific conductivity, total solids, ash, total carbon, total nitrogen, ammonia nitrogen, total phosphorus, potassium, calcium, magnesium, and volatile fatty acids were determined at selected tank locations for the raw or liquid fraction of the wastes, or both. With storage, the change in pH was small, but an increase in specific conductivity indicated substantial mineralization in both the raw wastes and the liquid fractions. Further analysis of data is in progress.

### Pollutant transport to tile-drainage water

A 7-yr study on quality of tile-drainage water from manured and chemically fertilized fields showed that nitrogen application rate influenced the mean concentration of nitrate nitrogen ($NO_3$-N) but not of total Kjeldahl nitrogen in drainage water. Manure nitrogen application at an annual rate of 500 kg/ha or more for several years resulted in elevated $NO_3$-N concentrations in drainage water that did not rapidly decline when nitrogen applications were reduced. Relative to $NO_3$-N, the year-to-year changes in mean concentrations of total phosphorus and potassium were small.

## CONTRACT RESEARCH

### Feasibility of ensiling waste activated sludge (WAS) as a livestock nutrient source

The physical, chemical, and microbiological properties of WAS from combined sewage–vegetable processing, dairy, potato processing, and a vegetable processing plant were determined prior to and after ensiling with whole corn, corn stover, wheat straw, or a grain mixture consisting of equal amounts of barley, oats, and corn. Concentration of heavy metals was higher in mixtures that contained vegetable processing and mixed sewage–vegetable processing WAS. Based on pH suppression and lactic acid production, mixtures containing corn or mixed grains and potato processing or dairy WAS ensiled best. Ensiling WAS was determined to be economically attractive only if sludge dewatering facilities are already in use at treatment plants.

### Feeding of vegetable processing waste products to livestock

The feeding of dairy and beef cattle with wastes from the processing of tomatoes, carrots, and beans was determined to be nutritionally safe if ordinary precautions are taken. It is logistically and operationally feasible, and can be economically viable for both processors and livestock operators. This conclusion was based on a thorough review of the available information and discussions with government and university experts, farmers, and processors. It was determined that only operators with a good knowledge of animal nutrition, including the possible use of least-cost ration formulations, would be able to take maximum advantage of waste feeds,

because the level of wastes to be included in the feed would be governed by a number of factors, such as animal type, daily weight gain requirement, and availability and price of conventional feeds and wastes.

## TRACE MINERALS AND BEEF CATTLE NUTRITION

### Beef production in the Great Claybelt area of northern Ontario

In studies at the Kapuskasing Experimental Farm, 64 steers sired by Charolais or Hereford bulls were housed in a totally enclosed barn or an open-front barn and were fed to market weight on either grass silage or on a ration of 60% grass silage and 40% barley. The feeding trial started in December, 6 wk after weaning, and the steers were marketed when they had 8–10 mm of fat over the loin. Compared with the Hereford-sired steers, the Charolais-sired steers had heavier initial weights and heavier final weights, 257 versus 217 kg and 471 versus 419 kg, respectively, but total gains were very similar. It took 7 days longer for the Charolais steers to reach market weight (212 versus 205 days).

Steers housed indoors gained 0.1 kg/day faster and took 23 days less to reach market weight than steers housed in the open-front barn. This difference in performance between types of housing was greater on the high-energy diet (silage and barley) than on the low-energy (silage) diet. On the all-grass silage diet, steers gained 0.9 kg/day, which was 0.25 kg/day less than that observed with silage plus barley.

### Development of reentrant cannulation and automatic digesta sampling

A reentrant cannula has been developed and patented that allows the continuous collection, sampling, and return of digesta. It is surgically inserted into the small intestine of sheep. The cannula is made of polyvinyl chloride (PVC) plastisol and consists of a curved intestinal tube joined to a stem. There is an external eliptical ring on the distal end, to prevent overgrowth by the skin, and an internal perforated flange that encircles the stem above the intestinal tube for retention of the cannula in the abdominal wall. A circular perspex valve with two curved channels fits into the cannula, allowing a maintenance or collection function. The cannula is commercially produced by Ketchum Manufacturing Sales Ltd., Ottawa.

To complement the reentrant cannula, a sophisticated automatic digesta sampler has also been developed and tested under experimental conditions. The sampler can be programmed and is fully automated for the continuous collection and sampling of digesta.

### Absorption of chelated zinc (Zn) and manganese (Mn)

The absorption from the small intestine of radioactive Zn and Mn, chelated with thiosalicylic acid (TSA) and hydroxyethylethylenediaminetriacetic acid (HEDTA), was studied in sheep equipped with a simple cannula in the proximal duodenum and a reentrant cannula in the terminal ileum. Chelation with TSA or HEDTA increased the absorption from the small intestine of both $^{65}Zn$ and $^{54}Mn$, as compared with unchelated forms, but the increase in absorption was accompanied by greater urinary excretion and endogenous secretion of the radioisotopes. The total urinary and fecal excretion of each radioisotope over 14 days approached 100% of the dose in animals given the HEDTA chelates and slightly less in those dosed with TSA chelates. Therefore, although the rate of absorption of chelated forms of Zn and Mn was higher, there was also a greater rate of their elimination, and the elements were not available for utilization by the animal.

### Rumen ciliate protozoa

A pelleted diet composed of 50% hay and 50% corn was fed to sheep for two periods to further examine the effects of protozoa on digestion. The sheep had been protozoa-free from birth. After an initial control period, the sheep were inoculated with ciliate protozoa to start the second period of the experiment. The inoculation with ciliates significantly increased levels of ammonia, volatile fatty acids, and pH in the rumen. There was a shift to higher molar proportions of butyrate in rumen fluid after introduction of the protozoa but they had no effect on rumen volume or dilution rate. Digestion of organic matter and nitrogen were greater in the presence of protozoa. In another experiment with sheep fitted with duodenal reentrant cannulas and fed a diet of 50% corn and 50% corn silage, it was found that ciliate protozoa had no effect

on the solubility of trace minerals in the rumen or the duodenum.

### Studies of vitamin D in cattle

The concentration of vitamin D in the milk of cows housed indoors was found to be less than 2 IU/100 mL and it was predominantly in the $D_3$ form. When the cows were given vitamin $D_3$, the concentration increased and reached a maximum between 3 and 7 days after oral administration and up to 10 days after intravenous administration. An oral dose of a mixture containing equal amounts (1 million IU) of vitamins $D_2$ and $D_3$ resulted in a maximum concentration 2–3 days later in plasma and 1 day later in milk. Equal concentrations of the two forms of vitamin D were found in milk, but in plasma the concentration of $D_3$ was double that of $D_2$. Therefore, different transport mechanisms for vitamin $D_2$ and $D_3$ forms probably exist for plasma but not for milk.

With the use of the rabbit doe as an experimental animal, radioisotope studies showed that much more vitamin D was secreted in the milk after dosing with 25-hydroxyvitamin $D_3$ than with vitamin $D_3$, though the tissue levels of radioactivity were higher in those receiving the vitamin $D_3$.

## DAIRY CATTLE BREEDING AND PRODUCTION

### National cooperative dairy cattle breeding project (NCDCBP)

The data are now complete for traits measured on heifers of the first generation of crossbreds (C line) of the Holstein-based H line and the Ayrshire-based synthetic A line and contemporary H line and A line heifers. Body weights and dimensions at various ages, and age at first detected estrus and subsequent reproduction have been summarized along with disposal (mortality and culling) rates from birth through several successive ages until first calving. With few exceptions, the means of the four genetic groups for body weights and dimensions ranked in the following order of decreasing weight or size: H line, crossbreds from A line sires and H line dams (A × H), crossbreds from H line sires and A line dams (H × A), and A lines. In a number of instances, the A × H crossline heifers were as large as or larger than the H line heifers. The H × A crossline heifers were only slightly smaller than the H line heifers. The differences between the daughters of H line versus A line dams were much greater than the differences between daughters of H line and A line sires for body weight and dimension traits. The difference between the reciprocal crosses (A × H versus H × A) suggests that there is some advantage in producing the crossbreds out of dams of the larger line. Crossline heifers were heavier and larger, respectively, than the average of A and H line heifers combined for body weights and dimensions from birth to 82 wk. The nonadditive genetic effect from crossing lines H and A resulted in a 1.9–3.8% increase in body weights and an advantage of up to 1.6% for body dimensions over the average of the pureline heifers. At 82 wk, body weights were 456, 438, 444, and 410 kg; heights at the withers were 126, 124, 125, and 121 cm; and heart girths were 175, 173, 173, and 170 cm for the H line, H × A crossbreds, A × H crossbreds, and the A line heifers, respectively.

As with body weights and dimensions, differences in reproduction traits between heifers with either A or H line dams were greater than differences between daughters of A or H line sires. The heifers from A line dams required more services per conception (2.0 versus 1.9), were older at first calving (698 versus 691 days), and had longer gestations (280 versus 278.5 days) than heifers from H line dams. Crossbreds had shorter gestation periods than purebreds (278.5 versus 280 days). The disposal rate (culling and death) was lower for H × A heifers (13.1%) than for A × H (25.0%), H × H (28.6%), and A × A heifers (24.4%) from birth to first calving. Health disorders were responsible for 77% of heifer disposals from birth to 1 yr of age, whereas 85% of heifer disposals between 1 yr of age and first calving was attributable to reproduction problems.

### Breeding studies using record of performance (ROP) data

Further evaluation was completed of the potential of a.m. or p.m. milk recording and milk sampling for fat and protein analysis instead of daily milk weights and composite a.m. and p.m. samples on the test day. Data were obtained on 12 800 individual-cow test-days in 50 Ontario herds enrolled in the ROP program to estimate daily milk weight, fat, or protein percentage from either a.m. or p.m.

values. Factors previously estimated were applied to the data from which they were derived, and accuracy of estimation of both daily and lactation values was evaluated. Only a 5–8% loss in accuracy of estimating daily milk yield and percentage of protein from a.m. or p.m. values was found. However, the loss in accuracy for estimating either daily percentage of fat or fat yield was 20–25%, making adoption of an a.m.–p.m. testing program difficult. This loss in accuracy arises from the substantial unpredictable variation in percentage of fat from a.m. to p.m. milkings that is averaged out in a daily composite sample. This is unfortunate, since a 30–40% reduction in costs of milk recording could be realized from recording results from one milking instead of both milkings on the day of the test.

**Detection of estrus in cows maintained indoors year-round**

As the trend toward larger herds and increased mechanization continues, dairy cows are receiving less individual attention, which contributes to the lower reproductive performance sometimes observed. Observation for estrus detection is often reduced or neglected. Over a 3-yr period, records of 1554 cows maintained indoors year-round were analyzed for observation of heat and reproductive efficiency. Variables included percentage of cows in estrus by 55 days postpartum prior to the resumption of breeding, days to first recorded heat, days to first service, conception rates, time between successive breedings of those cows that failed to conceive, days open, and services per conception. Each variable was analyzed for the effects of year of calving, month of calving, strain of cow, type of barn in which the cow was housed, and parity of the cow.

Cows housed in a tie-stall barn were detected in heat more readily than those in a loose-housing barn. This appeared to be due to closer observation of the cows in the tie-stall barn, because other experiments in this barn required more individual attention to the cow. In general, first-lactation cows, averaging 22 mo of age at calving, conceived sooner than older cows and had a shorter calving interval but required more services per conception. This increased number of services was attributed to a longer period for complete recovery of the reproductive tract in a small number of young cows with calving difficulties. The results showed that heat detection is important in all dairy operations but particularly so in a large mechanized dairy cattle production unit.

A second study assessed the time of onset of heat in postpartum dairy cows housed indoors year-round. More cows (65%) came into heat during the night, i.e., between 1800 and 0600 h, a time when there were no barn personnel present. Of the cows detected in heat by hormonally treated females, 22% were not seen by the herd workers who observed the herd twice daily. The results verified those of other researchers in which more cows housed under less intensive management conditions also come into heat during the night. It also confirmed the effectiveness of using hormonally treated females to detect estrus in dairy cows.

**Pilot genetic studies with mice**

Theoretical dairy cattle crossbreeding schemes, capitalizing on heterosis (superior performance of crossbreds relative to parental breeds), were explored and predicted performance was compared with experimental results from a study with mice.

Three crossbreeding systems were considered: crisscross (CC), repeat hybrid male cross (RHMC), and random mating within a population synthesized from multiple breeds (SYN). Under the CC system involving two breeds (lines), female crossbreds are mated with males whose breed alternates between generations. Under the RHMC system, female crossbreds are mated with $F_1$ hybrid males from two breeds in successive generations. After the first-cross generation, performance is expected to fluctuate (zigzag) over generations under CC but to be constant under RHMC and SYN. Expected performance under CC (averaged over four generations after the first-cross generation), relative to that under RHMC or SYN is $(59\ G_1 + 69\ G_2 + 82\ H) / 64(G_1 + G_2 + H)$, where $G_1$ is the additive genetic value of breed 1 and H is heterosis. Five CC lines, five RHMC lines, and one SYN line of mice were established and 533, 534, and 410 females were tested, respectively. Each female, pair-mated at day 42 with a male from SYN line, was recorded for the number of lactations during lifetime (NL), total number (TN), and weight (TW) of young produced during lifetime, and actual length in days of reproductive life (RL). The

observed performance averaged over the four generations was, under CC, RHMC, and SYN, 4.74, 4.62, and 4.56 for NL; 49.9, 48.2, and 48.8 for TN; 86.0, 83.6, and 85.1 g for TW; and 120.0, 117.6, and 116.7 for RL, respectively. Heterosis for female performance was 10.2, 29.6, 32.6, and 8.8% for NL, TN, TW, and RL, respectively. Additive values of the two groups of lines (breeds) prepared for CC and RHMC were 4.59 and 4.44 for NL, 42.7 and 44.1 for TN, 70.9 and 75.3 for TW, and 114.8 and 114.2 for RL, respectively. Additive genetic and heterosis values were applied to the formula above, and the expected performance was calculated. The ratio of CC to RHMC for the expected and observed performance was 1.01 and 1.03 for NL, 1.04 and 1.04 for TN, 1.04 and 1.03 for TW, and 1.01 and 1.02 for RL, respectively. Observed and theoretical values were in excellent agreement. The observed mean performance was slightly greater for CC than for RHMC. The national cooperative dairy cattle breeding project is testing RHMC and CC at five research stations of the Research Branch.

## DAIRY CATTLE NUTRITION

### Forage evaluation

Research comparing methods of preservation of alfalfa continued. For winter feeding, recoveries of formic-acid-treated silage (FS) and wilted silage (WS) stored in concrete stave silos (3.7 × 12 m) were 86 and 87% for energy, and 81 and 87% for crude protein (CP), respectively. Corresponding values for hay stored in large round bales (LRB) in a pyramid form (3, 2, and 1 bales placed in bottom, middle, and top rows) covered with plastic sheet were 78% for energy and 75% for CP. Field losses in making hay from the first cut of alfalfa (mid bloom) equaled 40% of dry matter (DM) yield, and therefore feed value of alfalfa hay relative to FS was only 44 and 37% for energy and CP, respectively. Moreover, quality of hay was very poor because of excessive loss of leaves.

For FS, WS, and hay, the values for total digestible nutrient (TDN) as a percentage of DM were 67.1, 60.7, and 54.6, respectively; the levels of CP expressed as a percentage of DM were 20.6, 18.4, and 14.4, respectively; the amounts of acid detergent fiber (ADF) as a percentage of DM were 37.2, 36.5, and 42.5, respectively. The heat-damaged CP was 10.7, 12.5, and 19.9% of total CP for each forage.

Second-cut alfalfa hay after 7 wk regrowth was harvested at 80% DM and stored in LRB in three ways: inside a hay barn (*A*); outdoors in a single row of uncovered bales (*B*); or outdoors in a pyramid form, covered with plastic (*C*) as described above for first-cut hay. All hay had been field dried for 2 days and was of good quality. After 1–5 mo of storage, recoveries of DM, energy, and CP for hay *C* were 81, 82, and 83%, respectively.

After 6 mo (August–February) of outdoor storage, bales of hays *B* and *C* were moved inside the barn and used after an additional 4–6 mo of storage. During 10–12 mo of all-indoor storage, hay *A* increased in DM from 80 to 86%. This resulted in shrinkage of 6% of stored DM, and another 3% was discarded because of mold spoilage. Corresponding losses from weathering and mold growth were 40 and 30% of DM for hays *B* and *C*, respectively.

The quality of consumable portions of hays *A, B,* and *C* was very similar. However, length of outdoor storage adversely affected the quality of hay. Hay *C* was sampled during 2–5 mo of storage and again during 10–12 mo of storage. During this time, DM recovery decreased from 81 to 70%; CP content decreased from 17.7 to 16.8%; ADF increased from 36 to 43%; and TDN decreased from 61 to 50%.

### Calf experiments utilizing clot-prevention treatment

To test the importance of the abomasal clot for good calf performance, calves were fed for 6 wk on whole milk or milk replacer with or without pretreatment with pancreatin to prevent clotting. Clot prevention resulted in a 23% decrease in weight gains, a reduction in feed efficiency, and lower digestibility of DM, nitrogen, and lipid. Measurement of the levels of essential amino acids in the blood showed that clotting resulted in slower absorption of amino acids owing to slower digestion of casein in the stomach. This slower digestion is useful for the young calf because it does not have a well developed proteolytic system in the gastrointestinal tract at this young age. It is apparent that when cheaper, lower quality protein sources are combined with skim-milk powder in milk replacers, clotting may not be useful unless the cheaper protein source is

occluded in the clot derived from the casein in the skim milk. Otherwise the excess of essential amino acids in casein, required to supplement the poor-quality protein, will be released from the clot too late to enable the amino acids in the poor-quality protein to be effectively used for protein synthesis.

**Improving the biological value of blood and soybean proteins for calves by incorporating limiting essential amino acids by the plastein reaction**

Calves fed soy protein supplemented with methionine and lysine either in the free or plastein-complexed form gained significantly more than those fed unsupplemented soy. The gains and feed efficiencies were higher but not significantly higher for the plastein group than for the free amino acids. For blood proteins, calves fed methionine and isoleucine, either as the free amino acids or plastein-complexed, gained better and showed improved feed efficiency over the untreated blood controls, but the differences between all three treaments were not significant at the 5% level. Apparent digestibilities of DM, protein, and fat were over 90% and were similar for all the soy and blood treatments.

The results indicate that when the soy or blood proteins were fed to calves, any more rapid movement down the gastrointestinal tract of the free amino acids than of the proteins or plasteins did not markedly reduce utilization of the free amino acids for protein synthesis—as shown by increased calf growth when the free amino acids were fed. It appears that manufacturers of milk replacers could effectively upgrade inexpensive proteins by supplementation with the limiting amino acids in the free form.

**Protection of feed protein against rumen degradation**

In a 4 × 4 Latin square experiment with four rumen-fistulated cows, each was fed four diets consisting of 60% corn silage and 40% concentrate, containing either formaldehyde-treated or untreated soybean meal. Each diet was fed for 2 wk, with rumen fluid samples collected hourly on 3 days during the 2nd wk. Rate of ammonia formation in the rumen was taken as a measure of in vivo degradation. Increasing the level of formaldehyde treatment led to a steady decrease in the rate and amount of ammonia formation. These rates correlated well with in vitro rates of protein degradation measured with rumen protease. A reduction in the rate of degradation of about 50% could be obtained with treatment of 0.3% (wt/wt) of formaldehyde. At this level of treatment, rumen microbial protein was not affected, but at higher levels microbial protein was reduced.

It was concluded that the 0.3% treatment of soybean meal would give a feed protein with good by-pass properties while supporting optimal microbial growth in the rumen.

**Rumen fermentation**

The artificial rumen was used to study the effect of pH on fermentation by mixed rumen cultures that were fed a typical dairy cattle ration. When rumen microbial cultures were maintained below pH 6, the concentration of ammonia decreased to very low (0.2 m*M*) levels and was accompanied by both decreased free amino acid concentrations and by less protease and deaminase activity of washed bacterial cells. Proteolytic microorganisms in concentrations of 0.5–1.0 × $10^8$ cells per millilitre were present in cultures maintained at pH 6 or above, but at pH 5.5 and lower their presence could not be detected (i.e., less than $10^4$ cells per millilitre). Similarly, microorganisms that possessed cellulolytic activity were present in appreciable numbers (i.e., 0.5–0.9 × $10^8$ cells per millilitre) at pH 6 and above, but when pH was maintained at 5.5 or below, the cellulolytic microorganisms were also no longer present. Thus these two very important classes of rumen microbes appear to be extremely sensitive to pH. Under practical feeding conditions where rumen pH is decreased, such as when feeding high-concentrate diets, their numbers in the rumen may be extremely low.

**Rumen bacterial cellulases**

Cellulase can hydrolytically cleave the $\beta$-(1 → 4)-glycoside linkages between glucose molecules in cellulose, resulting in the liberation of glucose fragments of variable size. The cellulases from *Bacteroides succinogenes* and *Ruminococcus flavefaciens*, two of the major cellulolytic bacteria in the rumen, have been isolated and partly purified for use in studies of their properties. The cellulases are extracellular, and conditions for maximum recovery from culture fluid have been established. The partly purified enzyme yields mainly cellobiose as the end product of cellulose

degradation, with the precise proportions of products dependent upon the species of bacteria.

### Biotechnology in rumen bacteria

The techniques of biotechnology are being applied to rumen bacteria of lactating dairy cattle to reduce the requirements for dietary protein. Protein produced by rumen bacteria normally meets the major part of the cow's protein requirement. By using genetic engineering techniques to increase the levels of the most limiting amino acids in bacterial protein required by the cow, the efficiency of bacterial protein utilization will be increased and dietary protein requirements will correspondingly be decreased. A synthetic DNA sequence that specifies a polypeptide of the most limiting amino acids, which are methionine, lysine, and threonine, has been cloned in *Escherichia coli*, and a plasmid vector capable of maintaining this new genetic material in the rumen bacterium *Butyrivibrio fibrisolvens* is being developed.

## SWINE PRODUCTION

### Vomitoxin and swine production

Four experiments with 142 growing pigs and one with 24 pregnant gilts have been conducted to determine the effects of vomitoxin-contaminated wheat on growth rate, feed intake, establishment of pregnancy, and fetal development. These results are reported in the section entitled "Animal feed safety and nutrition."

### Behavior and welfare of pigs

Death of piglets through inadequate early nutrition is an important drain on the pig industry, and poor nursing and suckling behavior has been identified as a major cause. Research is assessing how litter size, farrowing crate design, and other aspects of sow management influence suckling behavior, colostrum intake, and subsequent piglet growth and survival. A sow milking machine has been developed to determine the relationship between teat quality and piglet performance.

To allow liquid-manure handling and to reduce costs, many pig producers have eliminated the use of bedding. This has become one of the major controversies in the welfare of intensively housed pigs. Research is in progress to assess the specific benefits of bedding, such as improving floor comfort, providing an outlet for exploratory activities, and serving as a source of extra dietary fiber. Future work will identify how the significant benefits can be successfully incorporated into intensive production systems.

### Carcass evaluation

In Canada, the grade given a hog carcass is a function of back-fat thickness and carcass weight. At present, the fat at the point of maximum thickness at the loin, as determined by ruler measurement, is used for indexing carcasses. In order to streamline the grading process, electronic probing equipment is being considered. The Hennessy grading probe and the Fat-O-Meater probe were evaluated for their ability to predict percentage of lean product in the carcass. Preliminary results indicate that both instruments are of equal value for that purpose.

## POULTRY BREEDING

### Selection and flock management studies in egg-laying chickens

Six long-term-selected Leghorn strains and their 30 crosses were induced to molt and tested in a second cycle of egg production. Additive and nonadditive genetic effects significantly contributed to strain–cross performance for an array of economic traits in the second cycle of egg production, and first- and second-cycle performance were highly related.

In 252 days of the second cycle, selection (additive genetic effects) improved performance of the crossbred hens by 14 eggs per hen housed; 7 days earlier for the onset of second-cycle egg production; 2% higher viability; 1.8 g larger eggs; and 250 g less feed consumed per kilogram of eggs produced. Nonadditive genetic effects (heterosis) in crosses of unrelated strains improved performance by 15 eggs per hen housed; 3 days earlier onset of production; 5% higher viability; 1.3 g larger eggs; and 260 g less feed per kilogram of eggs. For related strains, heterosis was also substantial although smaller.

Mean differences between reciprocal crosses were large for second-cycle production, emphasizing the importance of genes on

the large sex chromosome for extended performance. Between unrelated strains, reciprocal differences averaged 10 eggs per hen housed; 3 days in onset of production; 4% in viability; 1.9 g in egg size; and 120 g feed consumed per kilogram of eggs laid. The differences between related strains were similar in size.

Inbred lines selected for Marek's disease resistance and high egg production, which were originally derived from the long-term-selected strains described above, were used to reconstitute the original strains. The "resistance-selected" strains were compared with three of the long-term conventionally selected strains. Mortality caused by Marek's disease was very low in the test, probably because of low exposure or low virus pathogenicity. The conventionally selected strains and crosses laid 261 eggs, with an average weight of 58.6 g, whereas the resistance-selected strains and crosses laid 250 eggs that averaged 59.4 g. Heterosis improved performance by 17 and 25 eggs in a full year, and 1.6 and 0.8 g in egg weight for the conventionally selected and the resistance-selected strains, respectively. The corresponding reciprocal differences averaged 10 and 12 eggs, and 1.9 and 1.3 g in egg weight.

Egg production and production of spermatozoa are under similar genetic control. Potential use of spermatozoa production to select males for high egg production was investigated in cooperation with McGill University, Montreal. Preliminary results indicated higher sperm production per ejaculate in strains selected for high egg production compared with unselected control strains, $6.2 \times 10^{-2}$ versus $5.3 \times 10^{-2}$ g, respectively.

Effects of aging on genetic and environmetal variation were studied in cooperation with the University of Agricultural Sciences, Uppsala, Sweden. Both genetic and environmental variance in Leghorn chickens increased with age. The increase was more rapid for the environmental than for genetic variation, and thus heritability generally decreased with increasing age.

The effects of red light versus white light during rearing were evaluated. Birds reared under white lights laid three more eggs owing to a slight (1%) improvement in viability and rate of lay. Differences for all other economic traits were negligible. In a separate study, the effects of group cage versus floor pen rearing were compared. Birds reared in floor pens had 0.5 g larger eggs and 40 g greater body weight than those reared in group cages.

**Genetics of poultry meat production**

Data from sire and dam populations synthesized from commercial stocks of broiler parents were used to estimate genetic parameters. There were no genetic antagonisms that would interfere with selecting for increased gain and improved feed efficiency from 28 to 49 days of age or for lower abdominal fat at 50 days of age.

Simple phenotypic correlations indicated that feed efficiency was correlated positively with weight gain and negatively with carcass fatness. Feed efficiency was essentially uncorrelated with feed consumption and body weight at the start of test. Partial correlations, which included corrections for differences in additional variables, revealed the following: a larger negative correlation between feed efficiency and carcass fatness after correction for weight gain (–0.62 versus –0.48); a larger positive correlation between carcass fatness and feed consumption after correction for gain (0.63 versus 0.40); a positive correlation between feed consumption and feed efficiency after correction for carcass fatness (0.24 versus 0.0); and negative correlation between feed efficiency and body weight at the start of test after correction for gain (–0.26 versus 0.01). Hence, it is important to adjust results of "age constant" feed efficiency tests for differences in broiler weight at the start of test.

In a separate study, the genetic correlation between feed efficiency from 28 to 49 days and body weight at 49 days was positive (0.46) but that with abdominal fat was negative (–0.62 for fat weight and –0.68 for fat percentage). Hence the prospects for genetic improvement of both feed efficiency and carcass leanness in conjunction with greater broiler weight appear good.

In studies on techniques to determine body fatness in live animals, correlations between abdominal wall thickness (including "leaf fat") and abdominal fatness were larger when broilers were restrained on a ramp during measurement (0.56 versus 0.44). Adenosine triphosphatase of red blood cells was not a good predictor of broiler abdominal fatness. Lipase, an enzyme that breaks down lipid, was found in higher concentrations in the fat of males than in the fat of females. Males have generally less fat than females.

**Disease resistance genetics**

Studies on lymphoid leukosis virus (LLV), a lymphoproliferative egg-transmitted disease of chickens, continued in cooperation with the Animal Disease Research Institute (ADRI) of Agriculture Canada. Eradication of the exogenous virus from ARC stocks housed in a filtered-air positive-pressure facility was completed. This allowed a preliminary assessment of the frequency of endogenous virus production and infection among the birds. Such a virus is produced from DNA that is part of the bird's genome, and strains of chickens were found to differ in both frequency and titer of an antigen-associated LLV.

ARC scientists cooperated with ADRI researchers, who developed a procedure for detecting the group-specific antigen of LLV in feather pulp. The test should be of value in the effort to eradicate LLV from poultry populations.

The effects associated with LLV infection were further studied in cooperation with ADRI and the U.S. Department of Agriculture (USDA) in laying hens reared in group cages or in floor pens. The level of positively infected hens was similar for strain crosses and for control strains, 17.2 and 20.8%, respectively. The effects of subclinical LLV infection were large, for example 25 eggs per hen housed and 16 eggs per surviving hen. The frequency of LLV shedders was 16.3% for hens reared in group cages and 15.3% for those reared in floor pens. Thus, method of rearing did not affect frequency of shedders. The proportion of congenitally infected shedders was 64% in the control strains and 37% in the crosses. The effects associated with congenital LLV infection were larger than those associated with horizontal LLV infection, for example five fewer eggs from 386 to 497 days, 5 days later sexual maturity, and 1.3 g smaller eggs at 240 days.

Green muscle disease is a degenerative disease known to affect only a deep-lying breast muscle in meat-type chickens and turkeys. Its location has required the development of indirect methods of identification in the live animal. Blood levels of the enzyme creatine kinase were significantly different between susceptible and resistant birds following wing exercise. In meat-type chickens enzyme levels peaked at 10–12 h postexercise in resistant males and females, and after 1 day in susceptible birds. The best time to collect blood for the most efficient separation of susceptible and resistant birds was 2–3 days postexercise. Enzyme levels in turkey females peaked at 1–2 days postexercise, and best differentiation of susceptible birds from resistant ones was at 3–4 days postexercise.

**Eggshell quality**

Vitamin $D_3$ deficiency in laying flocks causes reduced shell quality. An explanation was sought by examining adenosine triphosphatase (ATPase), an enzyme implicated in calcium transport. In vitamin $D_3$-deficient hens, low shell quality and low plasma calcium levels were accompanied by low activity of jejunal ATPase.

The relationship between prepubertal levels of the plasma sex hormone estradiol and shell quality was studied in two ARC Leghorn strains selected for high egg production and related economic traits, including shell quality. Strain 1, which had better shell quality than Strain 4, also had higher estradiol levels. Injection of labeled estradiol into mature hens revealed that its half-life was about 10 min and its main metabolite was estradiol-3-sulfate.

Repeatability of shell quality was assessed using measurements of specific gravity, nondestructive deformation, quasistatic compression force to fracture, shell weight, and shell thickness. Coefficients of correlation between eggs laid 1 day apart for these measurements were 0.67, 0.35, 0.50, 0.82, and 0.54, respectively, and decreased relatively little for eggs laid 55 days apart. Age and strain of bird did not have a large influence on repeatability of specific gravity, shell weight, and shell thickness but did influence nondestructive deformation and quasistatic compression force to fracture.

**Geese**

The egg production of 2-yr-old Chinese and Synthetic (Chinese × Pilgrim × Hungarian) strains of geese was compared under two light regimens. Geese were housed in windowless barns in January under 7 h of light and 17 h of darkness (7L:17D). Fifteen days later, half the geese of each strain were subjected to 10L:14D per day. The other half had light increases of 15 min/day from 7 h to 11 h and then 15 min/wk until a level of 13 h of light (13L:11D) was attained. During 24 wk, survivor egg production for the Chinese strain was 47 and 40 eggs under the 10L:14D and 13L:11D regimens, respectively, whereas the

Synthetic strain laid 36 and 24 eggs. In addition to laying fewer eggs, geese under the 13L:11D regimen came into and went out of production sooner than birds under the 10L:14D regimen.

## POULTRY NUTRITION

### Diet and sexual maturity of broiler–breeder hens

Growth of reproductive organs and the liver during the 3–4 wk period before the start of lay is important to the development of egg-producing ability in pullets. A prelayer diet for broiler–breeder pullets that provided a high protein level (180 g/kg), to promote reproductive organ and liver growth at this time, increased production of hatching eggs by eight eggs to 400 days during the subsequent laying period compared with a regular prelayer diet that contained protein at 150 g/kg. Peak production level was maintained longer, but the diet had no effect on age at sexual maturity, initial level of egg production, or egg weight. Additional income after subtracting the extra cost of high-protein diet was 68 cents per bird.

### Force molting of broiler–breeder hens

Induction of molt to allow a second or subsequent laying period can reduce the cost of hatching-egg production. Exploration of molting procedures with a commercial strain of broiler–breeder hens that were 400 days of age showed that the diet for the molting period should be adjusted according to the initial body weight of hens. When heavier hens were given a longer period of submaintenance ration (17 or 21 days versus 13 days), increased egg production of 9.2 or 2.1 eggs, respectively, was obtained in 140 days. Higher production was associated with shorter time to return to lay. There was no consistent effect on egg weight.

### Measurement of metabolizable energy

The time required for the indigestible residues of a single meal to pass through the alimentary canal of a previously fasted bird is proportional to the amount of indigestible material ingested. In the bioassay for true metabolizable energy (TME), the excreta-collection period must be sufficient for clearance of indigestible residues. Experiments with adult cockerels showed that an insufficient collection period causes the regression of excreta energy (FE + UE) on energy intake (IE) to deviate from linearity. When straight lines are fitted, the intercepts on the $Y$-axis, when $X$ is zero, differ among each other and are greater than estimates made with unfed birds.

During the TME bioassay, birds usually receive a submaintenance amount of dietary energy. Consequently, body tissues are catabolized to provide energy, and the by-products are excreted. The catabolism of protein leads to the excretion of energy-containing nitrogenous compounds. The amounts of such compounds vary among birds on the same treatment and among treatments. Energy- and nitrogen-balance experiments showed that the variation is controlled by correcting FE + UE to zero nitrogen balance. The correction, which is highly recommended, reduced error mean squares by 40–75%.

Modifications of the TME bioassay were developed that reduce the severity of the fast by provision of supplementary dietary energy. Most modifications, however, are associated with a decrease in precision. The preferred modification involves feeding each test material at two or more levels, for example 20 and 40 g per bird.

The TME value of hull-less barley was found to be similar to that of normal barley, despite a lower fiber content. White fragments of apparently undigested endosperm were found in excreta from cockerels fed hull-less barley. In a subsequent experiment, fine grinding of hull-less barley failed to increase its TME value.

A comprehensive review describing the evolution of methods to estimate the bioavailable energy content of feedingstuffs was prepared (Sibbald 1982). Many assays are described, and variables affecting the data they produce are discussed.

### Vomitoxin and poultry production

The effects on laying hens and on White Leghorn and broiler chicks of diets containing vomitoxin (deoxynivalenol) levels up to approximately 5 mg/kg are reported in the section entitled "Animal feed safety and nutrition."

## SHEEP PRODUCTION

### Development of specialized synthetic sire and dam strains

The establishment and repopulation of a minimum-disease flock comprising a synthetic sire strain, two synthetic dam strains, and three control strains from progeny derived by hysterectomy during August–September 1980 proceeded on schedule. Matings of hysterectomy-derived animals were carried out in September 1981 and May 1982, and a third will be carried out in January 1983. Ewe lambs (7 mo of age) produced from September 1981 matings were bred in September 1982. All matings were designed to reestablish the original genetic base of the synthetic and control strains and to maximize fertility. The required number of breeding ewes and rams for the synthetic and control strains will be reached by May 1983. Subsequently, comprehensive selection will be applied to improve growth and reproductive rates in the dam strains and to increase lean muscle yield and reproductive rate in the sire strain.

During the repopulation, body measurements of growing rams and ewes and measurements of testis size and reproductive behavior traits of ram lambs were made. The data are being used to establish a phenotypic standard for evaluation of conformation characteristics among strains and to develop a fertility index for ram lambs to improve the reproductive rate of their offspring.

### Intensive rearing of lambs

The weaning weights and average daily gains were significantly depressed (7.6 and 18.0%, respectively) when lambs were fed milk replacer (MR) from birth to 21 days of age that contained 12% rapeseed oil and 12% tallow compared with those that were fed a standard MR that contained 12% coconut oil and 12% tallow. Lamb survival and MR dry-matter consumption were similar in the two groups. The results indicate that rapeseed oil adversely affects lamb performance and cannot be considered as an economical substitute for coconut oil in MR formulations.

### Copper (Cu) toxicity

An outbreak of Cu toxicity occurred in the hysterectomy-derived sheep flock during the summer of 1981. Diagnosis was based on postmortem findings, clinical pathology, and highly elevated levels of Cu in the liver. Deaths were caused by hemolytic crises resulting in fatal jaundice. The cause of the condition was traced to a mineral supplement that contained excessive levels of Cu. The supplement was removed from the diet, and the flock was treated for 10 wk with a "medicated" premix added to the feed, which provided 0.1 g of ammonium molybdate and 2 g of sodium sulfate per sheep daily. Within 4–6 days of the start of the treatment, mortality related to Cu toxicity had declined by 80% and ceased after approximately 5 wk. Subsequently, liver Cu levels in sheep diagnosed as dying from causes other than Cu toxicity were within the normal range, indicating the effectiveness of the treatment.

### Reproductive physiology

*Control of the estrous cycle and ovulation.* The characteristics of the induced preovulatory luteinizing hormone (LH) release were studied in ewes after induction of a synchronized estrus with intravaginal sponge pessaries that contained 40 mg Fluorogestone Acetate (FGA) (17$\alpha$-acetoxy-9$\alpha$-fluoro-11$\beta$-hydroxy-pregn-4-ene-3,20-dione; SC 9880; G.D. Searle) or with subcutaneous ear implants containing Norgestomet (17$\alpha$-acetoxy-11$\beta$-methyl-19-nor-pregn-4-ene-3,20-dione; SC 21009; G.D. Searle) and projected to deliver Norgestomet at 35–100 $\mu$g daily. The duration of pituitary LH release and an estimate of the total LH discharged were similar between treatment groups. The onset of LH release occurred approximately 8 h earlier in ewes treated with implants. The use of 500 IU of pregnant mares' serum gonadotropin (PMSG), injected intramuscularly at the time of sponge or implant removal, shortened the mean interval to the onset of LH release from 41 to 28 h and doubled the total LH discharged, compared with treatments using sponges or implants without PMSG.

Duration of luteal function and length of the estrous cycle were determined in groups of ewes treated with Norgestomet-containing subcutaneous ear implants for 12 or 14 days, beginning 2, 9, or 16 days after induction of a synchronized estrus with intravaginal sponge pessaries that contained 40 mg of FGA. The ewes received 500 IU PMSG intramuscularly at the time of removal of sponges and implants. Based on plasma progesterone profiles, implant treatments beginning 9 or 16 days after FGA-sponge-induced estrus had no

effect on duration of luteal activity but suppressed the onset of a new estrous cycle for the duration of treatment. Similarly, if implant treatment was initiated 2 days after FGA-sponge-induced estrus, luteal function was of normal duration and a new estrous cycle was initiated 3–5 days after implant removal. In contrast, a 12- or 14-day treatment with FGA-impregnated intravaginal sponges beginning 2 days after an FGA-sponge-induced estrus shortened the duration of the luteal phase, and a new cycle was initiated within 48 h after sponge removal. These results indicate that Norgestomet-containing implants are unable to cause premature regression of the corpus luteum but will suppress the onset of a new estrous cycle for the duration of treatment when treatments are applied at the middle or the end of the estrous cycle.

Studies on the role of ovarian steroids in the regulation of the growth and maturation of preovulatory follicles continued, using the prepubertal gilt treated with hormones to induce follicular growth and ovulation as an experimental model. A method to obtain high yields of structurally and metabolically intact dispersed theca interna (TI) cells was developed. TI tissue was dispersed by incubation at 37°C with a mixture containing 0.5% collagenase, 0.1% hyaluronidase, 0.1% pronase, and 1% chicken serum in a Ca- and Mg-free balanced salt solution. A study of the changing patterns of steroid production by dispersed granulosa and TI cells from maturing follicles showed that both cell types contribute to follicular estrogen production. TI cells were the predominant source of follicular androgen, and an inverse relationship existed between estrogen and progesterone production by both cell types as the time of ovulation approached.

*Artificial insemination.* The cryosurvival of ram spermatozoa, as determined by percentage of motility and rate of forward progression, was similar after freezing and thawing in diluents that contained an egg yolk–skim milk base or a dextran–sugar base. However, moderately hypertonic diluents (600 mOs/kg), regardless of composition, produced higher cryosurvival of spermatozoa than isotonic diluents (330 mOs/kg).

Further studies on the penetration of fresh ram spermatozoa into bovine cervical mucus have shown that the number of spermatozoa that penetrate the mucus and the distance traveled per unit time are closely related to spermatozoa motility. Studies are continuing to standardize these relationships to provide an objective assessment of the potential fertilizing capability of ram semen samples.

## ANIMAL FEED SAFETY AND NUTRITION

### Mycotoxins

Mold contamination of grain crops is of concern to Canadian livestock and poultry industries because the presence of molds and their toxic metabolites, known as mycotoxins, poses a serious threat to animal health and productivity. Mold spores, which are widely distributed in nature, infect growing plants and grain during and after harvest. Under suitable environmental conditions, these spores may start to grow. Some molds may only reduce the nutritive value and palatability of feeds, whereas others, which may appear harmless, produce mycotoxins during their growing cycle. When these toxins are present in feedstuffs, farm animals may refuse to eat infected feeds or if they do eat them, they may become ill.

Two mycotoxins of concern are vomitoxin (deoxynivalenol) and zearalenone, produced by *Fusarium* mold that infects plant material. When vomitoxin was detected in wheat in Eastern Canada, a major research effort at ARC was initiated to study its effects on livestock and poultry. This is a part of a multidisciplinary Research Branch approach to the mycotoxin problem, which involves the collaboration of several Agriculture Canada and Health and Welfare Canada establishments. Samples of contaminated Quebec spring wheat that contained vomitoxin up to 7 mg/kg were acquired from several sources. Earlier feeding trials with lower dietary levels of vomitoxin ($<1$ mg/kg) were repeated and extended with swine, poultry, and dairy cattle.

In pigs, some feed refusal and decreased weight gains were observed; however, there was no evidence of vomiting, complete feed refusal, or hemorrhaging. Necropsies revealed no toxic damage to internal organs. No teratogenetic effects were observed when dietary levels of vomitoxin up to 3.5 mg/kg were fed to pregnant gilts during the first 52 days of embryonic development.

Preliminary results of a 24-wk experiment with laying hens indicated that dietary vomitoxin levels of up to 5 mg/kg had little effect on feed intake and efficiency, egg production, mortality, fertility, and hatchability of fertile eggs, as well as on egg and shell quality. White Leghorn chicks given starter diets that contained vomitoxin up to approximately 5 mg/kg tended to consume more feed and grow faster than birds that received a control diet that contained no vomitoxin. The feed-to-gain ratio, however, was similar for chicks that received the experimental and control diets from 7 to 35 days of age.

Vomitoxin levels up to 5.5 mg/kg in starter and finisher diets for broilers had no significant effect on feed intake, growth, and feed-to-gain ratio between 7 and 52 days of age or on chilled carcass and dressing percentage at 52 days. In the experiments with laying hens and White Leghorn and broiler chicks, there was no evidence of feed refusal, vomiting, or toxic damage to internal organs at necropsy.

## Pesticides

*Fenvalerate.* Studies on the metabolism and excretion of fenvalerate continued, with emphasis on detection methodology. Excreta from laying hens fed fenvalerate were extracted with hexane followed by methanol. These extracts were analyzed by a combination of thin-layer high-performance liquid and gas chromatographic techniques. Hexane extracts consisted mainly of unchanged fenvalerate, which amounted to 6.8–10.5% of the total amount consumed, 12.2–18.6% of 2-(4-chlorophenyl)isovaleric acid (C1-Vacid), and 4.3–7.2% of 3-phenoxybenzoic acid (3-PBA). Small amounts of glucuronides of C1-Vacid were also found in the hexane extracts. Methanol extracts did not contain unchanged fenvalerate, C1-Vacid, or 3-PBA. Hydrolysis of the methanol extracts with 6 *N* HCl or $\beta$-glucuronidase produced 35–57% of C1-Vacid and traces of PBA. C1-Vacid and 3-PBA were positively identified by comparing the gas chromatographic properties of their methyl or 2-chloroethyl esters with esters of these two acids. Gas chromatographic–mass spectrometer analyses were also performed.

In vitro studies that used laying hen and cow liver homogenates identified the metabolites produced in this organ. Fenvalerate was degraded very slowly (10% in 2 h) and the main pathway was the hydrolytic cleavage of the ester bond.

*Cypermethrin and deltamethrin.* A gas-chromatographic method was developed for detection and quantification of deltamethrin (decamethrin) and cypermethrin in milk, urine, feces, fat, kidney, and liver. The method involves extraction with acetonitrile followed by clean-up on a microcolumn using a benzene–hexane (1:1) solvent system. The method has been successfully employed for identification of deltamethrin in extracts from an in vitro study.

Studies of deltamethrin with various enzyme fractions of chicken and cow liver showed that approximately 27% was metabolized in 2 h. The major metabolic pathway was found to be the enzymatic hydrolysis of the ester bond. The hydrolyzing enzymes were largely located in the microsomal fraction. The primary and the secondary metabolites were identified by gas chromatography and gas chromatography–mass spectroscopy after derivatization where necessary. Further studies are planned to record the absorption, distribution, and excretion of deltamethrin in laying hens.

## Fats and oils

For the past 10 yr, scientists at Agriculture Canada have been studying a number of vegetable oils, specifically low erucic acid rapeseed (LEAR) oil, and their nutritional, biochemical, and pathological effects in experimental animals. The results indicated that the nutritional value of these vegetable oils was similar, and no specific alterations in biochemical parameters were observed in several animal species. On the other hand, male albino rats showed a unique pathological response of myocardial lesions to dietary fat. This was related to specific dietary fatty acids and demonstrated experimentally.

Members of the ARC research team, together with experts in other disciplines in rapeseed oil research, have now completed a comprehensive book on all aspects of rapeseed oil. Seven chapters were contributed by ARC scientists. To be published by Academic Press, NY, the text summarizes current knowledge regarding the development of rapeseed varieties and the processing of rapeseed, and provides a critical evaluation of all nutritional, biochemical, and pathological experiments conducted on rapeseed oil during the past 20 yr.

A study was completed to test the nutritional adequacy of the basal diet used in previous feeding trials with rats. It was concluded that the high fat diets used in the past 10 yr by most researchers appear to be inadequate in the level of methionine, because supplementation with this amino acid resulted in improved growth. However, supplementation of methionine or choline did not affect the incidence of myocardial lesions. Therefore, the fat component in the diet still remains as the major factor related to heart lesions in rats.

A novel thin-layer chromatographic technique has been developed to analyze complete complex lipid mixtures. The method involves developing the chromatographic plates in three directions and results in good separation of all lipid subclasses. The precision and advantages of this new technique are being evaluated and compared with established chemical and gas-chromatographic methods.

An experiment compared the nutritional and chemical changes produced in rats that were fed diets that contained various levels and types of fat. The diets were characteristically low in essential fatty acids and varied in the content of saturates and monosaturates. Preliminary results indicate that growth was dependent on the level but not the type of fat in the diet. Analyses of tissue lipids are in progress to assess the nutritional state of the animals and interactions of dietary fatty acids.

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# INTRODUCTION

This report summarizes highlights of research carried out during 1982 at the London Research Centre in support of departmental objectives in environmental quality and crop protection. The Centre was established in 1951 to investigate the problems created by the introduction of synthetic organic pesticides. Present research programs reflect the current health and environmental concerns regarding the agricultural use of pesticides by concentrating research efforts in integrated pest management (IPM) and environmental toxicology.

The IPM objective comprises four research activities. The pest management activity is aimed at developing IPM procedures, including biological control, for agriculturally and economically important insect pests. Research on stored products is directed toward the investigation of environmental and insect resistance problems and the development of more efficient fumigation procedures leading to a minimum of pesticide residues. The third activity concerns research on alternative pest control strategies. Studies on insects are aimed at identifying specific areas for attack so that pest control in the future will not rely upon the use of broad-spectrum toxicants. Research on natural plant defense mechanisms in disease-resistant and susceptible agriculturally important crops has the objective of using natural defense mechanisms by chemical manipulation or in the breeding of resistant varieties. The last activity under the IPM objective concerns research on systemic fungicides. Studies are carried out on the efficacy of systemic fungicides and on the plant pathological, biochemical, biophysical, and structural parameters of fungicide activity and resistance.

Research on environmental toxicology has three areas of activity. The first deals with the effect of pesticides on nontarget soil invertebrates and agriculturally important soil microorganisms. The second is concerned with the determination of the behavior, persistence, and environmental fate of pesticides and their movement through the environment. The third is concerned with establishing the mode of action of growth regulators and toxicants by carrying out studies on insects and plants related to vital processes of growth and development.

This report records only the highlights of our accomplishments for 1982; more detailed information can be obtained from the publication titles listed at the end of this report. Copies of this report, reprints of publications, and further information are available on request from the Research Centre, Agriculture Canada, University Sub Post Office, London, Ont. N6A 5B7.

H. V. Morley
Director

# INTEGRATED PEST MANAGEMENT

## Pest management

*Integrated control of the onion maggot.* Progress was made on the feasibility studies aimed at incorporating biological control into an integrated control program. Laboratory research identified the conditions required for the induction of diapause in the brachonid wasp, *Aphaereta pallipes*. Emergence of vigorous adults following long-term storage of infested onion maggot pupae should now be possible. The importance of soil type and compaction on the escape of *A. pallipes* adults from buried host pupae was also demonstrated. Ten centimetres of loose muck proved no barrier to adult wasp emergence, whereas more than 1 cm of brick sand effectively prevented emergence. Over 1 million parasitic wasps (*A. pallipes*) and 15 000 parasitic beetles (*Aleochara bilineata*) were released to examine their potential for control of the onion maggot. These two were selected as having the greatest potential importance in control of the onion maggot from the nine species of insects positively identified as parasites of the onion maggot. Analysis of the total arthropod predator complex associated with the onion maggot was expanded to 82 species, the bulk of which is made up of 46 staphylinids, 21 carabids, and 8 acarines.

Onion damage counts taken throughout the summer in experimental field plots and adjacent grower fields established that in 1982 first-generation onion maggot damage was far more important than second-generation damage. The most effective way of controlling this damage was with seed furrow application of chlorfenvinphos. Second-generation damage was significantly decreased by the release of *A. bilineata* or by foliar insecticide spraying. Rates of parasitism in the field were established by dispersing parasitized host pupae in onion fields. Examination of onion maggot pupae from beds of sliced onion initially seeded with onion maggot eggs showed that parasitism by *Aphaereta pallipes* increased from an average of 4.0% at control sites to 13.9% in the release blocks. At the end of September a parasitism rate of 40.9% was achieved, which emphasizes the potential importance of *A. pallipes* late in the season. *Aleochara bilineata* was also found parasitizing onion maggot pupae in release blocks at rates as high as 55%. Total parasitism owing to both parasites ranged from 32.3 to 62.9% and averaged 48.9%.

*Monitoring studies.* A comparison of seven monitoring techniques showed that yellow pan traps with or without allylisothiocyanate were the best tool for monitoring the cabbage maggot, *Delia radicum.*

The white cutworm moth, *Euxoa scandens* (Riley), is a sporadic pest of tobacco in Quebec and vegetable crops in light sandy soils. An efficient monitoring method utilizing the female sex pheromone would help in planning insecticide treatment. Results obtained using electroantennogram screening and field tests showed that the alcohol (*Z*)-7-dodecenol is a good attractant for male white cutworm moths and that this compound is probably the primary sex pheromone of the insect.

Flight interception traps impregnated with rapid "knock-down" pyrethroid insecticides were used to monitor flying insect activity at Thedford and resulted in exceptionally good records of Hymenoptera flight activity over an 18-wk period. Catches were proportional to temperature, with most Hymenoptera activity occurring from mid August to early October. Significantly low flight activity was observed in an area that had been sprayed with fonofos for control of adult onion maggots. Hemiedaphic Collembola activity was also enormously reduced in this fonofos-treated area. Comparable experiments on rutabagas clearly revealed Hymenoptera activity to be greatly concentrated to a narrow lamina stretching, in cross-section, from the soil surface to a height slightly above the crop.

*Resistance studies.* In studies on insecticide resistance, further base-line toxicity data were accumulated on carrot rust fly. Tests on cabbage maggot submitted from Newfoundland showed no evidence of resistance to fensulfothion. A comprehensive laboratory study indicated that the parathion-resistant onion maggot strain showed cross-resistance to chlorpyrifos, naled, and chlorfenvinphos. This strain is also resistant to DDT and thus showed low-level cross-resistance to pyrethroid insecticides. Even so, these materials were from 17 to 137 times as toxic as parathion to the organophosphorus-resistant onion maggot strain. Continued emphasis was placed on the problem of house-fly resistance to pyrethroid insecticides. Strains of susceptible and pyrethroid-resistant house flies were provided to Rothamsted Experimental Station, England, for genetic studies. In cooperation with Lethbridge Research Station, the susceptibility of both susceptible and resistant house-fly strains to the isomers of permethrin is being determined. In a continuing joint study with the University of Guelph, field studies confirmed previous laboratory studies, which indicated that development of house-fly resistance could be delayed by rotating insecticides with different modes of action. Tests on Colorado potato beetle strains from New Brunswick and several locations in Ontario indicated that all strains were still susceptible to organophosphorus, carbamate, and pyrethroid insecticides. A strain from Quebec that had previously been shown to be resistant to all recommended organochlorine, organophosphorus, and carbamate (except aldicarb) insecticides was shown to have developed resistance to the pyrethroid insecticides. One experimental insecticide was highly toxic to this resistant strain. A laboratory study on the inheritance of carbofuran resistance in the Colorado potato beetle was completed and showed that resistance is conferred by two loci that appear to segregate independently and are not sex linked.

*Toxicity studies.* Laboratory studies on the toxicity to *Aphaereta pallipes* and to the staphylinid beetle *Aleochera bilineata* of pesticides that are, or may be, used in onion

pest management programs were completed. None of the fungicides tested (anilazine, chlorothalonil, metalaxyl, captafol) was toxic to either parasite species. Of five herbicides tested (ioxynil, allidochlor, chlorpropham, cyanazine, niclofen) only ioxynil was toxic to *Aphaereta pallipes*; none was toxic to *Aleochera bilineata*. Parathion was the most toxic of 22 direct-contact insecticides to both parasite species; chlorfenvinphos was least toxic. Soil insecticide toxicity to the two species varied greatly, with some soil insecticides being very toxic in both mineral and organic soil; chlorfenvinphos was the least toxic of the soil insecticides tested. An insecticide-susceptible strain of *A. bilineata* was established, and subsequent comparative tests indicated that the Thedford strain is highly resistant to cyclodiene insecticides.

*Evaluation of pesticides.* Tests on 12 experimental insecticides begun in 1981 were completed. Most were effective broad-spectrum contact insecticides. A new pyrethroid insecticide showed excellent broad-spectrum activity, with high toxicity to cutworms being of special interest. Although several of the experimental insecticides showed potential against cabbage flea beetle, two insecticides showed excellent activity in soil and two others showed some potential.

Because of the increasing resistance shown by the onion and cabbage maggots to recommended insecticides, the effect of some chitin synthesis inhibitors (CSI) on their development was investigated. Because the CSIs have low mammalian toxicity and their unique mode of action with regard to chitin synthesis suggests a desired degree of specificity, they are obvious candidates for incorporation into IPM programs.

In laboratory studies, injection of female flies of the onion and cabbage maggots with CSIs (benzoylphenyl ureas) resulted in fewer offspring pupating. Direct contact toxicity, however, showed no significant toxicity to adults. Soil treatment at rates comparable to recommended soil insecticides significantly reduced pupation of onion maggots.

In greenhouse tests, drench applications of the CSIs to the soil reduced damage to onions or radishes infested with onion or cabbage maggot eggs, respectively.

In small-scale field trails, damage to onions was significantly less in CSI-treated plots infested with onion maggot eggs. Cabbage maggot damage was also less in CSI-treated rutabaga plots than in untreated plots. Residues of CSIs in treated crops were low, and soil residues were found to be moderately persistent under southern Ontario conditions.

*Crop loss studies.* Within the broad framework of IPM, there is an urgent need to obtain some hard data regarding crop losses by the total pest complex to serve as a base for decision making. With support from the Ontario Ministry of the Environment, London Research Centre has just completed a 2-yr study designed to obtain solid data on crop losses that would occur in the absence of adequate pest control programs. The three crops selected were potatoes, onions, and rutabagas. Briefly, results obtained indicate that the absence of adequate pest control measures, crop losses caused by insects, diseases, and weeds averaged 64%, 88.2%, and 100% for potatoes, rutabagas, and onions respectively. Based on the 1981 (estimated) farm value of these crops, this would represent losses of $29 960 960, $5 284 062, and $12 770 000, respectively. Such data help to justify the need to use pesticides and to spur efforts to develop effective IPM procedures.

*Analytical studies.* A commercial chiral phase high-performance liquid chromatography (HPLC) column was found to be capable of separating many of the pyrethroid isomers. Thus, it separated all the chiral isomers of fenpropanate and fenvalerate, three of the enantiomer pairs of the four cypermethrin diastereomers, and two of the enantiomer pairs of the four cyfluthrin diastereomers.

Concerns have been expressed regarding the stability of some formulations under alkaline conditions. Formulations of malathion, carbaryl, oxamyl, trichlorfon, diazinon, and chlorpyrifos were examined for base catalyzed, copper ion catalyzed, and copper ion plus amine catalyzed hydrolysis at "spray tank" concentrations. All except trichlorfon were stable for a least 24 h at pH 9. Dilution of these concentrations 10–100 times, however, resulted in significant hydrolysis.

**Stored products**

Collaborative work with the Engineering and Statistical Research Institute in Ottawa has shown that when adults of *Tribolium castaneum* (Herbst), the red flour beetle, were fumigated with mixtures of methyl bromide and phosphine for 5- or 10-h periods, the mortality was greater than if the fumigants acted independently. At low and middle range

response levels, the mixture is less potent than would be expected from additivity of doses. At higher response levels ($\geq$80%) the effect is close to and, in some cases, slightly in excess of additivity. This opens up the prospect of being able to combine and exploit the unique properties of each fumigant so as to conserve materials and to reduce residues.

**Alternative pest control strategies**

*Plant diseases.* An important finding was the demonstration that the interaction between race 4 of *Phytophthora megasperma glycinea* and the soybean cultivar Altona is temperature sensitive. Thus, by manipulating the incubation temperature the interaction can be expressed as resistant or susceptible. This has some important implications in the field and should provide an invaluable experimental tool for studying the fundamental basis of disease resistance.

Ongoing studies of the terpenoid toxin, coronatine, produced by the bacterial blight pathogen *Pseudomonas glycinea* (Png) continued. It was shown that coronatine production in Png cultures generally correlated with their ability to induce systemic symptoms in inoculated soybean plants. For the first time, evidence was obtained for coronatine presence in diseased plants. Although the results indicate that the toxin can play an important role in the development of symptoms of bacterial blight of soybean, it is probably not essential since some pathogenic strains do not produce the toxin.

Bacterial speck, a fruit and leaf spot disease of tomatoes, has been a growing concern in southern Ontario since the first major outbreak in 1978. The disease is caused by *Pseudomonas syringae* pv. *tomato* (Okabe) Alstatt, an oxidase-negative fluorescent pseudomonad. The majority of routine biochemical and physiological tests do not, however, conclusively distinguish this pathogen from other phytopathogenic fluorescent pseudomonads associated with tomato plants. An attempt was therefore made to investigate the possibility of using bacteriophage sensitivity tests supported by selected physiological tests to identify the bacterial speck pathogen.

Sixteen phages were isolated from tomato field soil and plant debris. Four of these phages were found to have a high degree of host specificity for *P. syringae* pv. *tomato.* In combination with select physiological tests (erythritol, D(−)-tartrate, DL-lactate utilization and pectate hydrolysis), phage-sensitive tests utilizing the four phages can be used to rapidly and accurately identify the bacterial speck pathogen.

Visual necrosis is the most conspicuous feature by which compatible and incompatible responses of soybean tissue to infection by *Phytophthora megasperma* f. sp. *glycinea* (Pmg) can be distinguished. In spite of this obvious characteristic, there have been no studies on why tissue turns brown in one instance and fails to do so in another. Browning in other plant systems has been closely associated with the enzyme polyphenoloxidase (PPO) and therefore the role of this enzyme in the resistant response was investigated.

The assay procedure developed to study enzyme activity involved replacing the zoospore inoculum drop on the hypocotyl surface with a drop of the substrate L-Dopa and measuring the formation of dopaquinone spectrophotometrically. Direct measurement of activity at the lesion site circumvented the problems associated with tissue extraction, such as inactivation as activation of the enzyme. Furthermore, it ensured that only the tissues involved in the host–parasite response were assayed.

Polyphenoloxidase (PPO) activity was demonstrated at incompatibly reacting sites 2–3 h following inoculation. No activity was detected at compatibly reacting sites, although these sites developed activity if subsequently reinoculated with an incompatible race. The results indicated that development of PPO activity is one of the earliest recognizable events in incompatible interactions and suggest that it is a consequence of cell damage that is induced by incompatible but not by compatible races.

The biosynthesis of sesquiterpene phytoalexins in inoculated potato tubers was investigated by the use of deuterated acetate as a simple precursor to indicate deuterium migration from one carbon to the next. This is a simpler, but similar, stratagem than that using mevalonic acid as a precursor, was devised for this purpose in this laboratory, and has been christened appropriately as the "beta-hop."

Utilizing the beta-hop technique, it was possible to demonstrate a hydride shift from C-5 to C-4 in the biosynthesis of rishitin and lubimin. The method is unambiguous, relatively economical in time and materials, and

should be widely applicable in biosynthetic and mechanistic studies in general.

Work was initiated on the experimental fungicide Dowco 444 [Pyroxyfur; 2-chloro-6-(2-furanylmethoxy)-4-(trichloromethyl) pyridine]. In preliminary experiments, no protection from disease was obtained in soybean seedlings inoculated at the hypocotyl with zoospores of Pmg when the fungicide was applied either as a soil drench at planting time or by direct immersion of the roots of seedlings up to 72 h prior to inoculation. When applied as a seed treatment, however, Dowco 444 provided effective protection but only for a relatively short period of time. In view of the very high activity of this compound against Oomycetes ($Ec_{90} \sim 1$–$2$ $\mu$g/mL) in vitro, a greater degree of protection would have been expected. Further studies on the systemicity of this compound will be carried out to determine why activity does not persist.

*Insect pests.* Research in this area is directed toward gaining an understanding of basic life processes peculiar to the insect so that methods of selective, specific control can be developed that do not rely upon pesticides that are broad-spectrum poisons.

Proctolin, first isolated and characterized in this laboratory, is being extensively investigated as a potential focus from the development of specific control agents in insects. It is widely distributed in insects and other arthropods, is active on a variety of insect muscles, and occurs throughout the cockroach central nervous system. Recent work in this laboratory has shown that proctolin cannot be transported via the hemolymph unless it is protected, perhaps by a carrier protein or as part of a larger molecule. Evidence has also been obtained for the existence of a diverse spectrum of biologically active neuropeptides and the preliminary characterization of an inhibitory neuropeptide that has been named neutrolin. This newly discovered inhibitory neuropeptide has been partly purified and appears to have a molecular weight of 1050–1150. Neutrolin inhibits hindgut contractions induced by proctolin, neural stimulation, glutamate, and 5-hydroxytryptamine.

Recent advances in neurobiology have led to a recognition of the importance of peptides as transmitters and neuromodulators in both vertebrates and invertebrates. One of the functions of proctolin is the induction of contraction in the hindgut of the cockroach *Periplaneta americana.* It has now been shown that contractions induced by both proctodeal nerve stimulation or bath application of proctolin are inhibited by micromolar levels of organophosphorus insecticides containing the thionophosphoryl group, but not by their oxygen analogues. A brief exposure to these insecticides can result in inhibition of proctolin contraction lasting many minutes.

Oxythioquinox, an insecticide belonging to the quinoxaline class, has been shown to have a potentiating effect on proctolin contractions that is consistent with its known phosphodiesterase inhibitor properties. Thus, a new site of insecticide action has been identified that, it is hoped, will function as a useful model system for the design and testing of pesticides that interfere with peptidergic transmission.

The main characteristics of the carrier-mediated transport of glucose in locust flight muscles have been established. The system is highly specific for D-glucose and is dependent on energy metabolism. A membrane transport system is therefore present, which is almost certainly important in muscle physiology.

Work continued on the study of chitinase activity during the larval and pupal stages of the housefly. A prerequisite for these experiments was the preparation of high specific activity radioactive chitin. This was achieved by acetylation of chitosan with tritiated acetic anhydride. Chitinase activity measurements at various stages revealed a peak at a specific pupal stage.

## ENVIRONMENTAL TOXICOLOGY

### Effects of pesticides on nontarget organisms

The relative toxicity of two formulated pyrethroid insecticides and 21 fungicides on *Rhizobium japonicum* and on four soybean pathogens, *Fusarium oxysporum, Phytophthora megasperma, Phytophthora parasitica,* and *Pythium ultimum,* was determined under laboratory conditions. The effect of these pesticides on the germination of soybean seeds was also investigated. Germtoxic and phytotoxic effects of some of the pesticides were demonstrated. Benomyl, carbendazin, chloranil, chloroneb, dichlone, fenaminosulf, propamocarb, and permethrin induced neither toxicity symptoms nor inhibitory effects on the growth of soybeans and inoculants.

A cooperative study with Delhi Research Station was carried out on the effects of

steaming and of the soil fumigants dazomet, allyl alcohol, and methyl bromide on microbial populations and on nitrification, urease, and dehydrogenase activities of microbes. Results showed that the treatments were stimulatory with regard to microbial populations and that dehydrogenase activities were greater in dazomet or steam-treated soils.

**Environmental fate of pesticides**

Work directed toward determining the persistence of pesticides in the environment continued. The behavior of furrow granular applications of aldicarb at an active ingredient (a.i.) rate of 3.36 kg/ha under wet, dry, and natural moisture regimens was similar to that observed for broadcast applications in 1981. The higher concentrations in the furrow did persist somewhat longer. Laboratory experiments demonstrated that large quantities of aldicarb could be leached rapidly from the soils used in the field under the conditions of the wet watering regimen and, contrary to previous statements, this could affect persistence. Aldicarb was rapidly absorbed from the treated soil by the potato seed piece, particularly in the mineral soil (maximum 70 mg/kg at 3 days) but the sulfoxide was the major toxicant in the leaves. Residues in the new tubers were low compared with those in other parts of the plant and decreased to $<0.2$ mg/kg at 14 wk after soil treatment. The pyrethroids AC 222705 (flucythrinate), BAY FCR 1272 (cyfluthrin), and deltamethrin were more persistent in organic than in mineral soil when applied to the soil surface at an a.i. rate of 140 g/ha. The order of persistence was deltamethrin $>$ flucythrinate $>$ cyfluthrin. Cyfluthrin was about as persistent as fenvalerate. Fenvalerate applied repeatedly (seven times at 2-wk intervals at an a.i. rate of 140 g/ha) to mineral soil disappeared almost as rapidly as it was applied but when applied to organic soil the residue levels rose to about 1 mg/kg over the application period and were still 0.6–0.7 mg/kg the following spring (34 wk after last application). Residues in the onions grown throughout the applications to fall harvest were $<0.01$ mg/kg.

Work continued on developing data that may be useful in predicting the fate and movement of pesticides in the water. Solubility studies of another 39 insecticides were completed, bringing the total number to over 60. Many of the measured solubilities (at 20°C) were significantly different from those reported in the literature. Octanol–water partitioning ($K_{ow}$) values were also obtained for these compounds. A high negative correlation has been shown to exist between log $K_{ow}$ and log solubility ($S$) values. As with solubility values, many of the measured $K_{ow}$ values differed significantly from values reported in the literature.

The disposal of pesticide containers by farmers has been a problem for many years owing to lack of data on the levels of pesticides left in the "empty" containers. Pesticide containers are not accepted at many landfill sites in Ontario because of concerns regarding possible seepage of residues into ground water from landfill sites.

To provide the required data to develop disposal guidelines, a pesticide container disposal project was organized, in cooperation with provincial and municipal authorities and the vegetable growers of the Thedford Marsh. Over 3000 containers were collected, and various rinsing and disposal techniques were evaluated for efficiency. A simple, commercially available device has been shown to be effective in the majority of cases, resulting in residues of less than 0.10% of original contents. Water samples from test wells at a landfill site were analyzed and showed no detectable levels of pesticides from containers deposited in 1981. In one case, problems were encountered with a particular formulation and product. Studies are continuing on this product in cooperation with the company.

**Pesticide toxicity and mode of action**

Although the use of organochlorine pesticides has declined in Canada, there is still widespread exposure to low levels in the environment. The mode of action of the DDT-type compound has still to be established. One point of interaction is the mitochondrial membrane. The interaction of mitochondrial and submitochondrial membranes with DDT, methoxychlor, and dicofol has been studied using the fluorescent probe 1-anilino-8-naphthalene sulfonate (ANS) to monitor the interaction.

The three organochlorine pesticides (OCs) reduced the succinate- and ATP-dependent quenching of ANS fluorescence of mitochondria. Since this was effected in a concentration-dependent manner, the OCs seem to act by blocking the energy supply to the inner membrane. Both DDT and dicofol, however,

were relatively ineffective inhibitors of substrate-induced quenching of ANS fluorescence of submitochondrial particles. These results suggest an asymmetry of the inner membrane with respect to DDT-type inhibition of substrate-induced energization.

Progress was made on unravelling the mode of action of glyphosate in the inhibition of plant growth. Experiments with a common natural phenol, cinnamic acid, showed that glyphosate treatment affected its metabolism, and the effect was still detectable 18 h after glyphosate treatment. The results indicate that the effect of glyphosate on the shikimate pathway is not limited to the early steps as previously reported by other workers. Since the chorismic acid step in the pathway is a branch point from which various products, including phenols, can be formed, the inference is that glyphosate may also interfere with other reactions beyond the chorismic acid step. The complexity of the involvement of the herbicide glyphosate in the shikimate pathway and its relation to indole acetic acid metabolism is being further investigated.

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# Research Station
# Delhi, Ontario

## PROFESSIONAL STAFF

| | |
|---|---|
| P. W. Johnson, B.S.A., M.Sc., Ph.D. | Director |
| E. G. Ashby | Administrative Officer |

### Tobacco

| | |
|---|---|
| H. H. Cheng, B.Sc., M.Sc., Ph.D. | Entomology |
| W. A. Court, B.Sc., M.Sc., Ph.D. | Chemistry |
| J. M. Elliot, B.S.A., M.S.A. | Soil science |
| S. K. Gayed, B.Sc., M.Sc., Ph.D. | Plant pathology |
| R. S. Pandeya, B.Sc., M.Sc., Ph.D. | Genetics and plant breeding |
| N. Rosa, B.Sc., M.Sc., Ph.D. | Plant physiology |
| E. K. Walker, B.S.A., M.S. | Plant science |
| B. F. Zilkey, B.S.A., M.Sc., Ph.D. | Plant physiology |

### New Crops

| | |
|---|---|
| R. C. Roy, B.Sc. (Agr.), M.Sc. | Agronomy |

## EXTENSION SERVICES[1]

| | |
|---|---|
| M. C. Watson, B.S.A. | Tobacco |
| N. W. Sheidow, B.Sc. | Tobacco |

# DELHI ENGINEERING RESEARCH GROUP[2]

D. A. Stier, B.Sc. Engineer

[1]Provided by the Ontario Ministry of Agriculture and Food.
[2]Provided by the Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers' Council.

# INTRODUCTION

The Delhi Research Station is the primary center for research on flue-cured tobacco in Canada and cooperates directly with staff members at both Charlottetown, P.E.I., and L'Assomption, Que. Multidisciplinary research is directed toward the production of high-quality tobacco to meet the requirements of both domestic and export markets and to reduce production costs for growers.

Research is conducted to increase the production efficiency, chemical and physical quality, and the usability of flue-cured tobacco, and to reduce the biological activity of smoke by altering crop chemistry through improved production practices, varieties, harvesting, and curing. Effective measures for controlling pests are sought to minimize pesticide residues through improvements in chemical, cultural, and biological control techniques. Basic research is conducted in biochemistry, chemistry, and physiology of flue-cured tobacco. Engineering research on energy utilization and mechanization is conducted by the Delhi Engineering Research Group (DERG), which is jointly funded by the Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers' Council. A new crops program is currently working to develop alternative or rotational crops for the sandy soil of the tobacco area.

Reprints of research publications and copies of this report are available from the Research Station, Research Branch, Agriculture Canada, P.O. Box 186, Delhi, Ont. N4B 2W9.

P. W. Johnson
Director

# TOBACCO PRODUCTION

## Seedling culture

Forking of seedbeds and decreases in density of seedbed population were associated with physical characteristics of seedlings leading to good survival, early days to flower, and optimum yield and quality.

Bordeaux mixture applied to young seedlings in Todd cells 3 wk after germination effectively controlled algae growth on the media surface.

## Fertilization

Fifteen consecutive crops of tobacco were grown on Fox loamy sand with three rates of P (0, 34.9, and 69.9 kg/ha), K (0, 89.6, and 179.2 kg/ha), and Mg (0, 6.1, and 12.2 kg/ha). Omission of P had little effect on the available soil P or the percentage of P in the leaf. The soil K declined on the no-K plots to 45% of the level found in the high-K treatments; the one-half rate was intermediate. The K in the leaves was low in the no-K treatment but the amounts of P, Ca, and Mg were much higher compared to the high-K treatment. The amount of Mg in the soil and leaves was slightly lower with the omission of Mg. The omission of K reduced yield and grade quality, whereas the omission of P or Mg had little effect on yield and grade.

## Growth inhibition of axillary buds

Eight fatty alcohol homologs ($C_6$ to $C_{12}$ normal alkane series) were observed to provide varying control of axillary bud growth or suckers when applied at rates of 5.6–22.7 L/ha. The $C_9$ and $C_{10}$ homologs provided the most acceptable control as did the higher rates of the $C_8$ and lower rates of $C_{11}$. The $C_{12}$ homolog (dodecanol) was very phytotoxic and the two lower homologs, hepanol and hextanol, were ineffective. The usable homologs did not affect leaf chemistry and appear suitable for control of bud growth.

## Curing

Introduction of ethylene gas into kilns during yellowing increased buyers' ratings of the cured leaves and reduced curing time. Better results were obtained with 50 mg/kg than with 10 mg/kg levels, and with carbon dioxide rather than nitrogen as a diluent. Smoke preference testing showed little difference between treated and nontreated leaves.

A commercial heat exchanger adapted by the Delhi Engineering Research Group for

use on a conventional downdraft, forced-air system reduced fuel consumption for individual cures by as much as 21%. Intake temperatures were raised about 4.5°C during early venting and about 10°C when the kiln temperature was over 49°C.

### Harvesting

Losses of leaves in field harvesting with a tobacco combine were 5–10%. Without a cutter bar for upper primings, losses were considerly higher than 10%.

## GENETICS AND PLANT BREEDING

### New flue-cured tobacco cultivar developed

A new strain, 77CD15, was developed and selected in 1977 from an interspecific hybridization study involving *Nicotiana tabacum* L. and *N. rustica* L. Test evaluations conducted over a period of 4 yr identified a sister line, 77CD15-A, suitable for release as a cultivar. This strain, 77CD15-A, has been submitted for licensing under the name Candel. Candel's pedigree is [Hicks Broadleaf ⅓(Babor × Delhi 34) Delhi 34⅓] Virginia 115.

Candel has exhibited better yield and grade quality than Virginia 115. In general, Candel resembles Virginia 115 for most agronomic factors but exhibits faster greenhouse and posttransplant field growth. It is an early-ripening strain that produces leaves of dark orange with a deep cast and improved leaf chemistry.

## CHEMISTRY

Chlorogenic acid, neochlorogenic acid, 4-*O*-caffeoylquinic acid, rutin, scopolin, and scopoletin in ripe green and cured leaves of flue-cured tobacco from different stalk positions were determined by high-performance liquid chromatography. Chlorogenic acid, rutin, and scopolin concentrations were higher in the leaves from the upper stalk positions. Neochlorogenic acid and 4-*O*-caffeoylquinic acid did not vary greatly with stalk position. Scopoletin concentrations appeared to be unrelated to stalk position. Except for the leaves from the lower stalk positions, increases were observed during curing for each of the isomers of chlorogenic acid, although the extent of these changes varied somewhat with individual years. The changes found for rutin after curing were similar to those of chlorogenic acid. An approximate prediction equation, for each stalk position, was developed for the changes in rutin and chlorogenic acid as a result of curing. Scopolin and scopoletin were observed to be high in the cured tissue. The percentage increase of scopoletin after curing was the largest of any of the phenolic constituents examined.

### Tobacco and tobacco smoke chemistry

A set of 25 test cigarettes was manufactured from various treatments, including cast tobacco sheeting of bright and burley tobacco grown in Ontario, and a tobacco substitute, Cytrel®.

Principal component analyses on certain tobacco characteristics such as total alkaloids, reducing sugars, total nitrogen, ash, lignin, cellulose, and fiber, and on certain smoke characteristics such as tar, nicotine, CO, HCN, neophytadiene, phenols, cresols, total aldehydes, pH, and nitromethane extractibles, showed that the variability among the cigarettes could be explained almost entirely by three independent tobacco factors—lignin, fiber, and total nitrogen—in the first analysis, and by three independent smoke factors—neophytadiene, carbon monoxide, and pH—in the second analysis.

## TOBACCO PROTECTION

### Entomology

*Cutworms.* A 5-yr field evaluation of blacklight and sex attractant traps for monitoring seasonal distribution of the darksided cutworm, *Euxoa messoria* (Harris), in Ontario, showed that moths of *E. messoria* were captured continuously from August to late October each year. The peak flight was generally observed between 5 and 25 September during the period of study. The sex attractant traps captured 3155 male *E. messoria* moths, whereas the blacklight traps captured 205 *E. messoria*, including 111 males and 94 females, in the same field. The data clearly indicate that the sex attractant traps were superior to blacklight traps for monitoring populations of this species. There was a variation in abundance from year to year, but the time of peak occurrence of *E. messoria* adults was the same in each of the 5 yr.

*Hornworm.* Sphingidae were collected from blacklight traps in southwestern Ontario from May to October over 15 yr from 1968 to 1982.

A total of 5200 hawkmoths representing 16 genera and 25 species were caught. Of these, only the tomato hornworm, *Manduca quinquemaculata* (Haworth), feeds on tobacco and was the most numerous, accounting for 82%, or more, of the total hawkmoth catch over 15 yr. There was not a single specimen of the tobacco hornworm, *M. sexta* (Linnaeus), trapped in this study, indicating that the tobacco hornworm was not a problem in Ontario. During this study, the tomato hornworm moth was present continuously from late June to the end of September each year. In general, a major flight period was observed between 15 July and 5 August each year. Four species of the Sphingidae were recorded for the first time in Canada.

**Plant pathology**

*Blue mold.* Contract research by Dr. Z. A. Patrick proved the scarcity and lack of viability of *Peronospora tabacina* oospores in the soil samples studied. In Canada, blue mold was not reported during the 1982 season.

Challenge infection of the weeds *Solanum dulcamara* (climbing nightshade), *Datura stramonium* (jimsonweed), and *Physalis alkekengi* (Chinese lantern); of the ornamentals *Petunia hybrida* and *Schizanthus* sp. (butterfly bush); and of two varieties of *Solanum melongena* (eggplant) proved that these plants are not hosts of our biotype of *P. tabacina.*

*Chemical sterilization of seedbeds.* Basamid or methyl bromide was effective in controlling weeds in tobacco seedbeds. Tobacco seedlings raised in chemically sterilized beds were comparable in size and weight to those raised in steam-sterilized seedbeds.

*Nematode control.* Three rates of Vorlex (28, 37, and 45 L/ha) and three rates of Telone II (73, 90, and 107 L/ha) were applied in the row and ridged. A check treatment was ridged without fumigant. The active ingredients contained in the fumigants, 1,3-dichloropropene in Telone II and 1,3-dichloropropene and methylisothiocyanate in Vorlex, diffuse 10 cm horizontally from the point of application. The concentration of 1,3-dichloropropene at the point of application declined over 95% in 1 day, and methylisothiocyanate declined 80% in the first day. There was a rapid build-up of nematodes in the check plot and fumigants had little effect on nematode populations beyond 10 cm from the point of application.

Preliminary studies indicate that packing the ridge immediately following application slows down the release of the chemicals into the atmosphere and tended to widen the band of horizontal diffusion of the fumigants.

*Weed control.* Various herbicide treatments were evaluated for their effect on flue-cured tobacco grade index, yield, return index, and lamina total alkaloid and reducing sugar content. Herbicides recommended for production, diphenamid and pebulate, and various experimental herbicides including the newly introduced annual grass control chemicals, BAS 9052 0H and TF 1169, provided acceptable agronomic and chemical results compared to the check. Diphenamid may be applied at the rate of 2.25 kg/ha for light tobacco soil and 3.25 kg/ha for heavy tobacco soil. Diclofop-methyl applied either alone postemergence or in combination with diphenamid provided inferior yield and quality results; hence these treatments must be discarded as potential tobacco herbicide candidates.

## NEW CROPS

**Peanuts**

Fenvalerate received full registration and is now being recommended for the control of potato leafhopper on peanuts.

The research prototype once-over peanut harvester continued to operate efficiently. Commercially produced harvesters operated satisfactorily; however, minor modifications are necessary to improve their efficiency.

P.I. line 355982, a new peanut cultivar with 20% greater yield, tested at Delhi, has been released by the Crop Science Department at the University of Guelph. Commercial seed supplies should be available by 1985.

A second peanut shelling facility, Kernal Peanuts Ltd., was opened in 1982. A total of 220 ha of peanuts, up from 120 ha in 1981, was produced in southern Ontario.

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# Research Station
# Harrow, Ontario

## PROFESSIONAL STAFF

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|---|---|
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| P. B. Marriage, B.Sc., Ph.D. | Assistant Director |
| E. Champagne,[1] M.A., M.L.S. | Librarian |

### Crop Science

| | |
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| R. I. Buzzell, B.S., Ph.D. | Head of Section; Soybean breeding |
| B. R. Buttery, B.Sc., Ph.D. | Soybean physiology |
| V. A. Dirks, B.S.A., M.Sc., Ph.D. | Statistics |
| S. J. Park, B.S., M.S., Ph.D. | Field bean breeding |
| A. H. Teich, B.A., B.S.A., M.Sc., Ph.D | Winter wheat breeding |
| T. W. Welacky, B.Sc., B.Sc. (Agr.) | Burley tobacco |

### Entomology

| | |
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| W. H. Foott, B.S.A., M.S.A., Ph.D. | Head of Section; Field crop insects |
| W. M. Elliott, B.Sc., Ph.D., D.I.C. | Vegetable and fruit insects |
| R. P. Jaques, B.S.A., M.S.A., Ph.D. | Insect pathology |
| R. J. McClanahan, B.A., M.Sc., Ph.D. | Greenhouse and field vegetable insects |
| B. C. Smith, B.A. | Field crop insects |

### Horticultural and Soil Science

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| W. I. Findlay, B.Sc., M.Sc., Ph.D. | Head of Section; Soil fertility |
| R. W. Garton, B.Sc. (Agr.) | Vegetable cultivar evaluation and management |
| T. J. Jewett, B.Sc. | Greenhouse energy engineer |
| F. Kappel,[2] B.Sc. (Agr.), M.Sc. | Orchard management |
| R. E. C. Layne, B.Sc., M.S., Ph.D. | Tree fruit breeding |
| A. Liptay,[3] B.S.A., M.Sc., Ph.D. | Vegetable management |
| A. P. Papadopoulos,[4] M.Sc. (Agr.), M.Sc. (Hort.) | Greenhouse management |

| | |
|---|---|
| J. A. Stone, B.S., M.S., Ph.D. | Soil physics |
| C. S. Tan, B.Sc., M.Sc., Ph.D. | Soil moisture and agrometeorology |

### Plant Pathology

| | |
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| W. R. Jarvis, B.Sc., Ph.D., D.I.C. | Head of Section; Vegetable diseases |
| T. R. Anderson, B.S.A., M.Sc., Ph.D. | Soybean diseases |
| W. G. Bonn, B.Sc., M.S., Ph.D. | Bacterial diseases of fruit and vegetables |
| B. N. Dhanvantari, B.Sc., M.Sc., Ph.D. | Bacterial diseases of vegetables |
| L. F. Gates, B.A., Ph.D. | Cereal and corn diseases |
| J. A. Traquair, B.Sc., Ph.D. | Tree fruit diseases |
| J. C. Tu, B.Sc., M.Sc., Ph.D. | White bean diseases |

### Weed Science and Chemistry

| | |
|---|---|
| A. S. Hamill, B.Sc., M.Sc., Ph.D. | Head of Section; Weed science |
| J. D. Gaynor, B.Sc., M.Sc., Ph.D. | Environmental chemistry |
| P. B. Marriage, B.Sc., Ph.D. | Weed physiology |
| D. R. Phillips, B.Sc., M.Sc., Ph.D. | Weed physiology |
| S. E. Weaver, B.A., Ph.D. | Weed ecology |

### Departures

| | |
|---|---|
| D. Bagnara, Dr.Sci.Agr., Ph.D.<br>Transferred to Research Station, St. Jean, Que. | Corn breeding |
| D. H. Lee<br>Retired December 1982 | Administrative Officer |

## VISITING SCIENTIST

| | |
|---|---|
| I. Ben Ze'ev, Ph.D.<br>Natural Sciences and Engineering Research Council visiting fellow | Insect pathology |

## EXTENSION SERVICES[5]

| | |
|---|---|
| J. C. Fisher, B.S.A. | Greenhouse and fresh market vegetables |
| L. A. Huffman, B.Sc. (Agr.) | Fruit crops and asparagus |

[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On educational leave, University of Guelph, September 1982–.
[3]On a transfer of work, the Institut f. Gemusebau, Germany, from August 1981 to August 1982.
[4]On educational leave, University of Guelph, September 1982–.
[5]Provided by the Ontario Ministry of Agriculture and Food.

# INTRODUCTION

The Research Station at Harrow serves southwestern Ontario, where favorable soils and climatic conditions permit an intensive and diversified agriculture. The Station has 32 scientists involved in interdisciplinary research in eight commodity-oriented programs designed to improve yield, quality, and efficiency of crop production. Crops under study include field and greenhouse vegetables, stone fruits, pome fruits, corn, soybeans, field beans, winter wheat, and burley tobacco. Crop improvements are achieved by the breeding of new varieties with superior characteristics and the development of improved crop, pest, and soil management practices.

Significant staff changes during 1982 are the addition of Dr. J. A. Stone, soil science; Mr. F. Kappel, pome fruits; and Mr. R. W. Garton, vegetable management; and the transfer of Dr. D. Bagnara, corn breeding, to the Research Station, St. Jean, Que.

The report provides brief summaries of results obtained in 1982. Further information can be obtained by writing to the Research Station, Research Branch, Agriculture Canada, Harrow, Ont. N0R 1G0.

C. F. Marks
Director

# FIELD CROPS

## Corn

*Electrical method of weed control.* In cooperative research with Dr. R. Hackam, University of Windsor, a method of weed control using electrical energy has been tested and found to be effective in killing over 50 species of annual broad-leaved weeds and grasses. The electric current passing through the plant on contact by a high-voltage applicator causes lethal heating of the plant. This method was tested in corn and soybeans and successfully removed weeds between the shielded rows without causing damage to the crop.

*Insects.* The European corn borer, *Ostrinia nubilalis* (Hübner), has a different life history in southwestern Ontario than in other parts of Canada. Southwestern Ontario has a two-generation strain, whereas other corn-growing regions have a one-generation strain. Grain corn hybrids that resist attack by the first generation are available, but none have resistance to the second generation.

The difference in levels of borer infestations between resistant and susceptible hybrids was examined by growing two resistant hybrids alongside a susceptible hybrid. The principal objective of the investigation was to determine if plants that resist attack by the first generation of the borer are more susceptible to infestation by the second generation. If so, this would nullify the advantages of growing a resistant hybrid because the second generation is the more destructive of the two in southwestern Ontario.

A 3-yr investigation showed that the resistant hybrids were effective in reducing first-generation injury and were no more subject to attack by second generation than the hybrid which was susceptible to both generations. Based on these results, the advice to grain corn growers in lieu of chemical treatment will be (*1*) to grow resistant hybrids to reduce damage by first-generation borers, and (*2*) to plant and harvest as early as feasible to reduce damage by the second generation. Recommendation *2* results from previous work which showed that early seeded plots are less subject to attack by the second generation, and an early harvest reduces the number of ears that are lost due to broken stalks and shanks.

*Soil fertility.* Laboratory studies on loss of nitrogen to the atmosphere from fertilized soil were conducted in cooperation with the University of Windsor. By using a gas flow method, reported on in previous work, it was possible to determine the temperature dependence of several steps in the denitrification process, including the effect on the net production rate of NO, an intermediate that is very reactive and therefore has proven difficult to measure in the past. The Arhenius parameters obtained show that at 20°C, nitrate loss is approximately twice as fast in Fox sandy loam than in Brookston clay. Loss

of $NO_2$– by biological processes is also much faster in sandy loam, six times the rate in Brookston clay. However, chemical loss of $NO_2$– is slower by a factor of 16 times in the sandy loam. Maximum net rates of production of nitric oxide and nitrous oxide are both greater in sandy loam than in Brookston clay by factors of 1.8 and 1.7, respectively.

Previous studies indicated that the evolution of $N_2O$ in the field was one or two magnitudes greater in Brookston clay than in Fox sandy loam. The present laboratory-based results suggest that aeration in the fine textured soil was considerably more restricted than that of the Fox sandy loam in the earlier work.

*Weed control.* Dry weather conditions following corn planting in an integrated weed management study resulted in reduced herbicide activity from preemergence applications for the control of lamb's-quarters, *Chenopodium album*, and velvetleaf, *Abutilon theophrasti*. Cultivation, along with the recommended rate of herbicide application, gave acceptable weed control. By either reducing the broadcast rate or banding the herbicide over the row coupled with cultivation provided good control of lamb's-quarters but unsatisfactory control of velvetleaf.

Six new herbicide treatments have been recommended for use in corn, based on herbicide evaluation and development trials; however, registration is still pending and these treatments are not available to growers.

*Weed physiology.* Clones of yellow nut sedge, *Cyperus esculentus*, have been regenerated in tissue culture experiments from excised rhizome tips. Manipulation of the growing conditions by alteration of growth hormones, and light quality and quantity has allowed differential initiation of root, shoot, rhizome, and tuber formation. Tubers produced in culture require only a 2-wk cold treatment prior to satisfactory sprouting, whereas freshly harvested tubers from the field require almost 3 mo of chilling before sprouting. The degree of dormancy of these tubers correlates to the presence of a yellow pigment, which when allowed to diffuse from a cut end of a tuber will permit sprouting to occur.

**Soybeans**

*Broad-leaved weed competition.* The competitive interference offered by velvetleaf, *Abutilon theophrasti*, and jimsonweed, *Datura stramonium*, plants emerging with soybeans was compared at various densities with that of the weeds emerging after the soybeans. By delaying weed emergence 2 wk, there was considerably less soybean growth reduction due to competition. For population densities of four or eight plants per square metre, velvetleaf emerging late had a negligible effect on the growth and final seed yield of soybean, whereas if the weed emerged at the same time, yield reductions of 12% and 40% were observed, respectively. At high densities (24 plants per square metre) little difference could be ascertained in soybean yield decreases between the early- and late-emerging velvetleaf plants, with both reducing yields by 70–80%. Jimsonweed, however, was a much stronger competitor with the soybean than velvetleaf and significant growth reductions were noted for each density within each emergence date. Even at the lowest density, jimsonweed competition caused a soybean yield reduction of 68% when emerging at the same time, and 14% when emerging 2 wk later. At the highest densities, this aggressive growth habit of jimsonweed accounted for a 92% reduction in soybean seed yield.

*Seed pigments.* Two compounds, cyanidin and delphinidin, cause black pigmentation in soybean hila and seedcoats. Gene *T*, which results in brown pubescence and is a phenolase gene involved in the formation of quercetin, is also involved in the formation of cyanidin. The $W_1$ gene, which results in purple hypocotyls and purple flowers, is involved independently of *T* in the formation of delphinidin. The delphinidin pigmentation is less intense than the cyanidin and results in imperfect black, which is a mixture of black and buff.

*Shielded rope wick applicator.* In cooperative research with Mr. P. Vogels, Jr., a contractor under the energy research and development in agricultural food (ERDAF) program, prototype shielded rope wick applicators were designed and constructed to treat weeds between the rows of corn and soybeans. Excellent control of annual and perennial weeds with glyphosate was achieved with two passes at 3.2 km/h. The metal shielding

effectively protected the crop leaves from contact with the rope wicks and prevented injury.

*Weed control.* The incidence of hormone herbicide (2,4-D, dicamba, mecoprop) drift to soybeans from application to rights-of-way or corn fields has caused much concern to growers. Symptoms from drift injury can take 2–3 wk to become visible. A method for simultaneous extraction and detection of the three herbicides was developed. It indicated that by the time the drift symptoms were visible accurate chemical analyses was not possible. Harvest data showed that etiolated soybean stems or cupped leaves did not necessarily mean reduced yields. The application of this information will dictate the procedures necessary to determine the seriousness of hormone herbicide drift in incidences of off-target receptivity.

**Burley tobacco**

*Harvesting.* A 3-yr study of the effects of hanging stalk-cut burley tobacco by impaling stalks onto nails, by plastic or string hangers, by notched stalks hung on a wire, and by the standard method of spearing a stick through the stalk indicated no significant effects on quality and yield of stripped tobacco. The unspeared stalks tended to have higher moisture after curing than those handled in the traditional manner. However, stalk moisture did not affect leaf moisture content or quality. The alternative methods may be more efficient in mechanized harvesting than the time-consuming, cumbersome spearing of stalks.

**Field beans**

*Anthracnose.* Four new cultivars (suggested names Fleetwood 83, Kentwood 83, Seafarer 83, and Ex Rico 83) of white beans with improved anthracnose resistance have been recommended for release jointly by the Harrow Research Station, Agriculture Canada, and the Crop Science Department, University of Guelph, to pedigreed seed growers. The new cultivars are resistant to the alpha, beta, delta, epsilon, gamma, and lambda races of bean anthracnose and races 1 and 15 of bean common mosaic virus. All other characteristics such as plant type, seed size, and cooking quality of the new cultivars are the same as their respective parents, Fleetwood, Kentwood, Seafarer, and Ex Rico 23, and have similar yield potentials.

*Bacterial blight.* In field evaluation of 12 advanced Harrow selections for blight (*Xanthomonas campestris* pv. *phaseoli*) tolerance, although they were equal to or better than GN-1-S27, generally used as a source of tolerance, the selection 408-81-6 was outstanding; it combined tolerance with erect growth habit, early maturity, and yield comparable to commercial cultivars. Among 80 field bean introductions screened, tepary beans (*Phaseolus acutifolius* Gray) were immune, and nine others (some with *Phaseolus coccineus* L. genetic background) were tolerant.

*Breeding.* A backcross-derived isoline of Sanilac was released as improved germ plasm. It carries gene *Are* giving resistance to alpha, beta, gamma, delta, epsilon, and lambda races (but not kappa) of bean anthracnose (*Colletotrichum lindemuthianum*) and gene *I* giving resistance to bean common mosaic virus 1 and 15.

Cranberry UI 51 and Taylor Cranberry were more tolerant to metobromuron applied postemergent to simulate splash-up than 28 other white and colored bean cultivars tested.

*White mold.* Although the white mold fungus (*Sclerotinia sclerotiorum*) is believed to be introduced to distant fields by sclerotia, it has been demonstrated that seed-borne dormant mycelia are capable of transmitting the disease. When the mycelium-infested seeds were sown, the seeds rotted and one to five sclerotia were produced. Apothecia from these sclerotia serve as primary inocula. Infested seeds treated with a fungicide containing thiram and benomyl failed to produce sclerotia in the soil.

**Winter wheat**

*Breeding.* A selection out of the cross Fredrick × Yorkstar was the highest yielding entry in southwestern Ontario in the Coop trials, outyielding its highest yielding parent, Fredrick, by 35%. A sister line of the selection had similar yield in the screening trials and a significant improvement in all quality criteria. A selection out of the cross Yorkstar × Halytchanka with resistance to wheat spindle streak mosaic virus was the highest yielding entry in the Screening Trials in the Ottawa Valley.

## HORTICULTURAL CROPS

### Field vegetables

#### Cabbage

*Weed competition.* The critical period of weed competition in early cabbage is from 3 to 6 wk after transplanting. The crop needs to be kept free from weeds for only 3 wk after transplanting, since weeds that emerge later do not reduce yields. This is the minimum period for which a residual preemergence herbicide must remain effective. Conversely, if weeds emerge shortly after transplanting, they can remain in the crop for up to 6 wk without reducing yields. This is the latest that a postemergent herbicide treatment could be delayed. A single weeding between 3 and 6 wk after transplanting is sufficient to prevent yield loss due to weed competition. Row spacing of the cabbage can affect the critical period of weed competition. Wide rows (2 m) must be kept weed-free for a longer period than narrow rows (75 cm). Yields per hectare are greater for narrow rows than for wide rows when weed competition is prevented. Weed competition reduces both yield per hectare and individual head size.

#### Crucifer crops

*Weed control.* A posttransplant treatment of alachlor plus chloramben gave outstanding broad-leaved and grass control to spring cabbage, and fall cabbage, cauliflower, broccoli, or brussels sprouts. No crop injury was observed in 2 yr of evaluation.

BAS 9052 (sethoxydim) is being recommended for registration for the control of annual grass weeds in cole crops.

#### Peppers

*Insect preferences in varieties.* Nine bell-type pepper varieties were grown without insecticide sprays to examine preferences of the pepper maggot and European corn borer. The lowest infestation of borer was 6.6% in Lady Bell compared to 18.8% in the least resistant variety. Preferences of the pepper maggot were somewhat different and the infestation ranged from 2.1% to 7.2%. Lady Bell was 3.5% infested by maggots and it had the highest yield.

#### Potatoes

*Insect control.* Granular applications of aldicarb at planting time provided excellent control of all potato insects, and a significantly higher yield than other systemic materials. A new synthetic pyrethroid insecticide, flucythrinate, provided good aphid control but was not effective against Colorado potato beetle.

#### Sweet corn

*Varietal resistance to first-generation corn borer.* In 1982, Calumet, Guardian, Seneca Horizon, and Ont. Hyb. 759 were identified as sweet corn cultivars with enough resistance to corn borer that they would need no sprays, similar to six resistant varieties tested in previous years. Another 10 varieties could be adequately protected with a single spray at 100% silk stage, whereas an untreated susceptible corn would have 69% infested ears.

#### Tomatoes

*Bacterial speck.* Field incidence of speck, *Pseudomonas syringae* pv. *tomato*, in Essex and Kent counties was widespread on the processing tomato cultivars H-2653, CC-7103, FM-6203, and Peto 95 but not on C-28, CC-7101, and E-870. Atypical fruit symptoms included depressed lesions and fruit distortions, raised scabby lesions, and large (2–5 mm diam.), smooth, black spots with or without a green halo. Unrelated to the symptoms, the speck bacteria appeared to be a mixture of four colony types distinguishable only on nutrient sucrose agar; the predominant levan-negative, large (3–5 mm diam.), mucoid type with translucent center enclosed by a ring of white growth, and levan-positive off-white, chalk-white, and translucent colonies. They were all pathogenic and retained the colony character after host-passage.

Thirty-seven strains of speck bacteria, screened against seven selected antibiotics, were sensitive to kasugamycin, oxytetracycline-HCl, and streptomycin. Kasugamycin, an agricultural antibiotic, appeared to have potential in controlling bacterial speck in greenhouse-produced tomato transplants, because it was effective as a spray applied 24 h before or 24 and 48 h after inoculation, at concentrations of 100 and 200 $\mu$g/mL.

*Bacterial spot.* In cooperative evaluation of 272 tomato accessions with Dr. E. A. Kerr, Horticultural Experiment Station, Simcoe, Ont., 44 were found to be tolerant but none

was immune to bacterial spot, *Xanthomonas campestris* pv. *vesicatoria*, in greenhouse and field assessments on foliage and fruit.

*Epiphytic survival of Pseudomonas syringae pv. tomato on tomato transplants.* An antibiotic-resistant strain (G13) of *Pseudomonas syringae* pv. *tomato* (Okabe) Young et al. survived as an epiphyte on tomato transplants shipped from Georgia to Ontario. Following inoculation in Georgia, New Yorker plants had a population of $7.5 \times 10^2$ cfu (colony-forming units)/leaf, which had increased to $1.3 \times 10^6$ cfu/leaf on arrival in Ontario. After storage at 12°C for 60 h the population of bacteria on the tomato leaves was $3.6 \times 10^7$ cfu/leaf. Symptoms of bacterial speck developed on tomato plants 4 days after transplanting into the field.

*Germination of tomato seeds at low temperatures.* In physiological studies designed to determine the underlying cause of the poor rate of germination of tomato seeds at low temperatures, it was determined that the water potential of the seeds is very high (>–1 bar), i.e., their ability to take up water is low. This condition results in a poor rate of germination at low temperatures. In further experiments designed to improve the uptake of water into the seeds, results indicated that if a pretreatment with polyethylene glycol was given to the seeds they would germinate much more readily at 10°C. For example, by day 2, PI 341988 seeds that were pretreated with polyethylene glycol essentially germinated to completion, whereas the untreated seeds took 10 days to reach the same stage of germination. With another tomato line, more difficult to germinate at low temperatures, the percentage of germination for control and pretreated seeds at day 20 was 9% and 97%, respectively. Further work is proceeding on the optimum conditions for the pretreatment and the length of time the pretreated seeds can be stored and still retain their improved ability to germinate.

*Mechanism of emergence of tomato seedlings through surface-crusted or compressed soils.* Tomato seedlings emerging through loose soil had hypocotyls with a diameter of 0.97 mm and a structural strength of 15.6 g. In contrast, the diameter of the hypocotyls emerging through compressed soil was 1.71 mm; the structural strength of these seedlings was 43.1 g. This supports the postulations that the thickened hypocotyls observed on seedlings attempting to emerge through surface-crusted soils are the result of the seedling modulating the cell enlargement and increase in thickness of the hypocotyl, in response to mechanical resistance, and that as the hypocotyl becomes thicker, its structural and compressive strength becomes greater; thus its chances of emerging through the soil are enhanced.

*Plastic tunnels and temperatures.* Field experiments were conducted in southwestern Ontario to determine the effect of various types of plastic films on the soil and air temperatures in low tunnels. The results indicated that a polyvinyl-chloride (PVC) film retained more heat (2°C warmer) during the night than a clear polyethylene (PE) film. An additional benefit of the PVC film was that mean air temperatures were also raised and the range of the daily temperature variations were smaller than with the clear-PE film. Soil temperatures in plastic tunnels were similar whether a black-PE mulch was included or not as part of the low tunnel system. However, air temperatures were raised by a combination of low tunnel with black-PE mulch. The addition of a plastic tunnel over the mulch results in improved air temperature, an effect which is conducive to earlier growth of vegetables. The plastic tunnels were not damaged by an unusually late snowfall of 33.5 cm that occurred on 5 April 1982. Soil temperatures outside the tunnels under the cover of snow remained at 0°C, whereas inside the tunnels soil temperatures reached 27°C during the day. The maximum air temperature above the snow cover was 4.5°C; the maximum inside the plastic low tunnels was about 24°C.

*Water relation and yields.* Yields of both H2653 and C28 tomato cultivars were affected in a season of below normal rainfall (1982) by irrigation treatments. The highest yields were obtained at medium irrigation (25% available soil moisture (ASM)) and high plant density (43 054 plants per hectare) treatment for H2653 cultivar and outyielded the standard practice (unirrigated + 21 527 plants per hectare) by 62%. Irrigation at 50% ASM level did not appear to be more effective than irrigation when available soil moisture level was allowed to drop to 25%. The best treatment combination (50% ASM + 21 527

plants per hectare) for C28 cultivar outyielded the standard practice (unirrigated + 21 527 plants per hectare) by 110%.

The effect of irrigation on incidence of blossom-end rot (BER) of C28 cultivar was also evaluated during the 1982 growing season. Incidence of BER rose with increase in soil water deficit. In the high stress, which received neither rainfall nor supplemental irrigation, 45.1% of total yield showed BER. In the unirrigated plots (moderate stress), which received only rainfall, 14.3% of total yield showed BER. Under irrigated conditions (low stress), a very low incidence of BER (1%) was observed.

*Weed control.* Diclofop-methyl at 1.0 kg/ha, BAS9052 (sethoxydim) at 0.15 kg/ha, or TFll69 (fluazifop-butyl) at 0.25 kg/ha, applied postemergence, effectively controlled annual grasses in direct-seeded tomatoes. Quack grass control may be obtained with sethoxydim or fluazifop-butyl without crop injury at rates up to 0.75 kg/ha.

## Greenhouse vegetables

### Tomatoes

*Leafminer trapping.* The leafminer, *Liriomyza trifolii* (Burgess), attacks tomatoes, cucumbers, and chrysanthemums, especially the last of these. Yellow sticky traps were efficient in monitoring adult populations in chrysanthemums. A density of one trap per 10 $m^2$ detected very low populations. Traps placed at one per 5 $m^2$ helped reduce adult numbers, and this technique could be applied to the vegetables as well.

## Tree fruits

### Apple

*Microbial control of the codling moth.* Applications of granulosis virus provided good protection of apples against codling moth, *Cydia* (=*Laspeyresia*) *pomonella* (L.), in orchard tests done in cooperation with the University of Guelph. Percentages of apples with deep-entry damage by codling moth were 12.6% and 0% in 1980, 10.4% and 0.7% in 1981, and 13.6% and 1.1% in 1982, in the nontreated plots and in plots sprayed with the granulosis virus 5–8 times in the growing season, respectively. Bioassay data indicated that the virus was rapidly inactivated on fruit in the orchard, losing 50% of original activity in 2 days after application. The effectiveness of the virus in these tests indicated that the virus has potential for use in integrated management of the codling moth.

### Apricot

*Breeding.* A new cultivar named Harglow, formerly tested as HW 425, was introduced for the mid-season fresh market. This introduction is late blooming, cold hardy, and consistently productive. The foliage and fruit exhibit a good level of resistance to bacterial spot, caused by *Xanthomonas campestris* pv. *pruni* (Smith) Young et al., and brown rot, caused by *Monilinia fructicola* (Wint.) Honey. The tree is resistant to perennial canker, caused by *Leucostoma cincta* (Fr.) Höhn. and *L. persoonii* (Wits.) Höhn., and the fruit are resistant to skin cracking even when heavy rains precede harvest. The medium-sized fruit are attractively colored with orange skin and orange flesh. The flesh is fully freestone, flavorful, sweet, and juicy with good texture. This introduction is well suited for fresh consumption and is equally suitable for processing as canned halves in sugar syrup or as puree. Harglow is likely to be adapted to regions where Goldcot and Veecot are successfully grown.

### Nectarine

*Breeding.* A new nectarine selection (H7938023) was made, the second backcross of the hardy Harrow introduction named Hardired to two high-quality California introductions. The first backcross parent was Stark Delicious and the second was Fantasia. This mid- to late-ripening selection exhibited satisfactory cold hardiness combined with generally good tree and fruit characteristics, including good appearance of the ripe fruit combined with firm flesh of good dessert quality. The primary purpose of the backcross program was to improve fruit type while retaining cold hardiness, and it appears that these objectives were achieved.

### Peach

*Breeding.* A new mid-season, productive, fresh-market cultivar named Harson was introduced. This introduction, formerly tested as H781, is in the same hardiness class as the Redhaven cultivar and is likely to be adapted to regions where Redhaven is successfully

grown. Harson, besides being cold hardy, is resistant to bacterial spot, caused by *Xanthomonas campestris* pv. *pruni* (Smith) Young et al., and brown rot, caused by *Monilinia fructicola* (Wint.) Honey. The tree may also have moderate tolerance to perennial canker, caused by *Leucostoma cincta* (Fr.) Höhn. and *L. persoonii* (Wits.) Höhn. The fruit of Harson attain uniform size and ripen very uniformly, thus requiring only two or three pickings instead of the usual five for Redhaven. They are attractively colored, roundish, with good flavor and texture. The flesh is firm, yellow, fully freestone, and slow to oxidize, thus avoiding browning from bruising or during slicing for dessert use or preservation. Although Harson is intended primarily for fresh consumption, it is also suitable for home processing as canned halves in sugar syrup or as frozen slices in granulated sugar.

*Irrigation and tree density.* An orchard management experiment of Harken/Siberian C in the 10th yr revealed that irrigation had its major effect in improving tree growth, reducing peach canker (*Leucostoma* spp.), enhancing tree survival, and increasing fruit size, compared with unirrigated checks. An increase in tree density had its major effect in greatly increasing fruit production, including total yield and marketable yield. A combination of the highest level of supplemental irrigation (50% available soil moisture) and the highest tree density (536 trees per hectare) resulted in the highest yield in 1982, which exceeded the commercial check (unirrigated + 266 trees per hectare) by 242%. Similar results were obtained from the 1st to the 8th year of production, clearly pointing to the superiority of the intensively managed production system compared with the standard management practice (unirrigated, low tree density) commonly used in southwestern Ontario.

*Water uptake by peach roots.* Peach seedlings were grown in large sectional boxes with root systems divided into four separate quadrants. Transpiration, photosynthesis, leaf conductance, and leaf water potential were measured in peach seedlings with 3, 2, 1, and 0 quadrants of the root system deprived of water for 3 wk. Subjecting a large portion of the root (50%) to stress by withholding water only caused a small reduction (17%) in transpiration, photosynthesis, and leaf conductance. Subjection of various fractions of the root system to severe moisture stress did not affect the shoot-to-root ratio. The reduction in root growth in dry quadrants was accompanied by the production of more roots in wet quadrants and less transpiring leaf surface and branch growth. The rate of recovery of transpiration and photosynthesis from water stress was greatly influenced by the duration and intensity of wilting as well as by the regeneration of new root systems.

*Weed control.* Various herbicide treatments were evaluated for efficacy of weed control in peaches in the year of planting. Simazine at 2 kg/ha in combination with oryzalin at 2 kg/ha or napropamide at 4 kg/ha provided adequate season-long weed control if sufficient precipitation to activate the chemicals was received within a week of herbicide application. No visible injury to the trees was observed from any of the treatments. Herbicide residues from these treatments was sufficient at the end of the growing season to be toxic to susceptible crops if intercropping was anticipated.

A postemergence application of simazine or linuron with paraquat gave good weed control through the growing season, but injury to the trees from paraquat was observed where the herbicide contacted the leaves of the peach trees either from spray drift or from treated foliage. Studies showed that glyphosate was as effective as paraquat in controlling weeds, but the difficulty of preventing herbicide contact with tree shoots precludes the use of glyphosate with currently available spray equipment.

## Pear

*Breeding.* Two selections from the 1972 hybridization program were advanced to second test and given the designations HW 610 and HW 611, respectively. Both selections were harvested for ripening at the end of the Bartlett season and are potential replacements for Bartlett. Blight resistance scores for 4 yr indicated that both selections had a high level of fire blight resistance. Both selections had better texture scores than Bartlett (less grit), whereas their fruit appearance and flavor scores approached Bartlett. The fruit of HW 610 were as large as Bartlett, whereas the fruit of HW 611 were smaller and comparable with Harrow Delight.

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| G. Fedak, B.S.A., M.Sc., Ph.D. | Head of Section; Cereal cytology |
| K. C. Armstrong, B.S.A., Ph.D. | Brome cytology and chromosome banding |
| I. L. Craig, B.S. | *Hordeum* cytology |
| B. E. Murray, B.S.A., M.Sc., Ph.D. | Haploidy—flax cytology |

### Entomology

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|---|---|
| D. G. Harcourt, B.S.A., Ph.D. | Head of Section; Population dynamics |
| R. Boch, Dr. Rer. Nat. | Physiology and behavior of bees |
| T. A. Gochnauer, B.S., M.S., Ph.D. | Pathology of bees |
| J. C. Guppy, B.S.A., M.S. | Population dynamics |

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| C. C. Loan, B.A., M.S., Ph.D. | Population dynamics |
| F. Meloche, B.Sc., M.Sc. | Population dynamics |

### Forage Crops

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| H. D. Voldeng, B.S.A., M.Sc., Ph.D. | Acting Head of Section; Soybean breeding |
| P. K. Basu, B.Sc., M.Sc., Ph.D. | Plant pathology |
| M. A. Faris, B.Sc., M.Sc., Ph.D. | Legume breeding |
| W. R. McElroy, M.Sc., B.Sc. | Grass breeding |
| F. S. Warren,[1] B.S.A., M.Sc., Ph.D. | Agronomy |

### Genetic Engineering

| | |
|---|---|
| W. A. Keller, B.S.A., Ph.D. | Head of Section; Cell genetics |
| D. Brown, B.Sc., M.Sc., Ph.D. | Developmental physiology |
| B. L. A. Miki, B.Sc., Ph.D. | Molecular genetics |
| S. J. Molnar, B.Sc., M.Sc., Ph.D. | Cell genetics |

### Ornamentals

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|---|---|
| E. V. Parups, M.S.A., Ph.D. | Head of Section; Physiology and floriculture |
| A. T. Bolton, B.Sc., M.Sc., Ph.D. | Pathology |
| S. Nelson, B.Sc., M.Sc., Ph.D. | Nursery research |
| J. A. Simmonds, B.Sc., M.Sc., Ph.D. | Physiology and floriculture |
| F. J. Svejda, Ph.D. | Plant breeding |

### Experimental Farm, Kapuskasing, Ont.

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|---|---|
| J. G. Proulx, D.V.M. | Superintendent; Crop and beef management |

### Experimental Farm, Thunder Bay, Ont.

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|---|---|
| J. Wilson | Superintendent; Crop management and evaluation |

### Departure

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|---|---|
| L. S. Donovan, B.S.A., M.S., Ph.D.<br>Deceased September 1982 | Corn breeding |

## VISITING SCIENTISTS

| | |
|---|---|
| A. Atanassov, Ph.D.<br>From November 1981 to August 1982 | Tissue culture |
| D. Brown, M.Sc., Ph.D.<br>From June 1981 to August 1982 | Selection of mutants |
| B. Giles, B.Sc., M.Sc., Ph.D.<br>From June 1981 to May 1983 | *Hordeum* cytogenetics |
| K. Klimaszewska, M.Sc., Ph.D.<br>From December 1981 to November 1983 | Tissue culture |

*Graduate students*

| | |
|---|---|
| S. Gleddie, B.Sc. | Somatic hybridization |
| T. Reich, M.Sc. | Genetic transformation |
| M. R. A. de Araujo,[2] M.Sc. | Forage breeding |
| O. V. Dos Reis, B.Sc. | Biometrics |
| C. A. Ventura, M.Sc. | Forage legume physiology |
| H. A. Burity, M.Sc. | Forage legume physiology |

[1]On a Canadian International Development Agency (CIDA) assignment to Sri Lanka from September 1982 to August 1984.
[2]Visiting graduate student from Brazil.

# INTRODUCTION

The Ottawa Research Station is the major center for plant breeding in eastern and central Ontario. It is a major center for ornamentals research, biotechnology for crop improvement, and integrated management of alfalfa pests. A small unit is engaged with studies of honeybee behavior and pathology. The central office for the Canadian Plant Gene Resources is also part of the Station. The management of the Central Experimental Farm, including numerous services, is also the Station's responsibility.

The breeding programs are supported by multidisciplinary research in plant, molecular, and cell genetics, cytogenetics, plant physiology and pathology, entomology, cytochemistry, and grain quality. The Experimental Farm at Kapuskasing continues to conduct experiments on crop production and on beef cattle management, in cooperation with the Animal Research Centre (Ottawa), for northwestern Quebec and northeastern Ontario. The Experimental Farm at Thunder Bay is engaged in methods of crop production for northwestern Ontario.

The Station was deeply saddened by the untimely death of Dr. Lorne S. Donovan, Canada's foremost corn breeder, who was named Man-of-the-Year for 1982 by the Canadian Seed Trade Association. The Station received the President's Award from the International Lilac Society, and awards were received by Messrs. Arthur Buckley, retired, and Trevor Cole, present curator of the Dominion Arboretum, from that same Society. The Director received a Distinguished Oat Improvement Award from the American Oat Workers Conference.

Two cereal cultivars obtained licenses and were released. Donald, a daylength insensitive, large-seeded and thin-hulled oat, and Léger, a consistently high-yielding and exceptionally widely adapted, six-rowed, feed barley. Five short-season corn hybrids were also licensed and released in Ontario and Manitoba. Three winterhardy shrub roses, Champlain, Charles Albanel, and William Baffin, and an impatiens variety, Northern Sunset, were registered with the Canadian Ornamental Plant Foundation and released to the nursery trade.

This report summarizes some of the more important research results from the Station in 1982. Further information can be obtained from the publications listed at the end of this report. Reprints of the research publications and copies of this report are available on request from the Ottawa Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Tibor Rajhathy
Director

# CEREAL CROPS

## Wheat

*Breeding.* The major emphasis of the Ottawa Research Station (ORS) program is to improve soft white winter pastry wheat for Ontario. Specifications for the ideal new cultivar call for excellence in 23 traits, in addition to high yield. The ORS cultivar Fredrick now occupies 90% of the wheat hectarage and is superior in 13 of the 23 traits, mainly in plant and seed characteristics. Gordon, licensed in 1980, has acceptable levels in 12 traits, seven in common with Fredrick, and has better quality but less disease resistance than Fredrick. The two most recent candidate cultivars, 0-466-27 and 0-468-77, from ORS both failed to meet the quality standards.

*Physiology.* Preharvest sprouting of grains is a major problem in the growing of soft white winter wheat. A research program has been initiated to investigate the physiological basis of resistance and to help breed resistant cultivars. The sprouting reaction of all entries in the Ontario Coop winter wheat test, after treatment of heads in a rain simulator, was evaluated. The percentage of germination and the development of $\alpha$-amylase in the seed 8 days after the harvested heads had reached physiological maturity were measured. Most cultivars were susceptible, but Houser and PF4-80-81 were very susceptible to sprouting. Cultivars showing equal sprouting varied greatly in $\alpha$-amylase content. Sprouting resistant lines derived from a hybrid between the susceptible parent Fredrick and the

resistant parent Kenya 321 were again evaluated in 1982 and the resistance of several lines was confirmed.

*Pathology.* Winter wheat production in Ontario was about 50% normal caused by winterkill due to icing and spring desiccation in southwestern areas. Prolonged snow cover in the east and central regions resulted in a 15–70% loss in some fields from snow molds, chiefly *Typhula* spp. and *Gerlachia nivalis* (Ces. ex Sacc.) Gams & Müller. Fifty percent of the seeded hectarage was plowed down and the crop that survived suffered from root and leaf diseases and weed competition because of thinned stand. The most important disease was fusarium head blight (*Fusarium graminearum* Schwabe), which also increased vomitoxin levels in harvested grain over that of the 1981 crop.

**Barley**

*Breeding.* Léger, a six-rowed feed barley, was licensed in 1982 and it represents a new level of excellence in spring barley in Eastern Canada. It has consistently exhibited exceptionally high yield, good test weight, large kernel size, and strong straw. SeCan Association is responsible for the distribution of pedigree seed to growers and certified seed will become available in 1984. Two other ORS six-rowed feed cultivars, Massey and Vanier, continue to be the highest-yielding commercial cultivars in Ontario, and they are resistant to smut, mildew, and scald.

*Pathology.* Net blotch (*Pyrenophora teres* (Died.) Drechsl.), scald (*Rhynchosporium secalis* (Oud.) Davis), and spot blotch (*Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur) were the most important diseases affecting barley in Ontario. The conclusion reached from experimental work on chemical seed treatments was that general treatment appears to be unnecessary unless a specific disease problem is identified.

**Oats**

*Breeding.* The ORS oat breeding program has concentrated on the breeding of oats for both feed and food. In 1982, Canada's first daylength-insensitive covered-seeded oat, Donald, was licensed and assigned to SeCan Association. Donald is a multipurpose oat and will be grown in Ontario for milling purposes for the food industry and as a feed oat for growing in pure stand or in mixtures with barley. It lacks a high level of crown rust resistance, which may limit its use in Eastern Ontario. Continued progress has been made in the improvement of naked-seeded oats and one strain, OA501-1, exhibited high grain yield, large seed size, high hectolitre weight, high groat protein content, very strong straw, smut resistance, and a form (slow rusting) of crown rust resistance. A new special naked-seeded oat has been bred that has a unique exaggerated multiflorous spikelet. It may contain as many as 12 seeds. The spikelet has been named a "chevron-type" spikelet because of its resemblance to the chevron pattern. The small apical florets of each spikelet, which are the ones most often covered with hulls in normal naked-seeded cultivars, are most often sterile in chevron-type oats and thus the threshed seed sample is virtually free from covered oats. Several hundred high-yielding dormoat strains are being evaluated for their agronomic and physiological qualities with a view to isolating superior strains that will respond to efficient seed and crop management.

*Physiology.* A program was initiated to study the physiological processes controlling dormancy in dormoats. Emphasis has been placed on development of a treatment that will synchronize seed germination by inducing a type of secondary dormancy in the seed which will prevent the seed from germinating in autumn but will disappear during winter permitting each seed to germinate in springtime. Exposure of moist seeds to high (40°C) temperature for several days resulted in an induction of dormancy in many strains, but some strains failed to retain this dormancy when sown in soil. Expression of thermodormancy appears to be conditioned by age of seed after harvest, the type of reserves present in the seed, and the presence or absence of hulls.

*Pathology.* Oat fields in eastern Ontario and western Quebec, especially those located near buckthorn bushes, suffered severe damage from crown rust. New cultivars Woodstock and Dumont were resistant to races of crown rust prevalent in Ontario. The fungicide Tilt (CGA64250) used alone or in combination with added nitrogenous fertilizer on Donald and Sentinel oats controlled crown rust, reduced hull percentage, and increased seed yield, kernel weights, and the protein content of grain and straw. Crown rust was also less prevalent on susceptible oats and spot blotch in barley when oats and barley were

grown in mixture. Mixed grain yields were in three out of four cases higher in yield than when the two components were grown in pure stands. Donald oats and Léger barley mixtures (1:1 or 1:3 ratios) also gave the highest kernel weights and protein content of the different mixtures evaluated.

### Grain quality and microchemistry

A comprehensive study was undertaken to determine the lack of deoxynivalenol (vomitoxin) in different mill stream fractions from infected wheat, and the fate of vomitoxin in these fractions was evaluated after food processing. The results indicate that milling and processing lead to reduction in toxin levels in finishing products.

Modifications made by Engineering and Statistical Research Institute to a cyclone mill to permit cereal seeds to be ground to subcellular particle size has aided researchers to perform more reliable infrared and chemical analyses of cereal components, including assays for protein, lipids, $\beta$-glucans, and enzymes. Collaborative studies with Food Research Institute have provided new information on the chemistry and distribution of carbohydrates in cereal grains. Analysis has confirmed the presence of $\beta$-(1,3)-D-glucan deposits in barley and the specificity of fluorescent reagents for mixed linkage $\beta$-D-glucans. The quality laboratory continued to evaluate and identify soft white wheat quality parameters such as milling quality, protein content, test weight, and baking performance. Discrepancies between test weights taken by breeders and by official agencies were detected and corrected.

## CYTOGENETICS

### Wide crosses in cereals

Common wheat has no resistance to barley yellow dwarf virus (BYDV) and in order to incorporate such resistance the winter wheat cultivars Yorkstar and Ticonderoga were crossed by *Agropyron intermedium* (Host) Beauvois 'trichophorum' (Link) K. Richt. and *A. elongatum* (Host) Beauvois. $F_1$ hybrids had the expected chromosome number of 42, and the average meiotic configuration consisted of 10 bivalents and one trivalent, probably indicative of autosyndetic pairing between *Agropyron* genomes. No backcross progeny were obtained from the *A. elongatum* combination; however, in the *A. intermedium* progeny, the chromosome numbers in $BC_1$ ranged from 42 to 63. Some $BC_1$ plants were partially fertile and, when combined with $BC_2$, a total of 600 seeds was obtained. The $BC_2$ progeny will be screened for BYDV resistance and then studies undertaken to determine the genetic basis and chromosomal location of resistances.

Efforts are under way to transfer chromosomes of barley into wheat as a means of transferring such barley genes as $yd_2$ (resistance to BYDV located on chromosome 3) and generally increasing the overall genetic variability of wheat. Hybrids between several combinations of wheat and barley cultivars have been produced. A 23-chromosome hybrid was obtained from the Chinese Spring × Bonus combination, which in $BC_1$ gave progeny with a chromosome number of 42 + telocentric (the latter originating from barley). Chromosome numbers of 31–49 were obtained in $BC_1$ progeny from Chinese Spring × CI2376, and $BC_2$ progeny have now been obtained. Chromosome numbers in $BC_1$ from Norin 29 × Betzes ranged from 28 to 49, and $BC_2$ progeny have also been obtained from this combination. A new hybrid with the expected chromosome number of 28 was obtained by crossing *Hordeum pubiflorum* Hook. f. × Chinese Spring.

### Chromosome banding

An accession of triticale cultivar Welsh contained four rye chromosomes (1R, 3R, 5R, and 6R) with characteristic telomeric and interstitial C-bands. Chromosome pairing in Welsh × 6*x* wheat (*Triticum aestivum* L.), indicated that there were at least six rye chromosomes present in Welsh and two of these had lost their characteristic terminal C-bands.

The three diploid species of South American *Hordeum* (*H. chilense* Roem. & Schult., *H. halophilum* Griseb., and *H. magellanicum* (Parodi & Nicora) Bothmen et al.) have different C-band karyotypes and the individual chromosomes in each can be identified. Differences were found in the accessions identified as *H. magellanicum*.

Tetraploid *Bromus inermis* Leyss. and *B. pumpellianus* Scribn. ssp. *dicksonii* Mitch. & Wilton both have chromosomes with prominent terminal bands, but *B. pumpellianus* has interstitial bands not found in *B. inermis* on as many as nine chromosomes. When used in conjunction with chromosome length, and

arm ratio, the bands are of value in identifying chromosomes.

### *Bromus* cytogenetics

Tetraploid $F_1$ hybrids ($2n = 4x = 28$) between $4x$ *B. ramosus* Huds. and $4x$ *B. benekenii* (Lange) Trimen were highly fertile and chromosome pairing indicated that they differed by one interchange. Diploid $F_1$ hybrids ($2n = 2x = 14$) between *B. ciliatus* L. and *B. latiglumis* Hitch. were completely self-sterile but chromosome pairing and chiasma frequency were normal.

### Flax

Haploid × diploid crossing in flax is a successful procedure for producing new genetic combinations and breeding stocks. Seed samples of flax hybrid lines, from double crosses involving haploid–diploid twins from cultivar Rocket and the fiber-type cultivar Natasja and the rust-resistant cultivar Dufferin, are to be evaluated and selected for high-yielding, rust-resistant, fiber types in field plot tests in a cooperative project with Dr. Gordon Rowland, University of Saskatchewan. Seed samples of another double cross combination involving a white-flowered, seeded cultivar Avantgard is to be selected for white-flowered seed and fiber types. The orientation of twins in the mature seed, their synchrony in germination and uniformity, and vigor of growth are factors to be considered when selecting haploids for use as parental stocks.

### *Hordeum* cytology

Variation in the results from interspecific crosses among and between diploid barleys (*H. chilense*, *H. magellanicum*, *H. patagonicum* (Hauman) Covas, *H. pubiflorum* Hook. f., *H. halophium*) suggest the presence of an incompatibility barrier. The morphology of the mitotic chromosomes and pairing behavior of these and other diploids is being detailed to aid in a determination of species relationships and broaden the potential genetic base.

Collections of diploid *H. bulbosum* have been extensively intercrossed and the results showed extremes in crossability. Diploid lines are being established with variation in requirements for flower initiation, winterhardiness, and high and low crossability with other diploids. Diploid seeds and seedlings have been treated with colchicine to induce chromosome doubling and thereby facilitate a study of diploid, induced tetraploid and autotetraploid chromosome pairing from wide geographic areas.

Genotypes of *H. bulbosum* are being evaluated for their capacity and efficiency to induce haploid plants when outcrossed to wheat cultivars. Pollen from a selected tetraploid was crossed to an awned-spring wheat (Pitic-62). Several embryos differentiated and one produced a plantlet. When the plant was removed from culture, the chromosome number varied and was not confirmed as 42 until flowering. At flowering, all the $F_1$ spikes were awnless and fertile. One hundred $F_2$ plants were vigorous and grew to maturity, fully fertile and awnless, but required vernalization. Meiotic analysis of the parents, $F_1$ and $F_2$s, is to be continued.

## ENTOMOLOGY

### Population dynamics and pest management

*Alfalfa weevil.* During 1982, populations of the weevil in southern Ontario ebbed to their lowest levels in a decade. Lifetable studies showed that the fungus disease and two parasitic wasps were almost entirely responsible for the continuing decline. In the Bay of Quinte area, wasps of the first brood *Microctonus aethiopoides* Loan attacked and sterilized about one-third of the ovipositing weevils during the last week of May. In early June, epizootics of disease destroyed 96% of the feeding larvae and 42% of the cocoons. In early July, roughly one-quarter of the emerging adults contained larvae of *M. colesi* Drea, and during late July and early August, a similar number was attacked by wasps of the second brood *M. aethiopoides*. Generation survival fell to an all-time low of 0.6%.

In a study of disease and parasite interactions, it was shown that *M. colesi* does not compete directly with the disease organism for individual hosts; in undisturbed plots, and in plots where the disease was suppressed by treatment with captafol, peak emergence of *M. colesi* did not occur until the 3rd wk of June when epizootics had begun to subside, and the wasps attacked the late instar larvae through late June and early July. However, adult weevils containing larvae of *M. colesi* were multiparasitized by both broods of *M. aethiopoides*, and in such cases the latter prevailed. *Bathyplectes* spp., occasional parasites of the larvae, attacked the early instars in low numbers before, during, and after the

epizootic, but their effectiveness was reduced by at least 25% through death of diseased hosts.

A fully computerized multipest-crop system has now been developed for use in alfalfa integrated pest management (IPM). Termed SIMWEEVIL/SIMABL, the system automatically monitors seasonal development of the alfalfa weevil and the alfalfa blotch leafminer, together with their host crop, and describes actions to be taken by field scouts and growers. It is implemented through the Agriculture Canada VAX-11/780 system and is now available on-line to agencies throughout Ontario. During 1982, IPM scouts used the system to manage a total of 40 ha of forage alfalfa across Ontario with scouting circuits in the Grenville–Dundas, Haldimand–Norfolk, and Bay of Quinte areas.

*Alfalfa blotch leafminer.* During 1982, the epicenter of leafminer populations shifted westward to encompass the Bay of Quinte area. Lifetable studies showed that the native damsel bug, *Nabis ferus* (L.), destroyed almost one-half of the feeding larvae and that competition by the larvae for space and resources within leaflets resulted in a further shrinkage of 20%. High mortalities also occurred immediately following evacuation of the mine and in the pupal stage; pupal mortality was caused by the exotic wasp *Dacnusa dryas* (Nixon), which has successfully adapted to conditions in southern Ontario. A nursery for the parasite has been established in Ottawa.

Life history studies on *D. dryas* showed that there are three annual generations, precisely synchronized with those of its host. Peak numbers of adults coincide with peak numbers of the first instar host larvae in which they deposit a single egg. Hatching occurs in 4–5 days and the parasite larva develops slowly within the second and third instar hosts; when the host pupates, it develops rapidly and is fully grown in about 1 wk. The winter is passed as a mature larva within the host puparia.

A sequential decision plan has been designed for use in IPM. Derived from the negative binomial distribution, it utilizes counts of the eggs in a sample unit of four leaflets taken from randomly collected stems of alfalfa. In economic situations, the scheme will provide the grower with sufficient lead time to consider alternative action strategies. Appraisal of the plan by field scouts showed that it rated the infestation status of the leafminer correctly in 48 of 51 cases. Scouting time averaged 20 min per field.

### Honey bees

*Behavior and physiology.* Worker honey bees use odor cues when recognizing (accepting) their own queen or rejecting a foreign (introduced) queen. The odors that queens possess are acquired either from the hive environment or from pheromones that the queens produce themselves. Queen pheromones were shown to vary widely among individuals in both quantity and composition, and to convey information on the physiological state of the queen, reflecting differences in diet, rearing history, age, mating, and so on. Moreover, experiments with different lines of inbred queens showed that genetic factors also contribute in determining the pheromone diversity of queens.

*Disease.* Chalkbrood disease of honey bee larvae, caused by the fungus *Ascosphaera apis* Maasen ex Claussen, has increased in severity and area of distribution in Canada over the past decade. An inoculum of $10^8$ *A. apis* spores applied in a 10-g cake of fresh pollen and sucrose will produce a rapid, linear increase in numbers of dead larvae (mummies), and the degree of infection may be determined from numbers of mummies collected in Nelson traps, which prevent the bees from removing cadavers from the hive. The development of infection was partly reduced in colonies when either octanoic acid or salicylic acid fungistats were given in food simultaneously with the inoculum. Infection was largely prevented by limewater (calcium hydroxide in water) painted on the internal surface of the hives. The fungus develops best in a slightly acidic environment and probably was inhibited by the alkalinity of the lime, which may alter the acid–base ratio in the larvae. The adult bees continually remove the lime from the hive walls and may transfer it to the larval food.

## FORAGE CROPS

### Alfalfa

The main objectives in alfalfa breeding have centered on yield, *Phytophthora* root rot (PRR) resistance, and selection for better nitrogen fixation.

Four cutting schedules of alfalfa were compared on six cultivars. The schedules were three cuttings at early bloom (S1) or at bud stage (S2); combinations of two cuttings at bud stage and one cut at mid-bloom as cut 1 (S3) or as cut 2 (S4). Highest dry matter yields (9777 kg/ha) and crude protein (1877 kg/ha) were obtained in S1; the yields of S3 and S4 were slightly lower, but those of S2 were significantly lower. In vitro digestibility of dry matter was inversely related to acid detergent fiber and acid detergent lignin. Among the six cultivars, Angus produced the highest dry matter yield (9180 kg/ha). Algonquin produced the highest crude protein (1741 kg/ha), whereas Saranac produced the lowest dry matter and crude protein. Dry matter yield data of cut 1 (at early bloom) in 1982 suggested that Angus, Vernal, and Iroquois have better potential for maintaining stand vigor than Algonquin, Thor, and Saranac. Also, cut 3 taken at the end of August or later on must be at early bloom or a later stage of maturity in order to maintain good stand vigor in the subsequent year.

Twenty-six isolates of *Phytophthora megasperma* Drechsl. were tested individually for their quantitative virulence on three phytophthora root rot-resistant cultivars (Apollo, 120, and Trident) and three susceptible (Algonquin, Banner, and Saranac) alfalfa cultivars. Seven isolates were differentiated as belonging to one highly virulent pathotype. These were morphologically characterized by having small-spored oogonies. The remaining less virulent isolates have large-spored oogonia.

Nitrogen-fixation subpopulations of three alfalfa cultivars were obtained and tested, with another cycle of selection for high and low efficiency under way.

Two trials were established to study different management practices on forage legumes (alfalfa–red clover, white clover, and bird's-foot trefoil) as plow-down crops, and to determine their effects on subsequent crops.

*Pathology. Verticillium albo-atrum* Reinke & Berth., the cause of alfalfa wilt, showed a strong ability to survive in alfalfa stems through a temperature range of –5°C to 35°C for 6 mo in the laboratory, comparable to outdoor temperatures. This indicated that infected alfalfa stems are likely to be a major source of inoculum and an agent for widespread distribution of the pathogen. However, nonsterile raw soil seemed to have a considerable suppressive effect upon the regrowth of the pathogen from host tissues. Certain isolates of *Phythium irregulare* Buisman, *Fusarium oxysporum* Schlecht., and *F. equiseti* (Cda.) Sacc., obtained from several counties of eastern Ontario, proved to be pathogenic to alfalfa seedlings, indicating their possible role in the root rot complex.

**Grasses**

The emphasis in grass breeding is on cultivar development and the evaluation of breeding techniques for autopolyploids. The main selection criteria for timothy and bromegrass are improved forage quality and dry matter yield. Extensive progeny testing is in progress and over 100 timothy synthetics are being advanced to the Syn-2 generation. Orchardgrass is being evaluated as a pasture species using frequent defoliation. Selection criteria are stable seasonal yield, improved forage quality, and winterhardiness. Vigorous plants with exceptional winterhardiness have been identified in the cultivar Kay.

Methods of parental selection for yield and digestibility are being investigated in timothy. Techniques developed for the generation of large numbers of second generation synthetics continue to be refined. An assessment of genetic variability for some physical indicators of forage quality is being made in timothy.

**Corn**

*Breeding.* Five new hybrids were supported for licensing: OX713, OX715, and OX719 in Ontario, and OX698 and OX701 in Manitoba. Commercial seed production and marketing rights for all of them have been awarded. The hybrids for Ontario are three-way crosses that require 2575 corn heat units (CHUs) to mature. They have excellent stalk and root strength, which derives from a series of inbreds developed by backcrossing with Iowa Stiff Stalk Synthetic as the nonrecurrent parent.

Hybrid OX698 is a single-cross that has shown exceptional yield, maturity, bushel weight, and stalk and root strength in Manitoba. Hybrid OX701 is a three-way cross and, like OX698, requires 2250–2300 CHUs to reach maturity.

Emphasis continued on the development of modified single-cross hybrids as a means of

resolving the difficulties encountered in economic seed production of recently released, very early maturing, true single-cross hybrids. However, a survey of seed production fields failed to show that the problem was significant as reported. It is postulated that seed production of early maturing hybrids may require a cooler environment than exists in southwestern Ontario.

### Soybean

*Breeding.* Two lines were supported for licensing by the Ontario Oil and Protein/Seed Crops Committee. Line OT80-18 required only 3 or 4 days more to mature than Maple Amber but yielded 13% more. It is also tolerant to the herbicide metribuzin. Line OT80-12Y matured midway between Maple Presto and Maple Amber, but yielded almost as much as Maple Amber. It has also shown outstanding performance in yield trials in Manitoba and Alberta. However, the line is sensitive to metribuzin and formal licensing steps will be delayed for 1 yr while the problem is assessed.

A narrow-leaflet (*ln ln*) isoline of Maple Presto has been developed and will be released as germ plasm. The high-pod line OT82-11 yielded, over five locations, 89% as much as Maple Arrow. The bottom pod height was 15 cm compared to 9 cm for Maple Arrow.

*Pathology.* Ten soybean cultivars (Maple Arrow, Maple Presto, Evans, Portage, Altona, McCall, Maple Amber, BD2215-13, K351-1, and PI153-293) were susceptible to races 2, 4, 5, 6, 8, and 10 of the soybean bacterial blight pathogen, *Pseudomonas syringae* pv. *gylcinea* Young, Dye, & Wilkie. Forty-seven isolates of the pathogen, collected from eastern Ontario, produced susceptible reaction on Maple Presto. It is highly probable that race 4 is widely present in this area. Intensive sampling in eight growers' fields indicated that during early- to mid-season bacterial blight is distributed in a nonrandom pattern, but later it becomes more or less regular or uniform throughout the field. Sampling along some predetermined path (W- or X-shaped) would be more appropriate than random sampling for estimating the incidence of this disease.

## GENETIC ENGINEERING

### Developmental plant physiology

An in vitro survey of commercial alfalfa (*Medicago sativa* L.) cultivars and wild strains (*M. sativa* L. and *M. falcata* L.) showed that 58% of the lines tested underwent somatic embryogenesis and plant regeneration. The best response was obtained with creeping rooted cultivars such as Rangelander (93% embryogenic), Rambler (62%), Kane (45%), Heinrichs (38%), and Roamer (34%). In some cultivars embryos formed directly on primary callus, whereas others required a brief high auxin (2,4-D) treatment followed by culture on hormone-free medium.

A system for regenerating alfalfa plants from leaf and cell culture-derived protoplasts was developed. Efficient protoplast isolation and culture was dependent on a rapid growth state in the donor tissue. Protoplasts cultured in Kao medium at a density of $1 \times 10^5$/mL developed into callus colonies. Embryos which differentiated on the colonies could be cultured and regenerated into plants at an efficiency of 26%.

A basic procedure for the isolation and culture of alfalfa meristems was established. In 12 cultivars tested, a survival rate of 40% was observed.

Methodology for high frequency (>75%) shoot regeneration in thin epidermal layer explant cultures of canola and broccoli was developed. The best response occurred when explants were excised from the upper stem of flowering plants and cultured on Murashige-Skoog medium supplemented with high (>5 mg/L) cytokinin levels. Shoots were rooted on hormone-free medium.

### Experimental haploidy

Pollen isolated from canola anthers was cultured in a modified Nitsch liquid medium supplemented with 13% sucrose and 0.25% potato extract. Embryogenesis occurred at frequencies of 0.1% when the cultures were subjected to an initial 12–72 h culture period at 32.5°C or 35°C prior to maintenance at 25°C. Plants were regenerated by culturing the pollen embryos on solid $^1/_5$ medium supplemented with a high cytokinin-to-auxin ratio.

More than 4000 embryos were obtained by culturing anthers of four winter × spring canola hybrids on liquid medium at densities of 18 anthers per millilitre. These were

shipped to the University of Guelph for plant regeneration and evaluation.

### Somatic cell genetics

Totipotent, embryogenic callus cultures of bromegrass cultivar Manchar were plated on streptomycin-containing medium and a number of potential streptomycin-resistant regenerates were obtained. Embryogenic callus cultures were initiated from a variety of explants in corn, barley, and *Triticum crassum* (Boiss.) Aitch. & Hensl. Tests with embryogenic alfalfa cell suspension cultures were initiated to identify appropriate conditions for mutant isolation.

Ten different azauracil-resistant variants were isolated from embryogenic eggplant cell cultures. One line displayed an unusual ability to undergo embryogenesis in the presence of 2,4-D.

Procedures for protoplast isolation and culture in eggplant, tomato, potato, and wild *Solanum* spp. were developed for application to somatic hybridization. Plants were regenerated from protoplasts of eggplant and *Solanum aviculare*.

### Molecular genetics

To identify species amenable to genetic transformation, cultivars of eggplant, tobacco, tomato, sunflower, alfalfa, broccoli, canola, and mustard were assessed as hosts for five *Agrobacterium tumefaciens* (Sm. & Towns.) Conn strains, and optimal conditions for crown gall induction and maintenance in culture were identified. High-frequency shoot proliferation was observed on broccoli, canola, and mustard tumors. Abnormal shoots lacking ability to root were predominant; however, in broccoli some normal-appearing rooted plantlets were obtained.

Experiments on transformation of alfalfa protoplasts with Ti plasmid DNA were undertaken. Several potentially transformed colonies were selected on hormone-free medium. Opines were detected in some of these colonies indicating the presence of functional T-DNA sequences, thereby providing evidence for genetic transformation.

Studies on microinjection of protoplasts were initiated to develop a system for high frequency transformation. Procedures for immobilizing protoplasts and accurately detecting nuclei were developed.

## ORNAMENTALS

### Floriculture

Flower initiation of the New Guinea *Impatiens* 'Starburst' was insensitive to photoperiod at 15°C and 20°C; however, shoot elongation and apical dominance were affected by photoperiod. In a 6-h photoperiod, short periods of light interrupting the dark period inhibited shoot elongation but enhanced flower development, correlating positively with shoot elongation. The increase of open flowers in short days was due to loss of apical dominance and development of flowers on lateral branches. Similar results were obtained in a 12-h photoperiod: interruptions of the night, simulating long-day conditions, resulted in strong apical dominance and a low production of flowers.

A new cultivar of New Guinea *Impatiens* 'Northern Sunset' was introduced with unique flower color combination of deep red and deep orange. It arose as a spontaneous mutant during vegetative propagation of the cultivar Orange Chiffon.

Leaf explants from photoinduced *Streptocarpus* produced flower buds in vitro in noninductive photoperiods correlating positively with the number of inductive short days, providing a physiological estimation of the quantitative development of flower-inducing stimuli. Leaf explants from vegetative plants also could be photoinduced in vitro, providing a means to study photoinduction in the absence of correlative influences of other plant organs.

Shoot explants of M26 apple rootstocks from shoot multiplication medium could be rooted directly in mist frames, eliminating the in vitro rooting stage. Ninety-two percent of the shoots developed roots, resulting in 83% plant establishment, and at a significantly higher rate than the standard micropropagation procedures, including an in vitro rooting stage. Elimination of the in vitro rooting stage and the enhanced plant establishment offers significant benefits to these programs.

Adventitious shoot formation on leaf explants of *Begonia* ×*hiemalis* Fotsch. was greater on explants from plants grown in long days (16 h) than on those grown in short days (8 h). Shoot formation on petiole explants showed a similar, less pronounced response. Temperatures of 15°C and 20°C, at which stock plants were grown, did not affect the in

vitro response; 20°C was superior to 25°C for adventitious shoot formation.

Stable free radicals promoted ethylene production in vitro and in plant tissues. The interrelationship of free radical promoted indole acetic acid (IAA) degradation and decreased ethylene production, and at the same time promotion of its production per se was recognized. The radical scavengers hindered the radical-promoted IAA degradation. Bromoxynil hindered the free-radical promoted ethylene production in plants. Inhibitors of the cyanide-resistant respiration inhibited ethylene synthesis in plants. The cyanide-insensitive pathway is a prerequisite for the stimulation of respiration by ethylene, since it has no effect on tissues whose respiration is strongly inhibited by cyanide. The compounds 8-hydroxyquinoline, isothiocyanate, 2-thenoyltrifluoroacetone (TTFA), and disulfiram retarded ethylene production. Sulfhydryl (SH) compounds and aminocylopropane carboxylic acid did not overcome the effects of (TTFA) and disulfiram.

Polyamines prevented ethylene-caused deterioration of plant cell permeability. The nuclear magnetic resonance (NMR) spectra of fresh, aging, or ethylene-aged petals of rose, carnation, and chrysanthemum showed that the values of nuclear spin relaxation times, $T_1$ and $T_2$, were considerably higher in the aged petals, indicating that the proton (water) movement in the cell membranes was restricted there.

*Mimulus*, *Bouvardia*, and *Lisianthus* plants and some of their cultivation practices were described.

**Pathology**

Steam-treated field soil, optimally up to 30%, when added to soilless growing media significantly protected against damping-off, caused by *Rhizoctonia solani* Kühn and *Pythium aphanidermatum* (Edson) Fitzp., in several species of bedding plants.

*Pythium ultimum* Trow considerably damaged outdoor tulips in the Ottawa area in 1982. The fungus, apparently present in imported bulbs, resulted in failure of the plants to produce roots and strong leaves. Drenching the soil with fungicide Lesan controlled the disease in greenhouse. Preplant dipping of bulbs in Lesan, Truban, and Ridomil also controlled the disease.

*R. solani*, introduced into soil or soilless mixtures previously inoculated with *P. aphanidermatum*, decreased damage to roses and poinsettias significantly. When the two fungi were introduced simultaneously into the growth media, the damage to poinsettias was significantly less than in mixtures inoculated with either fungi alone. Sterile filtrates from three strains of *R. solani* inhibited growth of *P. aphanidermatum* in vitro.

Several fungicides used as soil drenches to control *Pythium* spp., *R. solani*, and *Fusarium* spp. caused phytotoxicity in a number of bedding plants depending on type of growing mixture, temperature, moisture, and pH. Reaction to chemicals varied considerably between plant species and different cultivars.

**Ornamentals garden**

In annual trials, 219 cultivars of marigolds *Tagetes erecta*, *T. patula*, and *T. tenuifolia* were tested. Sunbeam was the best dwarf, Burgundy Ripple the best medium height, and Mammoth the best of the tall plants. One hundred and forty-four cultivars of painted nettle (*Coleus blumei*) were also rated. The top cultivars were Brilliant Mix, Emerald Pink, and Fiji Blush. Carnation (*Dianthus caryophyllus*) and the Chinese pink (*D. sinensis*) were evaluated: the best carnation was Orange Knight, and the best Chinese pink was Queens Court. The top rated cultivars of *Cosmos* were Radiance and Sunset. Other evaluated and outstanding plants were *Delphinium* 'Blue Dwarf' and *Hibiscus* 'Disco Belle'.

**Plant breeding**

The aim of the breeding program is to improve the winterhardiness, flowering, and ornamental features of roses, *Weigela*, and *Forsythia*.

Two winterhardy roses were registered. The cultivar Champlain is an everblooming bush rose with dark red flowers, obtained by crossing hardy roses and *Rosa* ×*kordesii*. The cultivar Charles Albanel is a hybrid of *R. rugosa*, which flowers repeatedly and is very resistant to black spot, *Diplocarpon rosae* Wolf, and mildew, *Spaerotheca pannosa* (Wallr. ex Fr.) Lév. It is suitable as a ground cover. Inheritance studies of *R. rugosa* Thunb. were continued. Inheritance studies of style length in *Forsythia* indicated that in crosses between short style parents, the

homozygous zygotes for the short style trait are eliminated, resulting in a ratio of 2:1 instead of 3:1. New *Weigela* selections with intensely colored purple foliage were obtained. Crosses between different parents were analyzed for the segregation of purple foliage; the ratios could be explained by a two-factor hypothesis.

### Nursery research

Deep hardwood chip mulch caused poor plant performance in poorly drained soils. Thaw was delayed under mulch, resulting in severe and lethal growth desiccation during warm air temperatures. Waterlogging was enhanced there and caused rooting into the mulch, resulting in nutrient deficiencies and desiccation during dry periods. Mulch application of less than 10 cm is recommended in poorly drained sites.

Overwintering of 1-yr-old container-grown cuttings of *Cotoneaster dammeri* and soil–plant–air temperatures were determined in the winter of 1981–1982 to test the usefulness of Coroplast structures for overwintering of nursery stock. In Coroplast and "polyhouse" structures, great daily temperature fluctuations and extensive winterkill were evident. Coroplast plus polyhouse combination prevented winterkill by reducing temperature fluctuations and increasing the daily minimum soil–plant–air temperatures, thus providing an excellent system for overwintering containerized nursery stock.

A system for preparation of endomycorrhizae inoculum using marigold roots was established. Seedlings of *Euonymus fortunei* (Turcz.) Hand.-Mazz. 'Coloratus' and rooted cuttings of *E. fortunei* 'Emerald Gaiety' responded to mycorrhizae treatment: *Glomus* mycorrhizae spp. increased plant growth in stem height and leaf growth at the expense of branching and branch leaf growth, and delayed leaf fall color development and abscission in non-P- and high-P-treated systems. Enhancement of rooting of softwood cuttings by mycorrhizae could not be demonstrated for seven common ornamentals. Initially, mycorrhized roots were less developed than nonmycorrhized ones, but the percentage of rooting was similar. After transplanting, the mycorrhized cuttings grew better and developed larger root and shoot systems. Manipulation of plant growth, form, vigor, and length of the growing season by mycorrhizal treatment are being investigated.

## PLANT GENE RESOURCES

### Plant gene information

Inventories of Canadian oat genetic resources were published in 1982. These are computer-produced lists of cultivars and genetic stocks classified under 83 traits. Descriptions for close to 7600 stocks of alfalfa, barley, oats, tomatoes, and wheat have been obtained to date, with 767 of these in 1982. The information on each stock is stored in the respective crop data banks, and computer trait inventories on the five crops are available.

### Conservation

More than 69 000 seed stocks of various plant species are being preserved under controlled conditions at the Plant Gene Resources of Canada (PGRC) Office. The seed facilities include 54 $m^3$ at 4°C and 20% relative humidity for medium-term storage and 145 $m^3$ at −20°C, using airtight containers, for long-term storage. Additional material received in 1982 under Canada's participation in the program of the International Board for Plant Genetic Resources for the preservation of international collections of valuable germ plasm, included collections of pearl millet, oats, barley, rapeseed, and mustard from Cameroon, Mali, Niger, Senegal, Togo, Benin, Syria, Jordan, Central African Republic, and West Germany. Almost 2750 of these collections are preserved in the seed stores.

### Exchanges

In 1982, activities in connection with exchanges of genetic stocks and cultivars involved 325 exchanges with individuals in 37 countries for a total of 6650 accessions.

Under the Canada/USSR 1981 Agreement on Agriculture Cooperation a scientific exchange mission was in the Soviet Union from 9 to 20 August 1982. Institutions visited included the N.I. Vavilov Institute of Plant Industry in Leningrad, responsible for the collection, evaluation, and identification of germ plasm for the Soviet Union, the National Seed Bank at the Kuban Experiment Station, and the Soviet Ministry of Agriculture in Moscow. The mission provided an excellent opportunity to establish personal contacts and to learn about the Soviet activities on plant gene resources and other related research programs.

### Newsletter

The PGRC newsletter, which was started in 1976, has a mailing list of 726 individuals, 550 in Canada and 176 in 37 other countries. The semiannual newsletter reports informally on activities in Canada and elsewhere, in connection with plant gene resources.

## EXPERIMENTAL FARM KAPUSKASING, ONT.

### Forage management

The common practice in northern Ontario is to cut or pasture bird's-foot trefoil almost anytime during the growing season. The need for a fall rest period to ensure good forage production is not well known. During the past 3 yr, three cultivars, Empire, Viking, and Leo, were subjected to a schedule of fall cuttings starting on 10 August and every 7 days until 28 September. Harvesting about 24 August reduced succeeding dry matter yields of the first cut to the lowest level for the three cultivars. Dry matter yields of the first cut were at their maximum when all three cultivars were harvested after 15 September, which would be after the critical fall rest period. Among the three cultivars evaluated, Empire appeared to be the most sensitive to the fall rest period, as the yields were 40% higher after 15 September, followed by Viking at 24% and Leo at 17%. An earlier study to compare the fall rest period of Leo trefoil to Iroquois alfalfa produced similar response. These results emphasize the need for a fall rest period and indicate that Empire and Viking are less tolerant to abuse than Leo.

### Cereal management

In a trial first sown in 1981 and repeated in 1982, two cultivars of barley, Laurier with large seed and Vanier with small seed, were sown at seven different seeding rates. The seeding rates were 50, 80, 110, 140, 170, 200, and 230 kg/ha, which represented 111, 178, 245, 311, 377, 444, and 511 seeds per square metre for Laurier and 166, 266, 365, 465, 564, 664, and 764 seeds per square metre for Vanier. A seeding rate of 444 and 465 seeds per square metre for Laurier and Vanier, respectively, produced the highest grain yields for two consecutive years. A seed population of 444 seeds per square metre for Laurier produced on the average 242–526 kg/ha more grain than all other seeding rates, whereas a population of 465 seeds per square metre for Vanier outyielded all other seeding rates by 399–1183 kg/ha. It would appear that a seeding rate between 425 and 475 seeds per metre is required to obtain maximum grain production. This would lead to different seeding rates per hectare for large- and small-seeded cultivars, because the large-seeded one would need a higher seeding rate than the small-seeded one to obtain a predetermined number of plants per square metre.

## EXPERIMENTAL FARM THUNDER BAY, ONT.

### Potato management

On 22 May 1982, tubers of 11 cultivars of potatoes were seeded for the purpose of tuber sizing and total yield. Prior to seeding, 8-16-16 at 560 kg/ha was broadcast. At seeding, 8-16-16 at 1120 kg/ha was banded with seed. Linuron at 1.0 kg/ha was sprayed on 4 June. On 22 July, a solution of Thiodan at 1.1 kg/ha and Manzate at 1.0 kg/ha was sprayed to control Colorado beetles and potato blight.

Harvesting took place on 9, 19, and 30 August, with final harvesting on 20 September 1982.

Conditions during the growing season were wet and cold, with a precipitation of +79.2 mm, of which 80% fell in the first 2 wk of July. Sunshine hours for July were −36.1. The 10-yr mean is 273.1 h. During 1982, a total of 237.0 h was received.

The top-yielding cultivar for the 9 August harvest was Yukon Gold at 31 574 kg/ha. Superior ranked second with 27 269 kg/ha. Jemseg, the top-yielding cultivar of 1981, ranked 10th, with a mean marketable yield of 13 395 kg/ha. The cultivars Rideau and Michimac tied for the top yield in August, with 42 338 kg/ha. Yukon Gold ranked fifth for the late-harvest date.

The hot, dry season of 1981 suited the varieties Jemseg (first), Nipigon (second), and Yukon Gold (third), whereas the cool, wet season of 1982 saw Jemseg and Nipigon with significantly lower yields. Jemseg at 13 395 kg/ha ranked 10th, and Nipigon with 19 614 kg/ha ranked ninth. Yukon Gold at 32 651 kg/ha ranked first.

Yukon Gold, a yellow-fleshed potato with pink eyes, had demonstrated the ability to

produce good yields in either hot, dry seasons or cool, wet seasons in northern Ontario. Yukon Gold is an excellent-tasting potato with good storage qualities.

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| N. Gibson-MacDonald<br>Transferred to Canadian Centre for Health and Safety, March 1982 | Librarian |
| C. M. Simpson<br>Retired December 1982 | Pesticide evaluation |

## EXTENSION SERVICES[4]

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| D. Ridgway | Fruit and vegetable crops |

[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]Appointed 3 May 1982.
[3]Appointed 4 January 1982.
[4]Ontario Ministry of Agriculture and Food, Trenton, Ont.

# INTRODUCTION

The Vineland Research Station serves the horticultural industry with a broad program of crop protection research. The multidisciplinary, mission-oriented program includes the application of entomology, acarology, virology, mycology, nematology, residue chemistry, and engineering to a variety of crops, ranging from tree fruits, grapes, small fruits, and vegetables to ornamentals, forage crops, and tobacco. The Smithfield Experimental Farm, located west of Trenton, is administratively linked to this Station and carries on horticultural production and processing research, as well as pest control research programs in cooperation with Vineland.

This report summarizes some of the research results from the Station in 1982; more detailed information can be obtained from the publications listed at the end of the report. For more information on these or other research projects, or for copies of this report, please write to the Director, Research Station, Research Branch, Agriculture Canada, Vineland Station, Ont. L0R 2E0.

D. R. Menzies
Director

## INSECTS AND MITES

### Integrated pest management (IPM)

*Pest management (manipulation of natural enemies).* A strain of *Chrysopa carnea* Stephens that is highly resistant (500×) to organophosphate pesticides has been identified and a method has been developed to mass rear these predators for innundative release. Another lacewing, *C. oculata* Say, has been found to be highly susceptible to a wide range of pesticides, and because the adult stage is as susceptible to pesticides as first instar larvae, this predator shows less potential for use in an integrated control program than *C. carnea*. A pesticide application at any time during its life cycle would be extremely disruptive.

A survey of the parasites of tentiform leafminer (TLM), *Phyllonorycter blancardella* (Fabricius), in major apple-growing areas in Ontario was completed and the major parasite identified was the braconid *Apanteles ornigis* Weed, with several chalcid wasps also showing importance. Although 30 other parasites were identified, *A. ornigis* was shown to prefer the first to third instars of TLM and shows the greatest potential for use in an IPM program as a means of reducing the size of the TLM population. *A. ornigis* is being mass reared for release in test orchards.

Two parasites of San José scale have been identified and will be used in pest management studies. Several parasites of spring feeding caterpillars have been reared and will also be studied. An egg card technique was developed for monitoring the egg parasite *Trichogramma* spp. of codling moth and other Lepidoptera, and was used in several localities in southern Ontario. To date, only *T. pretiosum* Riley has been recovered.

*Management and control of carrot insects.* Eight commercial carrot fields were monitored, using the carrot root-piece monitoring technique for ovipositional activity. Sprays for carrot weevil (CW), *Listronotus oregonensis* (LeConte), were recommended in six fields and where phosmet was applied as recommended, CW damage was nil or very light; in two fields where treatment was not recommended owing to light ovipositional activity, no serious CW damage occurred. This information will provide a tentative action threshold for spray decision-making.

### Ecology

*Monitoring of tentiform leafminer (TLM), Phyllonorycter blancardella (Fabricius).* Pheromone trap catches of TLM males are highly correlated with both male and female emergence, and the numbers of males caught are correlated with the amount of pheromone used. Even at low levels of pheromone in the traps, the catches accurately indicated emergence and activity in the field. This suggests that if smaller amounts of pheromone are used, fewer moths need be counted to give a reliable measure of the TLM population activity, and will result in a considerable saving of time.

The validity of using 40 ± 12 degree-days (DD) above 6.7°C, summed from 1 April, for

predicting first spring emergence of the spotted tentiform leafminer was tested. In Ontario's major apple-growing areas from 1978 to 1981, the observed day of first emergence occurred 12–45 days before the predicted day. An alternative method, summing DDs from 1 March above a base temperature of 5.5°C, was also tested using three methods. The number of DDs accumulated to the day of first emergence and to the day of 50% cumulative emergence varied greatly between years at one location and between locations during one year. A more thorough understanding of the relationship between habitat temperature, and weather factors such as temperature, insolation, and snow cover is necessary to develop a reliable predictive index.

**Chemical control**

*Evaluation of new acaracides.* In field tests of mixed populations of European red mite, *Panonychus ulmi* (Koch), and twospotted spider mite, *Tetranychus urticae* Koch, both partially resistant to cyhexatin and dicofol, the following experimental acaricides were very effective: NC 21314, Bay SLJ 0312, and WL 41706. In laboratory tests, NC 21314 and Bay SLJ 0312 were nontoxic to the predator *Amblyseius fallacis* Garmen and have high potential for use in the apple IPM program.

*Toxicology.* The toxicity of several commonly used pesticides were evaluated for their effect on beneficial species. The residual toxicity of pyrethroids and the organophosphates azinphosmethyl and phosmet to *Chrysopa* sp. was greater (10–14 days) than was the toxicity of phosalone (3–5 days). Pyrethroids were also toxic to the reduviid *Acholla multispinosa* (DeGeer) for 10–14 days. First instar assassin bugs were highly susceptible to most insecticides except phosmet and endosulfan, whereas first instar nymph and adults were highly susceptible to permethrin, cypermethrin, parathion, and methomyl.

*Resistance of European red mite (ERM) to cyhexatin and fenbutatin oxide.* Five orchards were tested for resistant populations of mites, and 11 orchards that had received additional treatments of cyhexatin since 1981 were reassessed. Tenfold resistance to cyhexatin is possible in two orchard strains of ERM and seemed to be single-gene type. Approximately 60% of the mite populations in two orchards were of resistant genotypes. High levels of cross-resistance have been confirmed between cyhexatin and the organotin fenbutatin oxide, indicating that if full resistance to cyhexatin develops in Ontario orchards, no control can be expected from either compound. A strain of organophosphate-resistant *Amblyseius fallacis* Garmen, an excellent predator of ERM, could not be established and maintained in orchards at levels sufficient for control.

*Evaluation of pesticides.* On small plum trees (1.5–3 m) fall applications of spray oil in volumes of $H_2O$ at 787–2360 L/ha controlled heavy infections of San José scale in a single season. On 6–8-m apple trees, volumes up to 6900 L/ha did not give complete control in a single season, and it is not clear, at this time, how directly spray volume affects controls of scale insects.

*Insecticide evaluation.* An extensive insecticide testing program was conducted to evaluate the efficacy of chemicals and application methods against European red mite, *Panonychus ulmi* (Koch); pear rust mite, *Epitrimerus pyri* (Nalepa); pear psylla, *Psylla pyricola* Foerster; oriental fruit moth, *Grapholitha molesta* (Busck); mealy plum aphid, *Hyalopterus pruni* (Geoffroy); apple aphid, *Aphis pomi* De Geer; and tentiform leafminer, *Phyllonorycter blancardella* (Fabricius).

*Insect pests of ornamentals.* The major insect pest of the floriculture industry in Ontario is chrysanthemum leafminer, *Liriomyza trifolii* (Burgess), on chrysanthemum. Leafminer resistance to permethrin has been evident for several years. Tests in the laboratory have shown that permethrin combined with piperonyl butoxide at the rates 0.6 and 3.0 mL/L, respectively, will control leafminer adults. Pyrazaphos (Afugan), applied as a foliar spray to chrysanthemum under commercial growing conditions, provided excellent control of leafminer larvae. Registration of pyrazaphos is being pursued in Canada. Methoprene (Minex 5E), applied as a soil drench as recommended under commercial growing conditions, did not provide adequate control of leafminer.

## NEMATOLOGY AND CHEMISTRY

### Host–parasite relationships

*Potatoes.* A survey of 50 potato fields in Simcoe County, Ont., representing 5600 ha, revealed that genera of plant-parasitic nematodes comprising 13 species were present. Two known potato pathogens, *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. and *Meloidogyne hapla* Chitwood, were present in 32 and 12 fields, respectively. Two other root lesion nematodes, *Pratylenchus crenatus* Loof and *P. neglectus* (Rensch) Filipjev & Stekh., occurred in 12 and 7 fields, respectively. *Paratylenchus projectus* Jenkins, *Tylenchorhynchus claytoni* Steiner, and *Merlimius brevideus* (Allen) occurred in 14, 13, and 3 fields, respectively. The remaining six species, *Helicotylenchus digonicus* Perry, *H. platyurus* Perry, *H. pseudorobustus* (Steiner) Golden, *Paratylenchus hamatus* Thorne & Allen, *Scutylenchus quadrifer* (Andrassy) Jairajpuri, and *Xiphenema americanum* Cobb, were found in one field each.

### Ecology

*Sugar beets.* The effect of plant age and transplanting damage on sugar beets *Beta vulgaris* L. 'Monogerm C.S.F. 1971' infected by *Heterodera schachtii* Schmidt was determined. Sugar beets sown into nematode-infested soil are damaged much more heavily by *H. schachtii* juveniles than seeds inoculated with the nematode immediately following sowing. An increase in tolerance of sugar beets to attack does not occur beyond the first 2 wk of growth and transplanting damage lowers the tolerance of seedlings to nematode attack.

### Control

*Oxamyl.* The movement and degradation of oxamyl in peach seeds, seedlings, soil, and pots were determined. Peach seeds coated with oxamyl were planted individually in sterilized soil in clay pots. One week later, residues of oxamyl in the soil and the pots were 5.7 and 1.4 mg/kg, respectively. The corresponding oxime was also found, but intact oxamyl constituted 97% and 52% of the total residue in the soil and pots, respectively. There was no evidence of oxamyl degradation on the treated seeds 3 wk after planting. Residues of oxamyl in leaves 2 and 3 wk after sowing were 4.8 and 2.7 mg/kg, respectively; similar oxime residues were 4.3 and 4.8 mg/kg.

*Effect of insect growth regulators on nematode development.* The insect growth regulators (IGRs) diflubenzuron and Bay Sir 8514 with active ingredient (a.i.) at 300 and 1000 mg/kg in potato dextrose agar inhibited the radial growth of the fungus host *Rhizoctonia solani* Kühn of *Aphelenchus avenae* Bastian. The IGRs had no effect on the growth of the bacterium host *Pseudomonas pseudoalcaligenes* Stanser of *Acrobeloides nanus* deMan and *Diplogaster iheritieri* Maupas. At 300 mg/kg, both compounds inhibited the population development of *A. nanus* and *D. iheritieri.* With single females of *A. nanus* and *D. iheritieri*, both IGRs at 300 mg/kg reduced egg laying, inhibited embryonation, and slowed larval development.

*Control of nematodes on gladiolus.* In greenhouse tests on gladiolus corms, over 22 wk, the pin nematode multiplied from 100, 1000, or 10 000/12-cm pot initial density to 5000, 5000, and 120 000/pot final density; high nematode numbers were correlated with smaller corm sizes. In field tests, all at a rate of 2.3 kg/ha, phenamiphos (Nemacur) provided the most effective control of pin nematode on gladiolus, followed by oxamyl (Vydate), aldicarb (Temik), carbofuran (Furadan), and fensulphothion (Dasanit); nematode counts with the last named compound were higher than the checks (near 30 000/kg of soil). At rates of 2.3–11 kg/ha (in 2.3-kg increments), none of the compounds produced any serious phytotoxicity to gladiolus; aldicarb produced a tipburn on early season leaves, with no evident effect on final yield.

## PLANT DISEASES

### Fruit crops

*Nematode transmission of the peach rosette mosaic virus (PRMV).* Comparative transmission trials with *Longidorus diadecturus* (Eveleigh & Allen) and a *Xiphinema* species collected near PRMV-infected peach demonstrated that both species acquire the virus from peach and transmit it to cucumber. Enzyme-linked immunosorbent assay (ELISA) and bioassay tests on cucumber indicated relative transmission efficiencies of 69% and 15%, respectively, for *Longidorus*

and *Xiphinema* species. Numbers of nematodes per cucumber plant ranged from 3 to 8. Transmission trials were expanded to small fruit and tree fruit cultivars other than peach to determine the potential host range of the virus.

*Occurrence of tomato blackring virus in the Niagara Peninsula.* The first occurrence of tomato blackring virus (TomBRV) in North America was reported in the Niagara Peninsula in Pinot Chardonnay imported from France. The virus was identified serologically with the European isolate and confirmed by host range tests. The soil nematode vector *Longidorus attenuatus* was not present and infected vines were removed and destroyed. The vineyard will be monitored for several years to determine whether further infection occurs. TomBRV is being examined for possible strain relationship to Joanne-Seyve virus.

*Resistant understock program.* The use of resistant understock on scion varieties susceptible to tomato ringspot virus was examined as a means to minimize the incidence and spread of virus infection in the vineyard. DeChaunac rooted on Sonona, SO4, 3309, 5BB, 44-53, and Concord and planted in an infected vineyard remained healthy over a 6-yr period. Productivity of DeChaunac rooted on Sonona and SO4 was similar to own-rooted vines. The mechanism of resistance is being studied.

To encourage the use of resistant understock in the industry, DeChaunac grafted onto Sonona understock will be supplied to growers on a trial basis as refills. This will permit long-term monitoring of resistance and spread of infection within the vineyard over a range of soil types and microclimates.

To evaluate the feasibility of commercial production of understock in the Niagara Peninsula, various training methods are being examined to determine conditions providing optimal wood production for each understock. In the first year of the study, Sonona and SO4 trellised with seven shoots per vine, produced the largest quantities of usable wood. Less wood was available from 3309 and 44-53 understocks.

*Evaluation of plant virus detection procedures.* The sensitivity and reliability of various methods of plant virus detection were studied. Of these, serologically-specific electron microscopy (SSEM) was the most sensitive assay, detecting virus at concentrations of 1 ng/mL. Virus acquisition by antibody sensitized collodion films was preferable to either sensitized formvar or evaporated carbon films and was uninfluenced by immunoglobulin purity or dilution. Collodion sensitized grids were stored for periods of 6 mo without significant loss of virus trapping ability. Diagnosis using SSEM could be made within 30 min for most viruses tested, while extended washing of grids to remove cellular debris had little effect on removing bound virus. ELISA and bioassay tests detected virus at 10 ng/mL and 100–300 ng/mL, respectively, the latter being the least reliable, possibly due to plant sap inhibitors. Sensitivity of the bioassay procedure was improved through uniform application of abrasive, controlled wilting of half leaves prior to inoculation, and incubation of leaves under continuous illumination at low $CO_2$ tension.

*Fruit diseases resistant to fungicides.* In 1982, resistance to benzimidazole fungicides (Benlate, Easout) in the apple scab fungus (*Venturia inaequalis*) was identified in three additional apple orchards, bringing the total to 18 locations in Ontario. Resistance to dodine (Cyprex) was shown in four orchards and is suspected of being widely distributed. The brown rot fungus (*Monilinia fructicola*) of cherry and peach was found, for the first time in Canada, to be resistant to benzimidazole fungicides. One of six strawberry fields contained *Botrytis cinerea* resistant to benomyl, and resistance had earlier been shown to be widely distributed in vineyards where *B. cinerea* causes bunch rot of grapes. The level of fungicide resistance in each case was sufficient to render the preferred fungicide ineffective, and acceptable alternatives are urgently needed to preserve the fruit industry.

## CONTRACT RESEARCH

### Mechanization

*Spray boom height control.* Nozzle-to-target distance variation was measured for various boom and sprayer designs. Tandem axles decrease nozzle-to-target distance by 48% compared to single axles. The "A" linkage-suspended boom varied 47% less than the center-suspended boom and 24% less than a rigid-truss boom. Tire pressure and tire size did not influence the nozzle-to-target distance variation.

### Energy conservation

*Product drying.* A mathematical model was developed that describes the drying process, and the preliminary design of a collector is completed to test the feasibility of using solar energy for desiccant regeneration.

## SMITHFIELD EXPERIMENTAL FARM

### Tree fruits

*Synanthedon bark borers in apple orchards.* Removal of larvae and pupae from burr knots on the trunks of commercial apple trees demonstrated that two species, *Synanthedon scitula* and *Synanthedon pyri*, are present in eastern Ontario orchards. The presence and flight activity of bark borer adults were monitored, using the Zoecon greater peach tree borer pheromone and the Conrel clear wing borer pheromone. In 1982, peak adult flights were observed from mid-July to late July. A trunk drenched with parathion or endosulfan applied when the adults were active provided control.

*Commercial juicing properties of apples.* The properties of apple cultivars required by juice plants are now being studied in addition to their canned sauce and frozen sliced pack qualities. Properties of commercial interest for juice include the storage ability of the fruit, fruit firmness, acid and soluble solids content, total yield on pressing, pressed "cake" characteristics, clarification properties after enzyme treatment, yield of readily available (siphonable) clarified juice, specific gravity, color, flavor, and aroma. A few varieties tested thus far, including Empire, Idared, Northern Spy, and McIntosh, have shown good juicing properties. Some scab-resistant cultivars (0-521), Macfree, and 0-622) also look promising in this regard.

*Growth of apple scion varieties on their own roots.* Softwood cuttings taken from commercial scion varieties were rooted in a polyethylene misting tent. Based on the rate of growth in the nursery most varieties would have to be grown for two seasons prior to placement in the orchard in order to obtain a suitable tree. The growth of 12 scion-rooted cultivars demonstrated that 2 yr after orchard planting the trees were intermediate in size between the same varieties on *M. robusta* 5 and 0–3 rootstocks. The trees on their own roots survived the severe winter temperatures that occurred in the winters of 1980–1981 and 1981–1982 when other trees were severely injured.

### Tomatoes

*Breeding.* Bellestar tested as ST-50 was released to the processing industry for coreless whole pack. This cultivar begins ripening several days after Earlirouge, but with concentrated ripening yields are higher within a week. Core size is small with a moderate stem scar and the size of 90 g makes machine harvest desirable. Other desirable characteristics include jointlessness, crack resistance, and firm fruit with excellent storage on the vine. The exterior is highly colored with slight ribbing, and the high crimson (*og*) gene gives excellent juice color comparable to Quinte. Bellestar forms a compact plant, allowing populations up to 25 000 plants per hectare. This cultivar is not intended for fresh market due to small fruit size.

*Management.* A spacing-variety trial conducted on three grower properties in Prince Edward County demonstrated the need for higher plant populations with some of the more compact vine types. With three varieties, Earlirouge, Bellestar, and Quinte, marketable yields increased as the population was increased from 13 000 to 26 000 plants per hectare. In a season such as 1982 with adverse weather conditions, Ethrel applied to Quinte gave the highest total marketable yields, with the earlier Bellestar and Earlirouge being less productive. However, by 17 September the marketable yields of Earlirouge, Bellestar, and Quinte were 44.2, 40.1, and 33.6 t/ha, respectively, at the highest plant density.

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## Research


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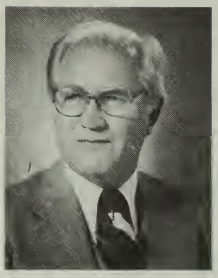
# WESTERN REGION
# RÉGION DE L'OUEST



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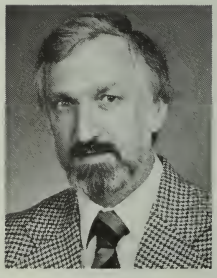
Dr. D. M. Bowden

Mr. H. C. Korven



Mr. I. M. Wood

Mr. J. J. McConnell

## EXECUTIVE OF THE WESTERN REGION
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# PREFACE

The Western Region consists of 15 research stations, four experimental farms, and eight substations, which serve agriculture throughout the Prairie Provinces and British Columbia. In 1982 the Region managed a budget of $58 million and employed approximately 350 professionals and 860 support staff in carrying out its research programs. The following are some highlights of achievements in the Region in 1982.

Cultivars of crops licensed were Medora durum wheat, Diamond and Leduc feed barleys, Dumont oats, Norlin flax, Westar canola, Walsh native western wheatgrass, and Carlton potato. Ornamentals released to industry were Autumn Blaze white ash, Northline silver maple, Wascana hybrid linden, Baron seedless boxelder maple, an *Alstroemeria* sp. (Peruvian lily), and a *Rieger* begonia. Westcot apricot was also released.

Natural resources research emphasizes efficient use of soil and water. Certain mycorrhizal fungi and bacteria in the soil were found to extract phosphorus from insoluble rock phosphate. A deflector attachment for swathers was developed that leaves a strip of stubble to trap snow moisture, thus helping to decrease the spread of dryland salinity.

Animal production research aims to increase efficiency and improve food products. Supplementing the diet with concentrates was found to reduce undesirable fat coloration in carcasses of steers finished off pasture on grass or corn silage. Feeding boars for at least 12 wk after castration before slaughtering eliminated taint in the meat. Replacing wheat with sorghum in diets for laying hens produced no detrimental effects on the economics of egg production. Replacing soybean meal in turkey starter diets with canola meal resulted in no reduction in growth rate.

Using a computer model to measure the impact of grasshoppers at various stages of maturity on wheat yields will improve the timeliness and efficiency of using insecticides for grasshopper control.

Research with forages continued to provide new information for improving management systems. In southwestern Saskatchewan harvesting irrigated alfalfa three times annually, with the third cut taken after 1 October, produced no adverse effects on yield in subsequent years. In southern Alberta alfalfa and sainfoin produced more forage when proper weed control methods were used during establishment.

Progress was made in research on crops grown to replace imports. Kiwi fruit was demonstrated to have potential as a commercial crop on Vancouver Island. The field production season for winter cauliflower was successfully extended in coastal British Columbia. Cooperative tests with producers of witloof (Belgian endive) were instrumental in expansion of the industry sufficiently to supply the local market in British Columbia.

Energy-related research in the Region was conducted mainly under the contracting-out program for energy research and development for agriculture and food (ERDAF). Western Region also managed the contract programs for agricultural engineering research and development (AERD) (mechanization and farm buildings), wild oat control, and vertebrate pest control for the Branch, as well as the station initiatives program for the Region. The annual allotment for all the contract programs was $1 418 000 during the fiscal year 1982–1983. Of the 65 contracts, valuing $3 908 400, 51% were with industry.

Achievements from research done under contract included the development of an electrostatic sprayer for livestock; a bog ditch digger; a low-bush blueberry harvester; a cauliflower harvester; an automated surface irrigation system; a zero-till drill system; and an automated depth control system for seeding. Also under contract, factors influencing dormancy of wild oats and the effectiveness of chemicals for wild oat control were further defined, and the usefulness of Landsat imagery was improved for identification of saline soil areas.

The research programs at six stations were supplemented by 38 projects that were financed by the Farming for the Future program of the Alberta Research Council.

Dr. W. N. MacNaughton, Associate Director General for the Western Region, retired at the end of June after 41 yr of service.

Further information may be obtained by contacting individual research establishments or by addressing inquiries to Western Region Headquarters, Research Branch, Agriculture Canada, P.O. Box 9241, Saskatoon, Sask. S7K 3X5.

J. E. Andrews

# PRÉFACE

La région de l'Ouest compte 15 stations de recherche, quatre fermes expérimentales et huit sous-stations qui desservent les collectivités agricoles des provinces des Prairies et de la Colombie-Britannique. En 1982, son budget atteignait 58 millions de dollars et son personnel comptait environ 350 professionnels et 860 techniciens travaillant à résoudre une vaste gamme de problèmes agricoles. Voici quelques-unes des réalisations importantes de la région en 1982.

Parmi les cultivars homologés, mentionnons le blé dur Medora, les orges fourragères Diamond et Leduc, l'avoine Dumont, le lin Norlin, le colza canola Westar, le blé fourrager indigène de l'Ouest, le Walsh, et la pomme de terre Carlton. On a également homologué les plantes ornementales suivantes pour l'industrie: le frêne blanc Automn Blaze, l'érable argenté Northline, le tilleul hybride Wascana, l'érable negundo sans graines, le Baron, une espèce d'*Alstroemeria* (lis du Pérou), une variété de bégonia *Rieger* et l'abricotier Westcot.

La recherche sur les ressources naturelles met l'accent sur l'utilisation efficace du sol et de l'eau. On a découvert que certains champignons mycorhiziens et certaines bactéries du sol peuvent extraire le phosphore du phosphate de roche insoluble. On a mis au point un dispositif déflecteur pour la moissonneuse-andaineuse, qui laisse une bande de chaume permettant de conserver l'humidité de la neige et de ralentir ainsi la salinisation des terres sèches.

La recherche sur les productions animales vise à en augmenter l'efficacité et à améliorer les denrées alimentaires. L'ajout de concentrés aux aliments du bétail réduit la coloration indésirable de la graisse des carcasses chez les bouvillons engraissés hors pâturage avec de l'ensilage d'herbe ou de maïs. On remarque également qu'en nourrissant les verrats pendant au moins 12 semaines après la castration et avant l'abattage, on évite l'altération de la viande. Le remplacement du blé par le sorgho dans les rations pour pondeuses ne réduit pas la production d'oeufs. De même, le remplacement du tourteau de soja dans les rations de début pour dindon par du tourteau de colza canola n'a pas abaissé le taux de croissance.

L'utilisation d'un modèle informatisé pour évaluer les répercussions sur le rendement des dommages causés par les criquets à différents stades de maturité du blé améliorera l'opportunité et l'efficacité des épandages d'insecticides dans la lutte contre ces insectes.

Du côté des céréales fourragères, la recherche continue de fournir de nouvelles informations pour améliorer le système de production. Au sud-ouest de la Saskatchewan, le fait de récolter la luzerne irriguée trois fois par année (la dernière récolte après le 1er octobre) n'a donné lieu à aucune baisse de rendement les années suivantes. Au sud de l'Alberta, la luzerne et le sainfoin ont produit plus de fourrage lorsqu'on a utilisé des méthodes appropriées de lutte contre les mauvaises herbes pendant l'implantation.

On a réalisé certains progrès dans la recherche sur les cultures destinées à remplacer les importations. La culture de kiwi semble présenter des possibilités comme culture commerciale dans l'île Vancouver. En outre, on a réussi à prolonger la saison de production du chou-fleur d'hiver sur la côte de la Colombie-Britannique. Des essais coopératifs avec les producteurs de chicorée Witloof (endive belge) ont permis à la profession d'accroître suffisamment la production pour approvisionner le marché local en Colombie-Britannique.

Les travaux de recherche sur l'énergie dans la région ont surtout été menés dans le cadre de programmes contractuels pour la recherche sur l'énergie et le développement agro-alimentaire (R.E.D.A.A.).

La région de l'Ouest s'est aussi occupée des programmes d'impartition des contrats pour la recherche et le développement en génie rural (R.D.G.R.) (mécanisation et bâtiments agricoles), et la lutte contre la folle avoine et les parasites vertébrés pour la Direction générale ainsi que du Programme sur les projets des stations pour la région qui bénéficiait d'un budget total de 1 418 000 $ pour l'année financière 1982–1983. Dans le cadre de ce programme, on a accordé 65 contrats dont 51% ont été signés avec l'industrie et dont la valeur totale atteignait 3 908 400 $.

Les progrès réalisés dans le cadre des programmes contractuels de recherche comprennent la mise au point d'un vaporisateur électrostatique pour le bétail, d'une défonceuse pour les terres marécageuses, d'une récolteuse de bleuets nains, d'une récolteuse de choux-fleurs, d'un système automatique d'irrigation de surface, d'un système d'ensemencement en ligne sans travail du sol et d'un système automatique de contrôle de la profondeur pour l'ensemencement. En outre, on a réussi à définir les facteurs qui influent sur la dormance de la folle avoine et l'efficacité des produits chimiques pour lutter contre cette mauvaise herbe ainsi qu'à améliorer l'utilité des images du satellite Landsat pour délimiter les régions de sols salins.

Les programmes de recherche dans six stations ont été appuyés par 38 contrats financés dans le cadre du programme 'L'agriculture dans l'avenir' du Conseil de recherche de l'Alberta.

W.N. MacNaughton, directeur général associé pour la région de l'Ouest, a pris sa retraite à la fin de juin après 41 années de services.

Pour obtenir de plus amples renseignements, communiquer avec les établissements de recherche ou s'adresser à l'Administration centrale de la région de l'Ouest, Direction générale de la recherche, Agriculture Canada, C.P. 9241, Saskatoon (Sask.), S7K 3X5.

J.E. Andrews

# Research Station
# Brandon, Manitoba

## PROFESSIONAL STAFF

### Administration

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| B. H. Sonntag, B.S.A., M.Sc., Ph.D. | Director |
| S. Bukowski | Administrative Officer |
| C. A. Grant,[1] B.S.A., M.Sc. | Information Officer |
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### Animal Science

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| G. W. Rahnefeld, B.Sc., M.Sc., Ph.D. | Head of Section; Beef cattle breeding |
| A. G. Castell, B.Sc., M.Sc., Ph.D. | Swine nutrition |
| R. L. Cliplef, B.Sc., M.Sc., Ph.D. | Meats physiology |
| G. W. Dyck, B.S.A., M.Sc., Ph.D. | Reproductive physiology |
| R. R. Grandhi, B.V.Sc., M.Sc., Ph.D. | Swine nutrition |
| D. L. Grinwich, B.Sc., M.Sc., Ph.D. | Reproductive physiology |
| R. M. McKay,[3] B.Sc., B.S.A., M.Sc., Ph.D. | Swine genetics |

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| L. D. Bailey, B.S.A., M.Sc., Ph.D. | Head of Section; Soil–plant relationships |
| P. N. P. Chow, B.S.A., M.A., Ph.D. | Weed physiology |
| R. D. Dryden, B.S.A., M.Sc. | Crop culture |
| R. I. Hamilton, B.Sc., M.S.A., Ph.D. | Corn physiology |
| R. B. Irvine, B.S.A., Ph.D. | Barley physiology |
| J. M. Sadler,[4] B.Sc., M.Sc., Ph.D. | Plant nutrition |
| R. Simons, B.Sc., M.Sc., Ph.D. | Forage agronomy |
| M. C. Therrien,[5] B.Sc., Ph.D. | Barley breeding |

## Departure

| | |
|---|---|
| J. H. Strain<br>Retired October 1982 | Head, Animal Science Section |

## VISITING SCIENTIST

| | |
|---|---|
| M. Buhr, B.Sc., M.Sc., Ph.D.<br>Natural Sciences and Engineering Research Council | Reproductive physiology—swine |

[1]Appointed January 1982.
[2]Appointed September 1982, seconded from Systems and Consulting Directorate, Finance and Administration Branch.
[3]Appointed March 1982.
[4]Appointed January 1982.
[5]Appointed October 1982.

# INTRODUCTION

The research program at Brandon encompasses beef cattle breeding; swine nutrition, physiology, genetics, and management; breeding, physiology, and management of barley, corn, soybeans, and sorghum; and soil fertility, agronomy, plant nutrition, and weed control in cereal, oilseed, and forage crops. Research programs are designed to solve production problems and to evaluate new opportunities that will enable Canadian farmers, especially those located in the eastern prairie area, to maintain or improve their competitive position in domestic and foreign markets.

Several important changes occurred in the professional staff in 1982. Dr. J. M. Sadler, soil scientist, joined our staff in January by way of a transfer from the Charlottetown Research Station. Mrs. C. A. Grant joined our staff in January as the Information Officer. Dr. R. M. McKay, swine geneticist, was appointed in March. Mr. R. J. Bomford joined us in September as a computer systems specialist. Dr. M. C. Therrien, barley breeder, joined our staff in October. Dr. J. H. Strain, Assistant Director and Head of the Animal Science Section, retired in October after 35 yr of dedicated public service.

This brief report contains highlights of recent findings of our research program. More detailed results can be obtained from our annual Review of Results, from published papers, or by direct contact with research personnel at the Research Station, Research Branch, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

B. H. Sonntag
Director

# ANIMAL SCIENCE

## Beef cattle

*Carcass characteristics of three-way cross progeny.* Carcass characteristics of 3673 steers and heifers born over a 6-yr period (1973–1978) under semi-intensive farm management at Brandon, Man., or in an extensive range management system on short-grass prairie at Manyberries, Alta., were evaluated. Calves weaned at Manyberries were fed and evaluated at Lacombe, Alta. Calves born at Brandon were fed and evaluated at Brandon. The progeny evaluated were three-way crosses produced out of 10 specific $F_1$ crosses of dams mated to bulls of the Charolais (C), Simmental (S), Limousin (L), and Chianina (Chi) breeds. Dam crosses included the Hereford × Angus (HA) and crosses sired by C, S, and L sires out of Hereford (H), Angus (A), and Shorthorn (N) dams. Steers dressed about 0.40% higher than heifers, apparently because of the greater percentage of hide weight of heifers (heifers > steers $P \leq 0.0002$). Sex differences for kidney fat weight (percentage of liveweight) and rib eye area-to-weight ratio ($cm^2$/100 kg) were heifers > steers and for shank, head, and feet (front and hind, Brandon animals only) as a percentage of liveweight were steers > heifers. For the carcass proportions of rib and long loin (short loin plus sirloin butt), and for the combined proportions of rib, round, and long loin, significant sex differences ($P \leq 0.05$) were observed with heifers > steers and for chuck and flank, steers > heifers. Brandon steers and heifers had greater proportions of chuck, plate, brisket, and flank, whereas Lacombe steers and heifers had greater proportions of the high-priced cuts of rib and long loin, and the combined proportions of rib, round, and long loin. Location differences in the proportions of low-priced and high-priced cuts were attributed to differences in degree of fatness, Brandon steers and heifers having 28–33% more average rib fat and 16% more kidney fat (percentage of liveweight) than those evaluated at Lacombe. Heifers relative to steers had significantly ($P = 0.0001$) lower percentages of bone in the round and rib and greater ($P = 0.0001$) lean-to-bone ratios for the combined proportions of long loin and round. Year differences were large, but year by sex interactions were nonexistent for virtually all carcass traits evaluated at both locations ($P < 0.05$).

Terminal sire differences involving progeny of Chi indicated that their carcasses averaged 1.6% heavier than C, 3.5% heavier than S, and 6.6% heavier than L at both locations ($P \leq$

0.0045). Simmental progeny had significantly heavier ($P = 0.0001$) hides and significantly lower ($P = 0.0001$) dressing percentages. Limousin- and Chi-sired progeny had the lowest percentage of hide and the highest dressing percentage. Limousin progeny averaged 5.2% greater rib eye area-to-weight ratios ($cm^2/kg$) than Chi progeny ($P = 0.0001$). Chi progeny had the lowest percentage of long loin, rib, brisket, and flank and the highest percentage of round and the combined proportions of rib, round, and long loin ($P < 0.05$). Chi progeny had the highest percentage of lean in the rib, chuck, and long loin, and L-sired progeny had the highest percentage of lean in the round. Chi progeny had the highest and L progeny the lowest percentage of bone in the rib, chuck, round, and long loin. Limousin progeny had the highest lean-to-bone ratios. At both locations, significant sire by year interactions were observed for all traits. Dam by year, dam by sex, year by sex, and the genetic interaction involving breed of sire and breed of dam effects were absent.

**Swine**

*Heritabilities of carcass traits and the correlated response of carcass traits to selection for postweaning growth.* Selection for postweaning growth was practiced for 11 generations in a Lacombe population. Heritabilities for total carcass back fat, carcass length, area of *longissimus dorsi*, ham weight, percentage of ham from side, percentage of lean in the ham face, texture score, and marbling score were moderate to high (0.30–0.68). The heritability for color score was low (0.10). Positive genetic correlations were found between growth rate and total carcass back fat, carcass length, area of *longissimus dorsi*, ham weight, and percentage of lean in the ham face, whereas negative relationships were found between growth rate and percentage of lean in the ham face, color score, texture score, and marbling score.

*Calcium–phosphorus levels for growth and reproduction in gilts.* Ca–P levels that were 50% higher than 1979 National Research Council recommendations were fed to a total of 515 Lacombe and Yorkshire gilts during finishing, gestation, and lactation periods, starting at 65 kg body weight, to determine the effect on growth and reproductive performance. Higher Ca–P levels during the finishing period did not improve ($P < 0.05$) average daily gains or feed conversion. Feeding higher Ca–P levels during breeding and gestation in the summer increased ($P < 0.05$) the number of live pigs born (9.2 versus 8.2) and weaned (7.7 versus 6.9). This increase was greater in Lacombe gilts than in Yorkshire gilts. A similar improvement in litter size was not observed in winter, probably because of seasonal differences in Ca–P intake and metabolism. Higher Ca–P levels during lactation did not improve sow or piglet weight gains. The dietary Ca–P levels required for maximum performance seem to vary with season and breed of pigs.

*Boar exposure and the occurrence of estrus in postweaning sows.* The effect of housing sows adjacent to or away from mature boars after weaning on the number of sows in estrus within 10 days of weaning was determined on 36 primiparous Lacombe sows. Eight of 18 sows housed adjacent to boars and 11 of 18 sows housed in isolation from boars were observed in estrus within 10 days of weaning. Vasectomized boars were used for 5 min each day to check the sows for estrus. These results indicate that boar stimuli are not involved in the occurrence of estrus in the postlactational sow.

*Control of farrowing.* Induced farrowing, using a prostaglandin analogue (Cloprostenol), was tested on the Yorkshire swine herd at the Brandon Research Station under practical management conditions. In addition to the benefit of having most farrowings occur during working hours, prostaglandin-synchronized farrowing reduced the expected farrowing period from 11 to 5 days, with 88% of the Yorkshire sows farrowing in a 3-day period prior to day 115.

*Luteal cell studies.* Studies on isolated luteal cells from the ovaries of sows between 70 and 90 days of pregnancy demonstrated the following: that prolactin acutely stimulated progesterone secretion; that lipoproteins enhanced secretion of progesterone, presumably by providing cholesterol substrates; and that prolactin–luteinizing hormones act on the luteal cell to increase lipoprotein uptake.

*Boar taint physiology.* Fourteen mature boars that averaged 178 kg were castrated, penned individually, and fed a 14% protein diet at 2.5 kg/day for 90 days. Twelve mature boars were maintained intact as controls and handled the same way. All animals were bled and had fat biopsies done weekly for analysis of 5$\alpha$-androstenone (boar taint). Results show

that serum levels of androstenone decrease diametrically at 4–6 wk postcastration, but that fat levels of androstenone begin to decrease noticeably several weeks later. Fat levels of androstenone are minute (insignificant) at 11–13 wk postcastration.

## PLANT SCIENCE

### Other cereals

*Barley production and management.* The barley cultivar developed at Brandon and tested as BT 337 was licensed in 1982 as Leduc. This cultivar is a six-row feed barley that is 1 day earlier in maturity than Johnston (Brandon cultivar), with better straw strength and disease resistance. However, its yield is similar to that of Johnston.

Examination of the subcrown internode of barley shows significant differences in length among selected cultivars. One cultivar, ABee, which has a significantly longer subcrown internode and smaller effective xylem radius, should have a reduced rate of water use. This may be a desirable characteristic for prairie agriculture.

*Weed control in barley and wheat.* Postemergence application of DPX 4189 (20 kg/ha) in mixtures with wild oat herbicides (barban, difenzoquat, diclofop-methyl, and flamprop-methyl) reduced Neepawa wheat yield, possibly because of an antagonistic effect on wild oat control. Soil incorporation of DPX 4189 (10–20 kg/ha) and triallate (1–4 kg/ha) also reduced wheat yield. However, in three-way mixtures of DPX 4189, triallate, and trifluralin (0.7 kg/ha) weed control was excellent and yield increased, possibly because of stimulation of wheat growth.

*Corn physiology and management.* Cold tolerance studies have identified superior genotypes. Vigor (measured by early germination and growth at low temperatures) was found to be an important factor in selecting for cold tolerance. Hybrids with superior cold tolerance performed better than less cold-tolerant lines in early spring field tests. An abnormally early killing frost (–3°C) occurred on 27 August 1982. Corn development in hybrids was approximately 5 wk, 4 wk, and 3.5 wk postfertilization for 2150, 2300, and 2400 corn heat units. In the early hybrid, yield was significantly reduced from a normal year, but kernel density and weight were normal. In the medium and late hybrids, all variables were reduced significantly. Yield was least for the late hybrid, whereas the medium and early hybrids were similar and higher. In the corn nursery, nearly all crosses made 4 wk prior to the frost were successful, and seed quality was normal. Crosses made during the first 2 wk in August were variable, with much shrivelled seed.

*Sorghum evaluation.* One-grain sorghum cultivar (NKX 8101) from the cooperative grain trial will be supported for licensing in 1983.

*Weed control in corn and sorghum.* Cyanazine plus an emulsified vegetable oil, applied at the three-leaf stage of corn, gave excellent control of green foxtail and broad-leaved weeds. This treatment has been recommended, pending registration, for weed control in corn in Western Canada.

Excellent weed control was obtained in corn with preplant disc incorporation of cyanazine in combination with EPTC + R25788, alachlor, and ometalachlor. This practice was recommended for use in Western Canada. Cyanazine and alachlor have a short residual life in the soil and provide alternatives to atrazine, a long residual life compound with a high risk of injury to other crops in the rotation.

### Oilseed crops

*Soybean production and management.* Under field and growth chamber conditions, the maximum growth, yield, and uptake of phosphorus (P) by soybean and the greatest efficiency of use of P fertilizer occurred when P fertilizer was placed in a narrow band 2.5 cm directly below the seed. This placement of P resulted in a rapid uptake of P early in the growing season, rapid plant development, and maximum grain yield. Root observations showed that there was a dense proliferation of roots in the fertilizer band early in plant development (21 days after emergence) and throughout the growing season. Although placement of P fertilizer in a band 2.5 cm below and 2.5 cm to the side of the seed gave good yield response and P uptake, this treatment was significantly less effective than banding the P directly below the seed. In field studies, placing P at a rate of more than 15 kg/ha with the seed reduced plant emergence and yield. However, good yield response was obtained with lower rates of P. Broadcast application of P was the least effective of all

methods used. At the highest rate of broadcast of P (at 55 kg/ha), yield of beans was equivalent to that obtained with banding P at 15 kg/ha, with or close to the seed.

*Weed control in flax, rapeseed, and soybean.* The addition of bromoxynil/MCPA (0.5 kg/ha), propanil (0.5 kg/ha), and DPX 4189 (10 g/ha) to TF 1169 (0.3 kg/ha) gave consistently better control of wild oats and broad-leaved weeds in flax, and resulted in a 23–28% yield increase over plots treated with TF 1169 alone. Other herbicide mixtures gave variable results, which may be attributed to year-to-year climatic variations. Dowco 453 (0.1 kg/ha) was compatible with bromoxynil/MCPA (0.5 kg/ha), propanil/MCPA (0.5 kg/ha), and DPX 4189 (15 g/ha) and gave excellent weed control, resulting in a 13–26% yield increase of flax.

In field tests 3,6-dichloropicolinic acid (Lontrel) at 0.25 kg/ha in mixtures with five grass herbicides (BAS 9052, Dowco 453, CGA 82725, Hoe 00654, and TF 1169) gave poor wild-oat control and reduced rapeseed yield by 15–30% in comparison with the grass herbicides applied alone, although 3,6-dichloropicolinic acid gave good control of broad-leaved weeds. Antagonism in the mixtures was not a contributing factor to reduced wild-oat control. The herbicides probably had an adverse effect on flowering and seed set of rapeseed. The addition of Agral 90 surfactant (0.5%, v/v) to CGA 82725, and Agral 90 and ammonium sulfate (0.5%, v/v) to Dowco 453, gave improved wild-oat control and resulted in increased yield of rapeseed.

*Soybean evaluation.* Experimental OT81-5 was highest in average yield in the U.S. Department of Agriculture's trial in Brandon and Ottawa. This cultivar has very wide adaptation and low genetic environmental interaction. Yield and quality (percentage of oil and percentage of protein) of soybeans were affected less by the early frost than was corn (see above). However, late cultivars were lower in yield than medium and early cultivars. In addition, a good differential for shelling was present with temperatures above 32°C on 8–10 September.

**Forage crops**

*Alfalfa production and management.* In field studies, it was found that three annual harvests (the third in October) of alfalfa forage can be taken from properly fertilized and managed stands without deleterious effects on stand density, forage quality, and yield. On coarse-textured soils with low exchangeable potassium (K) (30 kg/ha), and on all soils with low potential potassium supplying power (PKSP), annual applications of K fertilizer at rates as high as 200 kg/ha were necessary to maintain maximum yield of forage with K and N concentrations of 2.2% and 3.9% or greater, respectively. Without K fertilizer or with low rates of K fertilizer, the K and N concentrations of the forage were low (approximately 1.0% K and 2.0% N). Under these conditions, the crop suffered winter injury that reduced both stand density and yield.

There was a positive correlation between the concentration of K and N in the crop at the full bud stage. As the K concentration increased, the N concentration increased; at high values of K (2.2–2.0%), the N concentration ranged from 3.0% to 3.8% (19–24% crude protein), and yield of forage ranged from 8.0 to 11.6 t/ha. There were indications that K may have either stimulated the symbiotic nitrogen fixing ability of the crop or may have increased the efficiency of translocation of fixed nitrogen from roots to tops.

*Weed control in forage crops.* Preplant application of EPTC and postemergence application of 2,4-DB gave good weed control in the establishment of alfalfa. Good weed control was also obtained with separate postemergence applications of diclofop-methyl and 2,4-DB.

*Grass response to fertilizer N.* Four grass species, bromegrass, intermediate wheatgrass, crested wheatgrass, and Russian wild ryegrass, all responded well to annual broadcast N applications on both clay–loam and sandy–loam soils. Intermediate wheatgrass was the most productive grass on the clay–loam soil and crested wheatgrass on the sandy–loam soil. Russian wild ryegrass was the least productive on both soils.

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# Research Station
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| C. G. Campbell, B.S.A., M.Sc., Ph.D. | Breeding of buckwheat |
| J. Giesbrecht, B.S.A., M.Sc., Ph.D. | Breeding of grain corn |
| G. H. Gubbels, B.S.A., M.S.A., Ph.D. | Crop management, physiology |
| F. A. Kiehn,[3] B.S.A., M.Sc. | New crops |
| R. C. Zimmer, B.Sc., Ph.D. | Diseases of field peas |

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| G. Mazza,[5] B.S.A., M.Sc., Ph.D. | Food science and technology |
| D. A. Wall,[6] B.S.A., M.Sc. | Weed control |

### Oilseed Crops

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|---|---|
| E. O. Kenaschuk, B.S.A., M.Sc., Ph.D. | Head of Section; Breeding of flax |
| W. Dedio, B.Sc., M.Sc., Ph.D. | Breeding of sunflower |
| J. A. Hoes, B.S.A., M.S.A., Ph.D. | Pathology of flax and sunflower |
| K. P. Minogue,[7] B.Sc., M.Sc., Ph.D. | Pathology of sunflower |

## Departures

| | |
|---|---|
| W. G. Ronald, B.S.A., M.Sc., Ph.D.<br>Resigned April 1982 | Breeding of woody ornamentals |
| W. A. Russell, B.S.A.<br>Retired December 1982 | Breeding of potatoes |
| D. E. Vanstone, B.S.A., M.Sc., Ph.D.<br>Resigned April 1982 | Management, breeding of ornamentals |

## VISITING SCIENTISTS

| | |
|---|---|
| T. Holo, B.Agr.Sc., M.Sc.<br>Agricultural Research Division, Ministry of Agriculture, Forest and Fisheries, Tongatapu, Tonga | Research management |
| V. S. J. Yogiyo, B.Sc.<br>Department of Primary Industry, Highlands Agricultural Experiment Station, Aiyura, Kainantu, Papua New Guinea | Research management |

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[1]Seconded to CIDA Indo-Canadian Research Project for Dryland Agriculture from 1 January 1982 to 1 April 1982.
[2]Seconded to CIDA Barani Agricultural Research Project, Pakistan 18 October 1982–.
[3]Appointed 1 March 1982.
[4]FPNAppointed 1 February 1982.
[5]Appointed 4 May 1982.
[6]Appointed 19 April 1982.
[7]Appointed 15 October 1982.

# INTRODUCTION

The programs of the Morden Research Station are directed toward the development of new cultivars and the improvement of management for buckwheat, field corn, field peas, pulses, new crops, flax, sunflowers, potatoes, and herbaceous and woody ornamentals. During the past year, a new program on vegetable crops was implemented, and there was an increased emphasis on food technology. This report summarizes some of the results of research conducted during 1982.

Breeding and evaluation programs resulted in the licensing of NorLin flax and the release of germ plasm of semileafless peas, five ornamental shade tree cultivars, and Westcot apricot. Evaluations were continued on promising cultivars of other crops. Refinements were developed for several management practices, which may lead to increased productivity. Additional understanding was obtained of several diseases that affect crops. Information was generated on several new herbicides, which may lead to registration of these products and more effective weed control in the future.

Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 3001, Morden, Man. R0G 1J0.

D. K. McBeath
Director

## FIELD CROPS

### Buckwheat

*Breeding.* Transfer of resistance to downy mildew appears practical, because preliminary tests show $F_1$ progeny to be midway in resistance between the resistant and susceptible parent. Semidwarf lines responded poorly to a short growing season, and a breeding program has been initiated to increase their earliness.

*Management.* Buckwheat plots were swathed at about 6-day intervals in a 3-yr study to determine a reliable indicator of optimum swathing time. It was concluded that optimum swathing time for yield occurred when flowering was almost terminated and only 25% of the seeds were still in the green stage.

*Weed control.* Postemergence applications of desmedipham (Betanex) were selective for the control of wild mustard in buckwheat. This is the first herbicide to show such selectivity without noticeable injury to buckwheat plants. Buckwheat is also tolerant of most new grass-specific herbicides (alachlor, metolachlor, BAS 9052 OH, HOE 00736, fluazifop butyl, Dowco 453, and CGA 82725) at recommended rates.

### Field corn

*Breeding.* Several new versions of French inbred EP1 were identified. These produce hybrids equal in maturity to Pioneer 3995. These new inbreds have good stalk quality and combining ability. EP1 is a slow-drying European flint corn that has now been improved to suit Manitoba requirements.

A number of good inbreds were identified as parents of high-performing new experimental hybrids. These inbreds originated from a variety of sources, including North American and European synthetic varieties, single-cross hybrids, and backcross programs involving central corn belt inbreds.

Selection of plants with improved stalk quality was possible this year owing to the high incidence of stalk breakage brought on by an early fall frost. In the breeding nursery, this was further assisted by wounding the base of the plants, which allowed for penetration and development of the disease organisms in the more susceptible plants.

*Weed control.* Selective control of wild proso millet in field corn was achieved with a postemergence treatment of ametryne (Evik). It was also found that metribuzin tank mixed with EPTC, alachlor, metolachlor, or dimethachlor may provide broad-spectrum weed control equal to that of atrazine without the soil residue problems associated with it.

### Field peas

*Breeding.* One line of semileafless peas, MP 926, was released and registered with the Crop Science Society of America. This line provides valuable germ plasm to other breeders for incorporation of the semileafless characteristic into commercial cultivars. It is superior in standing ability compared with the commonly grown cultivars.

*Management.* It was discovered that bentazon (Basagran) is very toxic to semileafless cultivars of field peas.

*Diseases.* Delaying the planting date may increase significantly the severity of powdery mildew on field peas. Most of the lines planted on May 12 were resistant when assessed 90–95 days later. Those lines planted 1–2 wk later were moderately susceptible. The high resistance of the cultivar Tara was not reduced by delayed planting. In the cultivar Triumph and in advanced breeding lines CDC-4 and MP 947, high susceptibility to powdery mildew was evident at the early planting date.

### Pulse crops

The necessary data were obtained for the registration of diclofop methyl (Hoegrass) on dry white beans and soybeans for Western Canada. Data were also provided for the registration of BAS 9052 OH (Poast) and metribuzin (Sencor) for use on soybeans in Western Canada.

### New crops

Seventy-nine accessions of Jerusalem artichoke were evaluated for tuber yield, maturity, and disease rating. Yields ranged from 5500 kg/ha to 49 500 kg/ha for both Columbia and NC10-39 (nonbranching line). Maturity ranged from 96 days to lines that were still immature at 140 days. Four accessions exhibited a high degree of tolerance for sclerotinia.

Volunteer plants of Columbia Jerusalem artichoke were effectively controlled by the herbicide chlorsulfuron and by the mixtures dicamba + 2,4-D + mecoprop and dicamba + 2,4-D. Glyphosate with the active ingredient applied at rates of up to 4.0 kg/ha gave only temporary control.

In a plant spacing trial, Japanese artichoke, *Stachys affinis* Bunge (= *S. sieboldii* Miq.), yielded 21 000 kg of tubers per hectare. The tubers were also identified as being winter-hardy.

Dill showed excellent tolerance for the following experimental herbicides: BAS 9052 OH, TF 1169, HOE 00736, and CGA 82725. Preplant incorporated herbicides trifluralin, chloramben, and EPTC resulted in excellent control of annual weeds.

## OILSEED CROPS

### Flax

*Breeding.* NorLin (F.P. 698) was licensed in 1982. This cultivar combines high seed yield and medium-early maturity. It is 2 days later than Linott and 4–5 days earlier than Dufferin or McGregor. NorLin averaged 10% higher yield than Linott and 4% higher than Dufferin in 4 yr of evaluation in the cooperative tests.

*Management.* A 3-yr preliminary study at Morden indicated that flax and canola seedlings, incorporated into the soil immediately prior to seeding, reduced flax stand and yield through a toxic principle. Barley yields, however, appeared to be more affected by the amount of seedling residue incorporated than by the presence of toxicity.

*Diseases.* In assessing levels of postseedling resistance, varieties of known reaction to rust race 371 showed similar levels of resistance to exotic race 22, suggesting nonspecificity of this kind of resistance. Indications are that F.P. 707 and NorLin have high and low levels of postseedling resistance to race 22, respectively, and that Dufferin, Linott, and McGregor showed at least moderate levels of postseedling resistance. The fiber variety Natasja showed a high level of postseedling resistance to race 371.

*Weed control.* Several new grass-specific herbicides were found to be very selective in flax and offer promise for improved control of wild oats and other annual grasses in this crop. Data were provided for the registration of BAS 9052 OH (Poast) for the control of wild oats, volunteer cereals, and other annual grasses in flax. It was also confirmed that chlorsulfuron (Glean), at rates o 20–60 g/ha, provides excellent control of road-leaved weeds in flax. This herbicide wa found to be compatible as a tank mix with B AS 9052 OH (Poast) for broad-spectrum we d control in flax.

**Sunflowers**

*Management.* The use of chemical desiccants on sunflowers at harvest time hastened the drying of leaves, heads, and stems, but had a variable effect on drying of the achenes, depending on weather conditions. Advancement in harvest date ranged from 0 to 26 days. Yield and achene quality were adversely affected by diquat applications made before physiological maturity. Sunflowers have been found to be physiologically mature when the moisture level of 45% in the achene is reached. This corresponds to yellowing of the back of the head with browning of bracts.

By using hybrids with varying maturity requirements, it was found that early hybrids produced higher yields than did maturing hybrids when planted on 5 June or later at Morden.

*Disease.* Downy mildew race 3, virulent to all current sunflower hybrids, was discovered at one Manitoba location in 1981 and at another in 1982. Its distribution may be more widespread than was previously expected.

Twisted leaf is a newly recognized syndrome of systemic downy mildew. The true leaves of seedlings are dark green, rugose, curled, and often misshapen. Chlorosis is confined to the main vein, and no spores are produced under high humidity. In more mature plants, stunting may be severe or moderate, leaves may be twisted and densely crowded, and plants may produce either a single small fertile head or several sterile heads. Healthy shoots that produce seed may develop from various portions of the main stem. Hybrids that developed twisted leaf in response to race 2 developed systemic chlorosis when inoculated with race 3. Twisted leaf is apparently conditioned by a hybrid–race interaction and can be recognized when seedlings are inoculated by immersion.

*Weed control.* Shallowly incorporated preemergence treatments of metribuzin and trifluralin were selective for the control of wild mustard and other annual weeds in sunflowers. Fall applications of trifluralin, ethalfluralin, and EPTC + R33865 were as effective as spring treatments. Phenmedipham was most selective for the control of wild mustard when applied at the two- to four-leaf stage of sunflowers.

**Ornamentals**

*Breeding.* Six cultivars, five ornamentals, and one fruit were described and introduced in 1982.

*Acer negundo* 'Baron' was selected from a prairie strain of Manitoba, or box-elder, maple. It is a staminate cultivar and therefore free of seed, a characteristic that will overcome the reputation of this species as a weedy tree.

*A. saccharinum* 'Northline' is the first reliably hardy silver maple for growth on the prairies. Trees have a wide branching habit and a slow growth rate, two desirable characteristics, since this species normally tends to grow rapidly and to have weak branches. It was selected from open-pollinated seedlings of a northern source.

*Fraxinus americana* 'Autumn Blaze' is the first white ash cultivar adapted to the prairie region. It is late to begin growth in the spring, a desirable trait for areas experiencing late frosts. This cultivar develops a purple autumn leaf coloration and bears a light seed crop. It was selected from open-pollinated seedlings of white ash from Petawawa, Ont.

The linden *Tilia flavescens* 'Wascana' was selected from a first-generation seedling population of *T. flavescens* 'Dropmore' (*T. cordata* × *T. americana*). It is a hardy selection that has a faster growth rate and stronger wide-angled branches than the existing cultivar Dropmore. The aforementioned cultivars were released through the Canadian Ornamental Plant Foundation.

*Fraxinus mandshurica* 'Mancana' is a hardy and staminate selection of manchurian ash, which has been grown commercially under the number 6905. Mancana was selected from a seedling population received from the U.S. Department of Agriculture in 1940. This ash has wide adaptation for the prairies, as demonstrated by its performance in the prairie regional trials.

*Prunus armeniaca* 'Westcot' is a complex apricot hybrid that incorporates germ plasm of Scout and McLure apricots. It has demonstrated greater bud hardiness and increased quality compared with existing cultivars Scout and M-604. Apricots are recommended only for trial in most regions of the prairies.

*Propagation.* Propagation methods for the newly introduced cultivars were developed. Baron box-elder propagates well by budding

on box-elder seedling rootstock. Northline maple is budded on seedling rootstock of silver maple. Autumn Blaze ash is propagated by budding onto rootstock of green ash seedlings. Wascana linden should be budded onto rootstock seedlings of littleleaf linden. Mancana ash is budded onto seedling rootstocks of green ash. Westcot apricot is propagated by budding onto apricot seedling rootstock.

### Potatoes

*Breeding and evaluation.* Carlton, an early white-skinned shallow-eyed potato cultivar, was licensed in 1982. It was developed from seed produced from a cross made at the Fredericton Research Station, but was grown and selected at the Scott Experimental Farm and tested in the Prairie Regional Trials for 18 yr as seedling FS 6222. In the prairie region, Carlton is expected to replace Warba as a first early tablestock variety.

*Utilization and quality.* A nondestructive method for rapid evaluation of boiling quality of potatoes has been developed. The method is based on the degree of sloughing, after-cooking darkening, and color of tuber cores cooked in test tubes at 118°C for 25 min. The correlation coefficient between sloughing data obtained by the new method and the existing standard method was 0.1912. The new method has proven to be simple, reproducible, and highly suitable for evaluating a large number of potato samples. This should make it attractive for routine use by potato breeders.

Content of potato sucrose and reducing sugar, as well as chip color, were determined by standard methods and were compared and correlated with glucose and sucrose values obtained with a sugar analyzer. The correlation coefficient between sucrose data obtained by the two methods was 0.984 and that between reducing sugar and glucose levels was 0.964. The instrumental method has proven to be fast, simple, and reproducible.

*Weed control.* Weed control studies in potatoes yielded the following significant results: experimental grass-specific herbicides BAS 9052 OH, DOW 453, CGA 82725, HOE 00736, and TF 1169 gave excellent control of green foxtail in Netted Gem potatoes; and potato cultivars Alaska Red, Shepody, Rideau, and ND146-4R were found to be sensitive to metribuzin.

### Vegetables

*Utilization and quality.* The steam-volatile constituents of locally grown horseradish, *Armoracia lapathifolia* Gilib., were identified by gas chromatography and combined gas chromatography–mass spectrometry. Of the 10 components identified, six were isothiocyanates, two were nitriles, one was allyl thiocyanate, and one was carbon disulfide. The distribution and concentration of flavor components in crowns, primary and secondary roots, and rootlets differed from those in tops. The primary and secondary roots and crowns accounted for the bulk of the weight of the root fraction as well as its essence content. Based on allyl isothiocyanate content, the quality of horseradish essence deteriorated as the distillation time was extended. Freeze drying and dehydration of sliced roots improved the recovery and quality of the essence.

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### Research


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Zimmer, R. C. 1982. Downy mildew on buckwheat. Canadex 118.632.

# Research Station
# Winnipeg, Manitoba

## PROFESSIONAL STAFF

| | |
|---|---|
| D. G. Dorrell, B.S.A., M.Sc., Ph.D. | Director |
| M. D. Hamilton | Administrative Officer |

### Scientific Support

| | |
|---|---|
| G. F. Atkinson, B.S.A., M.Sc., Ph.D. | Biometrician |
| J. L. Buth, B.Sc. | Technical Information Officer |
| M. Malyk,[1] B.Sc., M.Sc., M.L.S. | Librarian |
| S. M. Woods, B.Sc., M.Sc., Ph.D. | Programmer/Analyst |

### Cereal Breeding

| | |
|---|---|
| D. Leisle, B.S.A., M.Sc., Ph.D. | Head of Section; Durum wheat breeding |
| V. M. Bendelow, B.Sc., M.Sc., Ph.D. | Cereal chemistry |
| D. Brown, B.S.A., M.Sc. | Oat breeding |
| A. B. Campbell, B.S.A., M.Sc., Ph.D. | Common wheat breeding |
| E. M. Czarnecki, B.S.A., M.Sc. | Common wheat breeding |
| P. L. Dyck,[2] B.S.A., M.Sc., Ph.D. | Wheat genetics |
| E. R. Kerber, B.S.A., M.Sc., Ph.D. | Wheat cytogenetics |
| M. I. P. Kovacs, B.Sc., M.Sc., Ph.D. | Cereal chemistry |
| O. M. Lukow, B.Sc., M.Sc., Ph.D. | Cereal chemistry |
| D. R. Metcalfe, B.S.A., M.Sc., Ph.D. | Barley breeding and genetics |
| R. I. H. McKenzie, B.S.A., M.Sc., Ph.D. | Oat breeding and genetics |
| J. S. Noll, B.Sc., Ph.D. | Physiology |

### Cereal Diseases

| | |
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| R. Rohringer, Dr.sc.agr. | Head of Section; Molecular biology of cereal rust |
| J. W. Martens, B.Sc., Ph.D. | Wheat stem rust |
| C. C. Gill, B.Sc., Ph.D. | Viruses |
| D. E. Harder, B.Sc., M.Sc., Ph.D. | Oat stem rust |

| | |
|---|---|
| N. K. Howes, B.Sc., Ph.D. | Molecular biology |
| W. K. Kim, B.Sc., M.Sc., Ph.D. | Molecular biology of cereal rust |
| J. J. Nielsen, Dr.sc.agr. | Smuts |
| D. J. Samborski, B.S.A., M.Sc., Ph.D. | Wheat leaf rust |
| A. Tekauz, B.Sc., M.Sc., Ph.D. | Leaf diseases |
| P. L. Thomas, B.S.A., M.Sc., Ph.D. | Microbial genetics, smuts |

## Cereal Crop Protection

| | |
|---|---|
| S. R. Loschiavo, B.Sc., M.Sc., Ph.D. | Head of Section; Stored grain insect biology |
| D. Abramson, B.Sc., M.Sc., Ph.D. | Mycotoxicology |
| P. S. Barker, I.A., M.Sc., Ph.D. | Biology and control of stored grain pests |
| J. T. Mills, B.Sc., Ph.D., D.I.C. | Development and control of storage molds |
| W. Romanow, B.S.A., M.Sc. | Insect surveys and control |
| R. N. Sinha, B.Sc., Ph.D. | Ecology of granary insects, mites, and fungi |
| L. B. Smith, B.Sc., M.S.A., Ph.D. | Ecology of stored product insects |
| N. D. G. White, B.Sc.Agr., M.Sc., Ph.D. | Biology and control of stored product insects |

## Integrated Pest Control

| | |
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| W. J. Turnock, B.S.A., M.Sc., Ph.D. | Head of Section; Ecology and population dynamics |
| G. L. Ayre, B.S.A., M.S.A. | Insect ecology |
| R. P. Bodnaryk,[3] B.A., M.Sc., Ph.D. | Biochemistry and toxicology |
| G. K. Bracken, B.Sc., M.Sc., Ph.D. | Physiology and behavior |
| G. H. Gerber, B.A.S., Ph.D. | Histology, physiology, and behavior |
| B. M. Hegdekar, B.Sc., M.Sc., Ph.D. | Diapause and cold hardiness |
| R. J. Lamb, B.Sc., M.Sc., Ph.D. | Systems biology |
| O. N. Morris, B.Sc., M.Sc., Ph.D. | Insect pathology |
| H. G. Wylie, B.A., Ph.D. | Host–parasite relations |

## Departures

| | |
|---|---|
| G. J. Green, B.S.A., M.Sc., Ph.D.<br>Deceased 22 February 1982 | Wheat stem rust |
| D. Sabourin, B.Sc., M.Sc.<br>Resigned 31 March 1982 | Biometrics |

## VISITING SCIENTISTS

| | |
|---|---|
| D. W. Holden, B.Sc., Ph.D. | Molecular biology of cereal rusts |
| Hui-Gen Huang, B.S.A. | Pathology of smut fungi |
| O. Imura, B.Sc. | Population ecology of stored product insects |
| A. M. Therrien,[4] A.Sc., B.Sc., Ph.D. Natural Sciences and Engineering Research Council visiting fellow | Oat genetics |

*Graduate students*

| | |
|---|---|
| C. Aitchison, B.Sc., M.Sc. | Entomology |
| A. Al-Hitty, B.Sc. | Entomology |
| B. S. Joia, B.Sc., M.Sc. | Entomology |
| M. Howlader, B.Sc., M.Sc. | Entomology |
| G. Maiteki, B.Sc. | Entomology |
| P. Peterson, B.S.A. | Plant breeding |
| A. Plourde, B.Sc. | Plant breeding |

[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On transfer of work to the Plant Breeding Research Institute, Cambridge, England, May 1982–April 1983.
[3]On a transfer of work to the Department of Agricultural Chemistry, Tottori University, Japan, May 1982–December 1982.
[4]Appointed to Research Scientist, Brandon Research Station.

# INTRODUCTION

Research programs at the Winnipeg Research Station emphasize three broad responsibilities: development of improved cultivars of cereals adapted to regions of the Canadian prairies, research on the protection of stored seed and seed products, and research on the integrated control of insect pests of field crops.

Improvement of cereal cultivars, historically the first mandate of the Research Station, requires close cooperation between plant breeders, geneticists, cytologists, plant pathologists, and cereal chemists. A new durum wheat cultivar, Medora, licensed in 1982, is superior to existing cultivars in the Black soil zone, has improved resistance to stem rust, leaf rust, and bunt, and exhibits excellent pasta quality. In addition, a new oat cultivar, Dumont, was licensed and has highly effective resistance to stem and leaf rust and smut, good yield potential, and plump kernels, which are desired by producers.

Research on the storage and protection of grains, oilseeds, and their products is national in scope and involves close cooperation with the Plant Products and Quarantine Directorate, the Canadian Grain Commission, and the grain industry. Particular emphasis is being placed on ecology of storage, insecticide control, and the detection, prevention, and dynamics of mycotoxins in stored grains and oilseeds.

Research on the control of field crop insects, particularly those that attack canola, includes the evaluation of new insecticides, assessment of economic damage, biological control, and the development of management systems.

In 1982 the Winnipeg Research Station and the Research Branch lost two valued colleagues and internationally respected scientists with the deaths of Dr. G. Green, plant pathologist, and Dr. G. Bucher, entomologist.

Several new staff members were recruited, namely, Dr. O. Lukow, cereal chemist; Dr. O. Morris, insect pathologist; Dr. G. Atkinson, biometrician; and Dr. S. M. Woods, programmer/analyst.

Further information summarized in this report can be obtained from Research Station, Research Branch, Agriculture Canada, 195 Dafoe Road, Winnipeg, Man. R3T 2M9.

D. G. Dorrell
Director

# BREEDING, GENETICS, AND CYTOGENETICS

Breeding programs for common wheat, durum wheat, barley, and oats emphasize production of high-yielding cultivars with improved agronomic characteristics and resistance to rusts, smuts, and other cereal diseases. Good quality is a primary objective, and is determined by milling and baking characteristics in common wheat, semolina quality in durum wheat, malting quality in barley, and feeding quality in wheat, oats, and barley.

## Barley

Approximately 25 000 t of the recently licensed cultivar Norbert will be available for 1983 planting. It is currently receiving plant-scale malting and brewing tests. A promising two-row malting barley selection, TR212, has resistance for stem rust, net blotch, and powdery mildew, is tolerant of the herbicide Hoegrass, and is well adapted to the parkland area of the prairies. TR212 has exceptionally good malting and brewing qualities. Further progress was made in breeding for multiple disease resistance with the incorporation of resistance to spot blotch, scald, and barley yellow dwarf virus into high-quality lines with resistance to stem rust and net blotch.

Barley lines with postharvest dormancy were examined for malting quality and dormancy at various times after harvest. It appears that a specific type of dormancy can be added to barley without significantly affecting the malting process. This would reduce sprouting and loss of grade, which are common to malting barley under poor harvest conditions.

Various methods of precipitating carbohydrates in malt wort using ethanol, ammonium

sulfate, and acetone were examined. The results indicate that it may now be feasible to determine mash filtration rate, wort fermentability, and carbohydrate quality in small samples, permitting early generation screening.

**Common wheat**

Benito, licensed in 1979, ranked second in Manitoba wheat hectarage in 1982, at 21.2%. Its major attributes, desirable for this area, are earlier maturity and better leaf rust resistance than Neepawa, the most popular cultivar.

Significant progress was made in combining resistance to loose smut and additional genes for stem and leaf rust resistance in the cultivar Benito. Several backcross lines are in preliminary yield tests. Backcrossing with Columbus to improve stem and leaf rust resistance continued. To accelerate the various backcrossing programs, including that for sprouting resistance, a method of culturing immature seed was developed. This reduces time for each backcross by about 30 days and is less time consuming than embryo culture.

Leaf rust resistance in Benito was shown to be conditioned by the seedling genes *Lrl* and *Lr2a* and the adult plant resistance genes *Lrl2* and *Lrl3*. As has been shown previously with other resistance genes, these genes have an additive effect, conferring greater resistance in combination. In genetic studies of 15 foreign cultivars, it was confirmed that at least nine have the same genes for leaf rust resistance, *LrT2* and *LrT3*, as the cultivar Terenzio. However, two new synthetic hexaploids developed from different accessions of *Aegilops squarrosa* will provide valuable new sources of leaf rust resistance.

Another instance of suppresion by the D-genome was identified during attempts to transfer leaf rust resistance from Stewart 63 durum wheat to the hexaploid level. The synthetic hexaploid was found to be moderately resistant to some races and susceptible to others, whereas Stewart 63 is highly resistant to all races tested. Further study of the diploids *Triticum bocoticum* and *T. monococcum* indicated that at least two accessions may carry a previously unidentified gene for stem rust resistance.

A study to determine possible mechanisms of sprouting resistance showed that higher peroxidase activity was associated with higher levels of dormancy. The plant hormone phytate was found to overcome the detrimental effects of sprouted grain on dough characteristics, either by inhibiting alpha-amylase activity or by influencing pasting properties of starch.

Wheat endosperm protein bands 44.5 and 50 were purified and compared from three wheat cultivars, Marquis, Little Club, and Wakooma. Band 44.5 had a high degree of sequence homology among the three cultivars, although the band from the durum wheat Wakooma had a slightly lower molecular weight. Band 50 from Marquis and Little Club differed in internal amino acid sequence, whereas Wakooma contained proteins that had sequences present in both other cultivars.

**Durum wheat**

A new cultivar, Medora, was licensed in 1982. Compared with present commercial cultivars, it yields 105% and 100% in the Black soil zone and Brown soil zone, respectively. It has the best straw strength of all cultivars, is highly resistant to stem rust, leaf rust, and bunt, and is moderately resistant to kernel smudge, root rot, and leaf spot. The pasta quality of Medora is excellent.

In a study of durum wheat quality, significant differences in glycolipids and soluble pentosans were detected among cultivars of varying cooking quality; pentosans appear to be involved in viscosity properties. An extensive study of quality parameters conducted with the Grain Research Laboratory indicated that sodium dodyl sulfate (SDS) sedimentation, farinograph bandwidth, and specific absorbance are the best indicators of cooking quality.

**Oats**

The area seeded to the cultivar Fidler, licensed in 1980, increased to 36% of the Manitoba oat hectarage, second only to Harmon at 37%. Fidler has excellent rust resistance, and its rapid adoption should reduce rust losses significantly. A new cultivar, Dumont, licensed in 1982, has highly effective multigenic resistance to stem rust, leaf rust, and smut. Dumont has good yield potential and a very attractive, plump kernel preferred by producers.

Preliminary evidence suggests that tan hull color is associated with lower hull content, which is a desirable trait in terms of feeding value. This apparent association is being

studied further, and an advanced tan-hulled line was increased to determine market acceptance. Other lines in the advanced testing stage combine excellent resistance to rust and smut with good tolerance to barley yellow dwarf virus (BYDV). A study of the inheritance of tolerance for BYDV indicated that it is multigenic.

## CEREAL DISEASES

Pathology research is multifaceted and plays an integral part in the breeding of all cereal cultivars. Annual disease surveys are conducted to determine the prevalence of races of rust and smuts; new genes for resistance to various diseases are identified and transferred to desirable germ plasm; breeders' lines are evaluated for resistance; basic studies are conducted on the biology, genetics, histochemistry, and ultrastructure of the pathogens; and long-term research is under way to explain the mechanism of host–parasite interactions and the molecular basis of resistance.

### Rust surveys

*Stem rust of wheat.* Stem rust was not found in 1982, but air-borne inoculum as measured by spore traps was more abundant than in any year in the past 16 yr. Susceptible cultivars at Morden, Portage la Prairie, Brandon, Indian Head, Arcola, Yorkton, and Regina were severely damaged or killed by mid August. If commercial cultivars had not been protected by genetic resistance, large crop losses would have occurred. Twenty-five races, including four new ones, were identified but none constituted a threat to commercial cultivars. Race C53, predominant since 1977, comprised over 70% of the cultures identified.

*Leaf rust of wheat.* Wheat leaf rust was widespread in trace amounts in Manitoba and Saskatchewan by late June, but adverse weather conditions delayed rust development, and severe infections on susceptible varieties did not occur until early August. Early crops of wheat escaped with little or no damage, but late planted fields of susceptible cultivars sustained losses estimated at 5–10% of potential yield. The cultivars Benito, Columbus, Sinton, and Glenlea were resistant, whereas Neepawa was susceptible to leaf rust in 1982.

The identification of races from leaf rust survey samples was carried out in 1981, with 22 differential lines each with a single gene for resistance. Lines with resistance genes *Lr19* and *Lr21*, and line T6X58548, were resistant to all survey samples. Two cultures from Western Canada were virulent on the new bread wheat cultivar Benito, which has genes *Lr1*, *Lr2a*, *Lr12*, and *Lr13*. Forty-seven virulence combinations were identified using 15 genes for resistance.

*Oat crown rust.* In Western Canada oat crown rust was first observed in mid July and became widespread throughout the rust areas of Manitoba and eastern Saskatchewan by mid August. Plants in early sown fields remained lightly infected but those in late sown fields of susceptible varieties sustained moderate damage. The new cultivar Fidler, which comprised about 80% of the oat fields examined in Manitoba, was resistant to crown rust.

A new race of crown rust with significance to the oat breeding program was isolated from a nursery grown near a natural stand of buckthorn at Brandon, Man. This new race attacks the cultivar Fidler. Buckthorn in Manitoba is not being controlled and its spread continues to be of concern.

*Oat stem rust.* Oat stem rust occurred throughout Manitoba and eastern Saskatchewan. By late August, infections on susceptible cultivars like Harmon ranged from 20 to 60% across Manitoba, except in the northern parts, into eastern Saskatchewan as far as Regina. Early fields escaped with little or no damage, but late planted crops sustained yield losses estimated at 10–30%. Fortunately, over half the fields surveyed in the rust area were planted with the cultivar Fidler, which is highly resistant.

A total of 14 avirulence–virulence combinations were identified from over 700 collections in 1981. The recently released cultivars Fidler and Dumont provide protection against all the prevalent races.

### Resistance to oat rusts in new accessions

The resistance of about 600 accessions of wild *Avena* spp. from Spain and Portugal and their off-shore islands was tested with crown rust and stem rust of oats. An unusually large number of *A. sterilis* and *A. barbata* accessions showed resistance to crown rust, whereas only 14 lines showed resistance to stem rust. It is not known if the resistance can be transferred to the hexaploid level.

**Molecular biology of cereal rust diseases**

Efforts were continued to detect and isolate the products of the genes for resistance and of the genes for avirulence. Detergent-soluble polypeptides from isogenic lines of Chinese Spring and from the 2D L ditelosomic line of the wheat cultivar Chinese Spring were separated by two-dimensional isoelectric focusing polyacrylamide gel electrophoresis. One polypeptide was absent in 2D L but present in other lines, suggesting the gene for its synthesis is located on the same chromosome arms as the *Sr6* gene, but is not the *Sr6* gene product. This polypeptide appears to be present in the plasmalemma-enriched fraction. Two polypeptides present in whole leaf extracts but absent in the plasmalemma-enriched fraction were only present in the line that contained the *Sr6* gene for resistance.

Of more than 290 polypeptides from urediospores of stem rust of wheat, 18 varied between isolates of four physiologic races. Some differences in polypeptide patterns were noted when extracts from germinated urediospores were compared with those from dormant spores. Preliminary studies indicated that occurrence of certain polypeptides is correlated with the presence of certain genes for avirulence.

Intercellular washing fluid (IWF) was obtained from detached leaves of barley and wheat. This liquid may be a potential source for the products of the genes for resistance or, when isolated from infected leaves, for the products of the genes for avirulence. Thirty and 40 proteins were detected in IWF from barley and wheat, respectively.

**Smuts**

Smutted plants were found in 79% of 190 barley fields in Manitoba, Saskatchewan, and Alberta, with an average of 0.05% loose smut, 0.1% false loose smut, and 0.5% covered smut. Seven known races of loose smut of wheat, *Ustilago tritici*, were identified in 13 field collections from across Canada.

Five races of *U. tritici* collected on five different species of *Aegilops* were hybridized on *A. bicornis* with a race from common wheat. Spores were formed, but various levels of lysis were found after germination, indicating various levels of incompatibility between the races. The race from *A. cylindrica* was found to be very compatible with that from wheat, whereas that from *A. kotschyi* was highly incompatible. This incompatibility probably reflects differences at many loci in the genotypes, brought about by long isolation of the races on various hosts.

*Ustilago aegilopsidis* was demonstrated to possess genes for virulence on *Hordeum*, thus providing further proof that *U. aegilopsidis* and *U. nigra* are conspecific. Scanning electron micrographs of hybrids from *U. nigra* × *U. hordei* crosses clearly showed segregation of a single gene for echinulation.

Large populations of host plants were tested to detect genes for smut resistance of potential use for cereal breeding programs. This included several thousand entries of oats from Canadian sources, 360 common wheats and 187 durum wheats from the USSR, and 21 species of *Aegilops*.

**Foliage diseases**

A comprehensive survey of Manitoba barley fields was carried out to assess the incidence of leaf stripe. Of 179 fields examined, 14% were infected. In contrast to the 1980 survey, leaf stripe was found in six-row barley in 9.4% of fields. The incidence in fields of two-row barley was 25.5%, lower than that found in 1980. Disease severity was generally less than 1% of plants infested. An experiment to assess yield losses caused by leaf stripe was conducted. The replicates sown with infected seed developed 32, 18, and 14% leaf stripe when sown on 5 May, 21 May, and 28 May, respectively. Infection declined with the season. Losses of approximately 0.6% of grain for each percentage point of leaf stripe were recorded.

Ten seed treatment products were tested for their efficacy in controlling leaf stripe of barley. The good control obtained by EL 228, C.G.A., 64251, Agrox NM, and Dithane M-45 in 1981 was confirmed, whereas three newly tested products, Baytan, Baytan Universal, and RH 5781-F, were found to be equally effective.

**Viruses**

A large area of late-seeded wheat was observed in the northern half of the Red River Valley. However, minimal damage resulted from BYDV because aphid populations were low. Greenhouse screening trials with cultivars of barley showed that only Norbert was fully tolerant of a virulent isolate of BYDV. The most tolerant oat variety of four advanced lines tested was Fidler, with a loss in seed weight of 14%. The *Rhopalosiphum padi*

specific strain of BYDV was successfully propagated in oats, and antiserum to this strain was prepared.

## STORED PRODUCTS PROTECTION

Research on the biology and control of pests in stored cereals and oilseeds emphasizes the interaction of insects and microorganisms in a dynamic storage environment. The program includes the following: studies of the ecology of stored grain; factors that limit long-term storage; identification and quantification of insects in stored products; influence of attractants and feeding stimuli on insect behavior; control of insects and mites by environmental, physical, and chemical means; and identification and control of mycotoxins in stored grain and oilseeds.

### Storage ecology

The results of the 2nd yr of a 5-yr on-farm cereal-storage study to determine the efficacy of a 2.2-kW two-duct ventilation system have demonstrated excellent keeping quality of the crop. Wheat or barley was stored at a moisture content of up to 15.8% in four steel bins (545 t per bin) and ventilated only on cold days. Weekly monitoring of biotic and abiotic variables showed no unusual changes in the levels of $O_2$:$CO_2$, free fatty acids (up to 18 mg KOH for wheat, 16 mg KOH for barley), seed germination, and microflora. The moisture content of samples collected 10 mo after storage ranged from 11.5 to 14.8%. Some of these samples contained *Acarus* spp. mites. No adverse effect was observed when pigs were fed on feed composed of these cereals.

Safe storage limits were developed for wheat. With the aid of charts, producers can determine the number of days they can safely store wheat harvested with 12.7–22.2% moisture content and stored at 5–40% without losing germination, developing a musty odor, or affecting any other factors that could result in loss of grade.

Feeding damage and the loss caused by three storage moths were determined. The meal moth *Pyralis farinalis*, a grain pest in Western Canada, consumed significantly more bran, endosperm, and germ of wheat kernels than did *Ephestia cautella* and *Plodia interpunctella*.

A study was conducted to determine which of 88 strains of postharvest fungi isolated from stored rapeseed could release fatty acids from refined canola oil. Most strains of *Aspergillus candidus* and *A. flavus* tested were strongly lipolytic, whereas most strains of *A. glaucus* group species, *A. versicolor*, and *Penicillium* spp. had moderate to weak lipolytic properties. Presence of *A. candidus* and *A. flavus* on damp and heated grains may be associated with elevated levels of free fatty acids and a deterioration in quality.

### Mycotoxins

Damp barley under granary conditions produced both ochratoxin A and sterigmatocystin during a 66-wk storage period (0.24 and 3.45 mg/kg, respectively). *Aspergillus versicolor* or species of the *A. glaucus* group probably accounted for the production of sterigmatocystin. *Penicillium verrucosum* var. *cyclopium* was associated with production of ochratoxin A in barley stored at 20% moisture content.

Microfloral analyses were completed on cereal seeds and foods associated with 51 suspected cases of mycotoxicoses of farm animals in the Prairie Provinces. Presence of toxins was confirmed in five cases. *Penicillium* spp. and *Aspergillus ochraceus* were associated with production of ochratoxin A, *Fusarium* spp. with T-2 toxin and diacetoxyscirpenol, and *A. glaucus* with sterigmatocystin. The first known incidence of suspected sterigmatocystin poisoning of poultry through feed ingestion was encountered.

Reculturing toxigenic *Penicillium* spp. resulted in a loss of ochratoxin-producing ability, a common problem in mycotoxicology. To better understand this phenomenon as it relates to storage fungi, investigations are being conducted on *A. versicolor* and *A. glaucus* group species, which are thought to produce sterigmatocystins.

### Biology

Adults of the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), moved downward in the columns of grain that contained 13% moisture. After 3 days, most had migrated to the bottom. From 80 to 92 of the beetles aggregated at the top or middle zones of the column when wheat of 16–17% moisture content was placed in these zones. Geotactic and hydrotactic stimuli are important factors in the distribution of the insect.

A random sample of residents in 2341 and 1152 dwellings in Winnipeg in 1979 and 1980,

respectively, were interviewed to determine the prevalence of the merchant grain beetle. About 14 houses and 18 apartments were infested with this insect. Estimates based on the Winnipeg data indicated that the total cost of infestation in Canadian residences was $6 million in 1980, excluding the costs of commercial pest control services. The results of the survey suggest that the merchant grain beetle is a widespread and economically important household pest in Canada, particularly in apartments, where it is a chronic problem.

Larvae of the flour beetle, *Tribolium madens*, required 5–6 days longer to develop on 16-mo-old than on 9-mo-old Bonanza and Klondike barley cultivars. There was no difference in development time between the 16-mo-old and the 9-mo-old Neepawa wheat or Hudson oats. Development was 2 days faster on the older Coulter durum.

A two-component rusty grain beetle pheromone was tested in farm-stored grain in 1982. More beetles were caught in pheromone-baited traps than in unbaited traps and more were caught at 100–200 cm than at 50 cm below the surface of the grain. Fewer were caught at grain temperatures lower than 14°C than at higher temperatures. The generally low catches were attributed to poor winter survival, application of chemical and physical control methods last fall, and a cool summer. Since the beetles can be caught in unbaited traps, a synthetic pheromone may not be necessary.

The preliminary identification of insects from the samples collected in a survey of farm granaries in Manitoba was completed. Adults and larvae of the rusty grain beetle and the black flour beetle, *Tribolium audax*, were found on 50% of the farms sampled. This study will provide an up-to-date list of insects found in farm-stored grain and will identify problems that require research to improve the protection of stored grain.

A preliminary experiment with the flour beetle indicated that adults can survive at −5°C for 4 wk. The information obtained in this study will enable an assessment to be made of the ability of the flour beetle to survive in railway boxcars used to ship to ports in the Maritime Provinces in winter.

**Control**

Three pyrethroid insecticides (cypermethrin, fenvalerate, and permethrin) were shown to have long residual activity on plywood surfaces for the control of the red flour beetle, *Tribolium castaneum*. However, these insecticides are of limited use for control of this insect when they are applied alone to structural surfaces, since high knockdown does not correspond to high mortality. These insecticides may have some potential when used in combination with organophosphorus insecticides.

Malathion applied to stored wheat at 8 mg/kg caused a constant level of mortality in malathion-resistant red flour beetle when applied as a dust. A liquid formulation resulted in higher mortality levels and low reproduction.

A comparison of malathion and pirimiphos-methyl applied to wood or concrete surfaces for control of the larger grain borer, *Prostephanus truncatus*, was completed. Malathion appears to be as effective as pirimiphos-methyl for long-term control of this insect, which is potentially a pest in corn-growing regions of Canada.

Malathion was more effective than fenitrothion when applied to plywood or steel surfaces for control of the red flour beetle and the rusty grain beetle over 33 wk. Fenitrothion was taken up more rapidly than malathion by stored rapeseed. Fenitrothion offers no advantages to malathion for control of malathion-susceptible insects.

Data were obtained on the susceptibility of adults of the black flour beetle to methyl bromide, carbon disulfide, carbon tetrachloride, and ethylene dichloride. The black flour beetle was 1.5 times as tolerant as the red flour beetle to methyl bromide.

The $LC_{50}$ values were 10.8, 59.3, 122.1, and 161.4 mg/L for methyl bromide, ethylene dichloride, carbon disulfide, and carbon tetrachloride, respectively. Eggs of the mite *Lepidoglyphus destructor* in wheat were more tolerant than hypopi to the fumigant hydrogen phosphide.

Synergistic effects have been found between some pyrethroids, such as permethrin, and other insecticides, such as Galecron. Adults of the red flour beetle were used to determine the optimal ratios of permethrin to Galecron to obtain the highest mortality. A ratio of 1:2 or 1:3 permethrin to

Galecron reduced the need for the pyrethroid by up to 75%.

## CROP PROTECTION

Research on insect pests of oilseed, cereal, and vegetable crops emphasizes aspects of their biology and control leading toward better prediction of infestations, crop protection, and the reduction of pest populations. The program includes the development of pest monitoring techniques, development and field testing of chemical and biological insecticides, and investigation of methods of reducing pest populations by biological and other nonchemical control methods. These programs are supported by research on sampling techniques, survival, development, phenology, host selection, induction and termination of diapause, overwintering strategies, reproductive biology, and biochemical bases of neurotransmission.

### Monitoring and prediction

In 1982, approximately 2425 h were spent on spraying for grasshopper control in Manitoba compared with 16 200 h in 1981. The largest and most heavily infested area was in southwest Manitoba, extending from Deleau west to Highway 83 and south to Melita. Infestations were largely light, with a moderate infestation present in the middle of that area. In the south-central region, the largest area infested extended from Ingelow south to Highway 2 and east to Cypress River. The infestations were largely light, with two small pockets of moderate infestation, one west of Shilo and the other between Treesbank and Stockton. An area of light infestation was present south of Gladstone and extended southwest to Melbourne and southeast to McGregor. In the Red River Valley, the area infested was east of the Red River and covered approximately half the municipality of Franklin. Infestations were largely light, with a small moderate infestation present east of Dominion City. In the northwest region a small area of moderate infestation was present in the vicinity of Renwer and a light infestation between Ukraina and Ashville.

In the Red River Valley, infestations were mainly along roadsides, and the twostriped grasshopper, *Melanoplus bivittatus* (Say), was the dominant species. In the remainder of the province, pastures, hay land, and some roadsides were infested, and the clear-winged grasshopper, *Cammula pellucida* (Scudder), was dominant.

The forecast of grasshopper infestations in Manitoba for 1983, based on the adult survey, shows that the area infested has decreased by almost 50%, with little change in the density of expected populations.

The numbers of male moths of the bertha armyworm, *Mamestra configurata*, captured in six attractant traps, were lower this year than in 1981, leading to a prediction that damaging infestations of larvae would occur only in a few fields. Although larval surveys detected larval density of about 8/m² in a few fields, no insecticidal spraying was needed, or conducted, in Manitoba. Additional information was collected to show that sex attractant traps placed in canola fields in the early bloom stage capture more moths than those in other stages of crop development.

A survey of canola fields in Manitoba showed that only 0.3% of the plants had root infestations of cabbage maggot, *Delia* spp. These root maggots, although pests in cole crops, are not a problem to canola growers in Manitoba.

### Damage assessment

Preliminary experiments show that pea aphids can transmit virus in fababean fields.

Studies on the indirect effectiveness of insect feeding on canola seed quality showed that severe spring damage by flea beetles (*Phyllotreta* spp.) caused a three- to five-fold increase in the chlorophyll content of seed. Pod feeding by the bertha armyworm also reduced seed quality, although the effect was not as dramatic as that observed with flea beetles.

### Insecticides

Field experiments to control flea beetles on canola included tests of insecticides formulated as in-furrow granules, seed dressings, seed coatings, or postemergence sprays, alone or in combination with fungicides or other insecticides and at various rates of application. Evaluation of the effectiveness of the various treatments based on bioassays generally verified previous findings, such as the extended period of effectiveness of in-furrow granules and the resulting reduction in the numbers of larvae feeding on the roots, and the short period of activity of most of the seed dressing and seed coating treatments.

Differences in damage between insecticidal treatments at seedling and early plant development were not as pronounced as in previous years because periods of cool weather reduced the activity of the flea beetles. Emergence was delayed, and plant stands were reduced because of phytoxicity or disease among some of the in-furrow granular treatments and the seed coating treatments. Plant stands appeared unaffected in two in-furrow granular treatments where the seed was treated with a fungicide or with a dual-purpose seed dressing. In the latter treatment the duration of effectiveness of the granular insecticide was low, as in 1981. There appears to be a detrimental interaction between insecticides and fungicides when they are combined in a treatment. Most of the postemergence sprays tested gave good initial knockdown. The effectiveness of the synthetic pyrethroids was greatly reduced 48 h after application, particularly at the lower rates. The effectiveness of one synthetic pyrethroid was enhanced when applied on combination with a synergist.

A significant advance in the understanding of theoretical and practical aspects of insecticide synergism was made during the course of research, which showed that certain classes of insecticides disrupt processes that are controlled by the cyclic nucleotide cAMP (class A insecticides), whereas other insecticides disrupt processes that are controlled by the cyclic nucleotide cGMP (class G insecticides). Combining an insecticide from each class and treating pest insects with the mixture disrupt processes controlled by cAMP and cGMP and result in a synergistic effect on mortality. With the use of the A plus G principle of insecticide synergism, new and highly effective combinations of insecticides have been discovered that are many times more effective than either of their individual components used alone.

Biochemical analyses revealed that calcium ion has two distinct effects on octopamine-sensitive adenylate cyclase stimulation at submicromolar concentrations and potent inhibition at slightly higher concentrations. With the use of a computer program and biochemical analyses, levels of free calcium ion that affected adenylate cyclase activity were determined. It was further demonstrated that calcium ion acts through the calcium-binding protein calmodulin. The results suggest that disruption of processes controlled by calcium ions and cyclic nucleotides may be important in many types of insecticidal actions.

**Biological control**

A total of 77 adults of the European parasite *Microtonus bicolor* (Wesm.) and 1148 flea beetles (*Phyllotreta striolata* and *P. cruciferae*) were exposed to *M. bicolor* in the laboratory and were released at Glenlea, Man. A total of 6309 adults of the flea beetles were collected at Glenlea in April 1982 and reared. There was no evidence of establishment of *M. bicolor* released there in 1978–1981. Numerous parasite adults were collected from a canola plot at the Glenlea release site during June–August 1982 and will be identified for additional information on establishment of *M. bicolor*.

A survey of pea aphids indicated that although several parasite species were abundant, *Aphidius smithii* was not present. This species, introduced and established in several parts of North America, is being considered for introduction into Manitoba.

The European tachinid *Ernestia consobrina* was found to be capable of parasitizing and completing its development in larvae of the bertha armyworm. Preliminary experiments indicate that it will be univoltine under Manitoba conditions. It is being considered for introduction into Manitoba.

**Plant resistance**

A method for screening *Brassica* lines for resistance to flea beetle attack was refined, and 100 breeder lines from the three Prairie Provinces were screened in three sequential tests. Much variation in plant survival, biomass production, and yield, both within and among species, was identified. Two varieties of radish that can be crossed with rape were found to have very high levels of resistance to flea beetle attack. A study was initiated on mechanisms of resistance in Cruciferae to flea beetle damage. Damage levels varied with time and differed among the three lines of *Brassica juncia*, a *B. hirta* variety, and two *B. napus* varieties studied. These preliminary tests indicate that both plant tolerance and feeding preferences are factors in plant resistance.

### Parasitism

Parasitism of larvae of the bertha armyworm by *Banchus flavescens* and *Athrycia cinerea* averaged 59 in 1982. Higher parasitism by both species coincided with a general reduction in host population levels.

### Natural control

Lower than average snowfall during the winter of 1981–1982 caused lower soil temperature and reduced survival of bertha armyworm pupae and flea beetles. In tilled soil, overwintering mortality of pupae of the bertha armyworm was 25–43% higher than it was in untilled soil.

Populations of the red turnip beetle, *Entomoscelis americana* Brown, were at low levels in Manitoba in 1982. No parasites were found in larvae collected on volunteer rape, flixweed, and wild mustard.

### Biology

The eggs of the red turnip beetle are laid from early August to late October in growers' fields. In 1980, the hatching rate was high (usually >72%) in eggs laid before the middle of October. Less than 1% of eggs laid after the middle of October hatched. These data suggested that overwintering mortality resulting from eggs laid late in the season is not an important factor in the population dynamics of the beetle, because the eggs laid after the middle of October represented <1% of the total. The time and pattern of hatching were different in the eggs laid at various times in September and October. The eggs laid in the first half of September and October were the first and last to hatch, respectively. It has been reported in the literature that the red turnip beetle overwinters as a late-stage embryo in the egg. This field data, therefore, suggested that this may not be the case in the eggs laid after the middle of September.

In the laboratory, the eggs required about 11 days at 20°C to complete the prediapause part of embryogenesis. However, the eggs were able to overwinter successfully if they had been exposed to 20°C for as short a period as 1–2 days before being placed in overwintering conditions. If the prediapause part of embryogenesis was not completed before hibernation, it was completed after hibernation and hatching was delayed by an amount of time equivalent to the time it would have taken to complete the prediapause part of embryogenesis. The laboratory data show that the eggs have to complete only 10–20% of the prediapause part of embryogenesis in order to overwinter successfully.

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# Melfort, Saskatchewan

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# INTRODUCTION

Researchers at the Melfort Station are developing more efficient forage production, harvesting, storage, and utilization systems aimed at providing beef cattle producers with an alternative to expensive feed grains and encouraging greater use of perennial forage crops in rotation to prevent a further decline in the productive capacity of the soil. They are also conducting research to improve the production efficiency of cereals, oilseeds, pulse crops, and other special crops, without causing soil deterioration. A large-scale cooperative project with the Saskatchewan Department of Agriculture is under way to develop efficient beef cow–calf management systems in the aspen parkbelt.

This report contains brief summaries of some of our research findings. For more information, readers can obtain a copy of our *Research Highlights 1982* by contacting the Agriculture Canada Research Station, Box 1240, Melfort, Sask. S0E 1A0, or by telephone (306) 752-2776, or telex 074-29122.

S. E. Beacom
Director

# FORAGE PRODUCTION AND UTILIZATION

## Forage species population trends on Pathlow community pasture

On pastures used in a cow–calf management project at Pathlow community pasture, the ground cover of forage species was measured in the spring of every 2nd yr, 1976–1982, with the use of the point quadrat technique. During this period, the proportion of grass in the area has remained constant at 70–75% of the total, but the species making up this fraction have changed markedly. Creeping red fescue (*Festuca rubra* L.) has been reduced from 80% to 30% of the grass fraction. It has been replaced with a natural increase of Kentucky bluegrass (*Poa pratensis* L.) and seeded populations of bromegrass (*Bromus inermis* Leyss.) and Russian wild ryegrass (*Elymus junceus* Fisch.). The amount of dandelion (*Taraxacum officinale* Weber) in the pasture has also decreased, whereas the legumes alfalfa (*Medicago media* Pers.) and alsike clover (*Trifolium hybridum* L.) have increased. No single cause of the changes in the proportion of species can be identified. It is probable that drought in 1980 and 1981 killed some creeping red fescue; that increased fertility was advantageous to bluegrass; and that rotational grazing favored bromegrass and alfalfa. It is probable that a return to the pasture management system of continuous grazing with minimal input used prior to 1976 would result in a rapid return to the species balance that existed at that time.

## Rejuvenation of pastures by seeding legumes into the sod in the fall

Strips of pasture 30 cm wide were sprayed with glyphosate [*N*-(phosphonomethyl)glycine] in mid September and seeded with legumes in late October. With the use of a triple disc seeder, adjacent untreated areas were also seeded. The number of seedlings established by midsummer of the following year was higher in the sprayed area in a dry year, but not much different in a normal year. Seedling vigor was superior where the sod has been killed.

## Cow–calf management

The cost of applying N at 90 kg/ha and P at 20 kg/ha to rough-land community pastures in alternate years since 1974 has been offset by the value of the increased calf gains. The longer grazing period (shorter winter feeding period) and the higher carrying capacity of the pasture have been additional benefits. In unfertilized (control) areas, dry-matter (DM) yield has averaged 1157 kg/ha annually compared with 2600 kg/ha where fertilizer was applied and rotational grazing practiced. In the 1982 grazing season, a cow–calf unit required 2.2 ha of nonfertilized, continuously grazed pasture; 1.5 ha of fertilized, rotationally grazed pasture; and 1.3 ha of fertilized, rotationally grazed and partly

reseeded pasture. Since 1978, gains per hectare on these treatments have averaged 58 kg, 86 kg, and 90 kg, respectively.

Cows calving in January–February consumed about $15 worth of additional feed compared with cows calving in April–May, but weaning weights of early born calves averaged 50 kg more. This provided an advantage of $50 per calf when both extra feed and winter housing costs were taken into account.

### Comparison of protein supplements for wintering beef cows

Canola meal (DM content of 0.34 kg/day per head) that was hand fed as a supplement to a straw-based diet for wintering mature, pregnant beef cows reduced feed costs by $0.17/day per cow compared with a urea–molasses supplement fed by lick wheel. Animal performance on the canola-supplemented diet was equal or superior to that obtained by using the urea–molasses supplement.

### Effect of the antibiotic Avoparcin on performance of yearling heifers on pasture

Avoparcin (Cyanamid of Canada Ltd.) is a feed antibiotic currently under evaluation for possible registration as a growth promotant for growing–finishing beef cattle on pasture and in the feedlot. Results of a 4-yr pasture study, in which the antibiotic was fed with a mineral mix to yearling heifers grazing a grass–legume pasture, indicated that the antibiotic increased gain significantly in only 1 of the 4 yr. Intake of mineral, and hence of Avoparcin, was highly variable, which may have reduced the potential efficacy of the antibiotic.

### Coping with frozen silage

At –30 to –40°C, mechanical silo unloaders can suffer the breakage of chip knives, bending of the torque arm, and excessive wear on the wheel hubs caused by the extra force required to break up the layer of frozen silage at the top. At Melfort, these problems have been overcome by fabricating thicker knives and by reinforcing the auger flighting on which the thick knives are mounted. Welding the bushing to the hub of the wheel eliminates hub failure. Bending of the torque arms is prevented by tying a cable or chain from the steel ring at the door to the suspension cable at about 90°, and allowing the end to slide on the suspension cable.

### Energy required to fill tower silo

With diesel fuel valued at $0.33/L and electricity at $0.22/MJ, the cost of blowing silage into an 18.5-m-high tower silo using a blower powered by an IHC 684 diesel tractor was $0.45/t of dry matter (DM) (1.35 L/t DM) compared with $0.15/t DM when a 22.5-kW electric motor was used.

### Feeding value of tall wheatgrass hay grown on saline soils

Heifer calves that averaged 290 kg initially were fed tall wheatgrass hay (12.8% crude protein (CP), 51.0% digestible organic matter (DOM)) in the long, chopped, and ground forms plus a daily allowance of 0.9 kg of grain supplement. Rates of gain (kilograms per day per head) and feed-to-gain ratios for heifers fed long, chopped, and ground (1.3-mm screen) hay averaged, respectively, 1.12, 8.16; 1.25, 7.54; and 1.41, 7.10. In another test, 235-kg steer calves fed a ground, tall wheatgrass (12.2% CP, 48.6% DOM) ration containing 4% acidulated fatty acids, but no grain, consumed 9.5 kg of the ration daily and gained 1 kg/day over a 104-day period. Dry-matter yield was 5.6 t/ha in 1982.

### Eating quality of forage-fed beef

Rib roasts from steers fed ground brome–alfalfa hay (15% CP, 58% DOM) and grain-based (12% CP, 70% DOM) rations were evaluated at the Food Research Institute in Ottawa. Roasts from forage-finished steers scored 8.5, 8.6, and 9.6 for flavor, juiciness, and tenderness, respectively, whereas those from grain-fed steers scored 8.5, 8.8, and 9.5. Roasts from forage-fed steers contained less fat than those from grain-fed steers (10.7 versus 12.0%).

## CEREAL, OILSEED, AND SPECIAL CROP PRODUCTION

### Wheat

Columbus wheat has yielded 113% of Neepawa in 5 yr of testing at Melfort. It is easier to thresh, has good rust resistance, and resists sprouting and weathering. Unfortunately, Columbus is 4 days later in maturing than Neepawa, and under cooler conditions, its maturity may be delayed even

more, compared with Neepawa. At sites north and east of Melfort, where maturity is more critical, Columbus has not outyielded Neepawa. The earlier maturing varieties Benito and Katepwa are generally recommended for northeastern Saskatchewan.

### Canola

Westar canola is highly recommended for production in northeastern Saskatchewan, primarily because of its high yield—115% of Regent in 7 station-yr of testing. In addition, Westar is early maturing and has a relatively strong stem.

### Lentils

The small-seeded variety Eston has yielded 25% more and has averaged 5 days earlier maturity than Laird in 4 yr of testing; however, its short stature makes harvesting difficult.

### A comparison of methods of seeding wheat into stubble

Five methods of seeding the spring wheat cultivar Neepawa into standing stubble have been compared for 4 yr. The standard method, i.e., preparing the seedbed by cultivating and harrowing and by seeding with a narrow shovel-hoe-press drill, produced 2202 kg/ha. With the use of a single disc press drill, a narrow shovel-hoe press drill, a triple disc press drill, and a discer seeder, without any other cultivation, yields averaged 1963, 1855, 1921, and 2734 kg/ha, respectively.

In addition to higher yields, the minimum tillage seeding methods have been equal to or better than zero-till seeding in soil moisture, nutrient storage, and weed control.

### Chemical summerfallow

In 14 yr of testing on a 2-year wheat–fallow rotation, chemical summerfallow yielded 3446 kg/ha compared with 3289 kg/ha for normally tilled fallow. There was no significant difference between the treatments in moisture or nutrient levels in the soil or in weed problems. However, the chemical summerfallow conserved a greater quantity of trash, which provided significantly better soil erosion control.

### Emergence of canola seedlings

In greenhouse experiments with Gray Wooded soils, seedling emergence of the canola cultivars Target, Zephyr, Span, Regent, and Candle was significantly higher when seeded at 1.5 cm rather than at 3.0 cm deep. In emergence of canola seedlings the *campestris* cultivar Span was 69% versus 61% for the *napus* cultivar Zephyr, 13 days after seeding. With the low glucosinolate Candle (*campestris*) and Regent (*napus*), emergence was 56 versus 74%, respectively, under a high-moisture regime (watered to 100% field capacity). Under low moisture (50% of field capacity), emergence averaged 15% for both species. Under the low-moisture regime, there was no emergence of Regent on seven soils, whereas with Candle, there was no emergence on four soils.

The greater percentage of emergence of the smaller seeds of Span compared with the larger seeds of Zephyr was attributed to less energy required to push the smaller cotyledons of Span through the soil crust. Similarly, under dry soil conditions the smaller seeds of Candle emerged on more soils than did the larger seeds of Regent.

### Weed control in canola

Four new herbicides were identified as having potential for the control of grass-type weeds in canola. BAS 9052 is registered under the trade name Poast. TF 1169, DOW 453, and HOE 00736 are not registered, but they controlled wild oats, green foxtail, volunteer cereals, and quack grass in research trials.

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On transfer of work to May 1982.
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# INTRODUCTION

The Regina Research Station is a major center for the study of the biology and control of weeds in cultivated crops and pastures. The extensive use of herbicides in crop production creates a demand for increasingly sophisticated information on efficacy, crop tolerance, environmental persistence, and health hazards. New technology developed for biological control with insects and plant pathogens and cultural means is providing important information on alternatives to control with herbicides.

In addition to the weed research program, the Station has responsibility for increase of new crop varieties developed by Agriculture Canada and for a winter plant breeding nursery in California. Cereals, oilseeds, forages, and pulse crops are evaluated for adaptability to southeastern Saskatchewan. Agronomic experiments develop information for soil and crop management.

Enquiries for more detailed information on research activities may be directed to the Research Station, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask. S4P 3A2.

J. Dueck
Director

## BIOLOGICAL CONTROL

### Knapweed

The larvae of two-root feeding moths, *Agapeta zoegana* (L.) and *Pelochrista medullana* Star, were released in November 1982 at Kamloops and Grandforks, B.C., for the control of spotted and diffuse knapweed. It is anticipated that these insects will have a synergistic effect in reducing knapweed stands attacked by the previously released seed-head flies *Urophora affinis* Frfld., *U. quadrifasciata* (Meig), and *Metzneria paucipunctella* Zell.

European knapweed rust, *Puccinia jaceae* Otth., was found to be a promising candidate for biocontrol of diffuse knapweed, although further tests are needed before a release can be approved. Safflower rust, *P. carthami* Cda., and a black knapweed rust, *P. centaureae* DC., demonstrated little potential as biocontrol agents of diffuse knapweed.

### Leafy and cypress spurge

Two root-feeding beetles, *Apthona flava* Guill. and *A. cyparissias* Koch., were released on both leafy and cypress spurge at locations in Alberta, Saskatchewan, Manitoba, Ontario, and Quebec during the summer of 1982, but no evidence of breeding was found. Screening tests continued for two spurge aphids, *Acyrthosiphon cyparissiae* Koch. and *Aphis euphorbiae* (Kltb.), as candidates for biocontrol.

### Canada thistle

Efforts to investigate the host selection behavior of the leaf-feeding beetle *Lema cyanella* (L.) continued. Results from a field cage experiment with one native and two introduced thistle species showed that the beetle will concentrate feeding and oviposition on those species present in the highest proportion. This finding is in agreement with similar investigations and observations in the literature, which have shown that the number of insect species and individuals within a species present on the range of potential host plants is positively correlated with the amount of biomass available. This theory constitutes supporting evidence that *L. cyanella* will concentrate its feeding on the large stands of Canada thistle, in preference to species with lower population densities, as is the case in Europe.

### Perennial sow-thistle

The leaf-gall fly *Cystiphora sonchi* (Bremi) overwintered and increased slightly at two locations in Saskatchewan. There were no recoveries from the releases made in Alberta, Manitoba, or Quebec. Screening tests revealed that the leafminer fly *Phytomyza marginella* Fallen would not breed on any economically important plant species, although it did develop on dandelion and a species of hawk's-beard.

### Round-leaved mallow

A pathogenic fungus was isolated from round-leaved mallow with seedling blight symptoms in 1982. In field experiments, this species was found to be damaging to round-leaved mallow when applied as a spore suspension. Best results were obtained when spores were applied late in the evening to take advantage of dew formation. Steps have been taken to explore the development of this fungus into a bioherbicide.

## WEED ECOLOGY AND PHYSIOLOGY

### Weed surveys

Counts of weeds taken in randomly selected fields during the third annual provincial survey in Manitoba indicated that green foxtail was once again the most common weed found in cereal and oilseed fields. Wild oats and wild buckwheat were about one-third as common as green foxtail, and smartweed, Canada thistle, and lamb's-quarters were one-third as common as wild oats and wild buckwheat. In total, 107 different species were encountered in farm fields, with about 20 of these species considered as relatively important weeds.

Background information on the history of herbicide treatment of each surveyed field was obtained through a questionnaire. It was found that herbicides for control of broad-leaved weeds were applied to 67% of the surveyed area. Wild oat herbicides, either alone or in combination with other herbicides, were applied to 64% of the area. Only 46% of the surveyed area was treated with a herbicide to control green foxtail.

### Seed dormancy in wild oats

An inverse relationship was shown to exist between the depth of dormancy of a given line of wild oats and the level of inorganic phosphorus ($P_i$) in the mature caryopsis. By controlling the supply of phosphate to the parental plants, it was possible to adjust the endogenous level of $P_i$ in the caryopses. In dormant wild oat lines, a highly significant correlation existed between the levels of $P_i$ present and the ease with which dormancy could be terminated. No such relationship was found for the nondormant wild oat lines and cultivated oats studied. It is suggested that $P_i$ may participate in the regulation of dormancy through its involvement in key phosphorylation reactions during the processes of maturation and imbibition.

### Weed seed germination

A 100-cell germinator that is able to define the range of temperature conditions that stimulate germination of weed seeds was designed and constructed in cooperation with the Swift Current Research Station. The temperature of each individual cell was individually controlled to obtain all possible combinations between 0 and 45°C in 5°C increments. The germination pattern of small alyssum, bluebur, green foxtail, leafy spurge, and scentless chamomile, including minimum and maximum temperature conditions for optimum germination, was defined for each species. Requirements were least specific for green foxtail, which germinated in the range of 7.5–42.5°C.

## ENVIRONMENTAL CHEMISTRY OF HERBICIDES

### Mass balance studies: 2,4-D *iso*-octyl ester

Dissipation of *iso*-octyl ester of 2,4-D and of its acid metabolite in air, crop, and soil components was measured in a wheat field during and following application. Drift losses during application were only 0.19% of the amount applied. Air samples showed distinct ester gradients in the air. The highest concentration was measured in the sample closest to the canopy during the afternoon of day 7. The vertical flux of the ester showed definite diurnal variations with maximums reached in the early afternoon of days 1 and 2, followed by a rapid decline. The total or cumulative losses of the 2,4-D ester were estimated to be 20.8% of the amount applied. The crop canopy intercepted 77% of the applied ester and thus acted as the major source of vapor losses. The magnitude of vapor activity was controlled primarily by the atmosphere stability and air temperature following application. On entry into the crop, the ester was hydrolyzed to the acid metabolite. There appeared to be a rapid initial metabolism of the acid followed by a slow decline, with the maximum level reached in day 3. Ester losses from the soil occurred only when the soil surface was moist. No detectable 2,4-D remained in the soil after 34 days.

### Herbicide persistence in soils

The persistence of sethoxydim was investigated in soils at 20°C and at 85% of field capacity in the laboratory. Degradation was rapid, with half-life values of 12 days in the clay loam and sandy loam. In the heavy clay, the half-life of sethoxydim was 26 days. After 28 days there was negligible breakdown of the herbicide in any of the air-dried soils. In field studies using small plots, the persistence of sethoxydim applied at a rate of 1 kg/ha was examined. For three consecutive years, no residues of the herbicide were detected in clay loam, heavy clay, or sandy loam soils at either the 0–5 or 5–10 cm depths in September following a May application.

### Herbicide residues in leeks

Analytical methods to determine the levels of allidochlor and bentazon in leeks were developed, with the limits of detection being 10 and 5 μg/kg, respectively. Bentazon residues in leeks that had received a single postemergence application of the herbicide were less than 5 μg/kg. When there were two postemergence applications and harvest occurred 15 days after the second application, some samples showed residues in the order of 6–8 μg/kg. Leeks that had received a preemergence application of allidochlor showed residues of less than 10 μg/kg. The majority of the samples that had a single postemergence application showed residues less than 10 μg/kg, although residues as high as 65 μg/kg were observed. A second postemergence application did not significantly increase residues. The residues detected in leeks for both herbicides were found to be much less than the 100 μg/kg residue tolerance level, which is the basis for registration for use in other crops in Canada.

## CROP MANAGEMENT

### Fertilizer and sweet-clover establishment

The establishment of sweet-clover for use as a green-manuring crop in a partial fallow–wheat–wheat cropping program on clay soils was significantly affected by nitrogen (N) and phosphorus (P) fertilization practices. In 1982, five rates of N ranging from 0 to 112 kg/ha were applied in combination with P at 39 kg/ha to the wheat component of the cropping sequence. Wheat grown on partial fallow failed to respond to P alone that was applied with the seed. The addition of 28 kg of N raised yield by only 134 kg/ha, whereas higher increments had a negative effect on crop yield. Wheat grown on stubble had a positive, linear response to all increments of N with the 112-kg rate, which produced a yield increase of 237.0% over the nonfertilized crop. Yields ranged from 806.4 kg/ha to a high of 2721.6 kg/ha. The cumulative effect of applying N and P to both wheat years in the rotation impaired clover establishment and reduced forage yields from 2710.4 kg/ha to 582.4 kg/ha.

### Triticale seed yield

In field trials in 1981 and 1982, Welsh triticale produced an average of 9% more seed than Gazelle rye or Neepawa wheat. A seeding date of early or mid May resulted in higher yields than seeding in early June. Triticale and wheat were more tolerant of late seeding than was spring rye. Nitrogen fertilizer applied at rates to 100 kg/ha on land previously cropped increased seed yield by 45–60%. Highest seed yields were obtained when the total of the applied and soil-available N equaled 130–150 kg/ha.

## SEED INCREASE AND DISTRIBUTION

In 1982, Agriculture Canada released to the SeCan Association 22 220 kg of Otal barley, 8330 kg of Diamond barley, 2890 kg of Leduc barley, 6530 kg of Katepwa wheat, 400 kg of Medora durum wheat, 1020 kg of Dumont oats, 360 kg of Westar canola, 3840 kg of Norlin flax, and 180 kg of Apica alfalfa. Breeder seed of 56 varieties was distributed to 669 growers.

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# Research Station
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| F. J. H. Fredeen, B.S.A., M.Sc. | Black flies |
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| L. B. Hayles, D.V.M.&S., Ph.D., M.R.C.V.S.<br>Resigned January 1982 | Mosquitoes and arboviruses |
| A. J. Klassen, B.S.A., M.Sc., Ph.D.<br>Resigned April 1982 | Oilseed breeding—canola |
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| S. N. Acharya, M.Sc., Ph.D.<br>Canola Council of Canada visiting fellow, 1980–1981; research associate, 1982 | Plant pathology |
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| Zhang Yan<br>Assistant Research Scientist, Shanghai Academy of Agricultural Science, Shanghai, People's Republic of China, 1982–1983 | Plant breeding |

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# INTRODUCTION

This report covers the major research achievements in 1982 at the Saskatoon Research Station and the Scott Experimental Farm, 160 km west of Saskatoon.

Four research programs are conducted. The oilseed, forage crops, and cereal programs include research on breeding, agronomy, and control of diseases, weeds, and insects. We have the major responsibility in the Research Branch for research on rapeseed/canola and mustard. We, along with the Lethbridge and Kamloops stations, are an integral part of the Branch's research program on development of bloat-safe alfalfa. We have a major responsibility for the development of forage grasses for the northern prairies. The cereal program is mainly concerned with reducing losses from root rot in wheat and barley, and with the breeding of utility wheats. The integrated pest management program deals with the development of control systems for problem insects (i.e. grasshoppers, wireworms, black flies) that are not specifically restricted to any one commodity. A major objective in the program is the minimization of our dependence on insecticides for the control of these pests.

Two retirements occurred in 1982: Dr. R. H. Burrage, Head of the Insect Pest Management Section, after 29 yr, and Mr. K. S. McKinlay, insect toxicologist, after 21 yr. Dr. L. B. Hayles, who worked on mosquitoes, resigned to take full-time employment with the Food and Agriculture Organization (FAO), and Dr. A. J. Klassen, rapeseed/canola breeder, resigned to return to his farming activities.

Two members were on leave to work on foreign assignments for CIDA: J. D. Smith to Njoro, Kenya, to work on plant diseases, and M. S. Bahrey to Zambia, to work on a cereal breeding program.

Previous reports and reprints of publications can be obtained from the Saskatoon Research Station, Research Branch, Agriculture Canada, 107 Science Crescent, Saskatoon, Sask. S7N 0X2.

J. R. Hay
Director

# OILSEEDS

## Rapeseed/canola

*Breeding.* The low-erucic-acid, low-glucosinolate *Brassica napus* L. strain ZN6-2836 was licensed under the cultivar name Westar and released to seed growers through the SeCan Association in 1982. In 3 yr of cooperative tests, Westar consistently yielded 12–15% more seed, matured 2 days earlier, and contained 1% more seed oil than the standard variety Regent. Westar, together with the Tobin, a *B. campestris* cultivar released from this station in 1981, is expected to dominate the canola hectarage in the coming years.

The development of biotechnological techniques to produce *Brassica* plants that are haploid (half the normal chromosome number) will greatly accelerate conventional and hybrid breeding programs. Successful methods of anther culture for the production of haploid plants of *B. napus*, *B. campestris*, and *B. juncea* have now been developed. However, until recently, the rate of androgenesis has been too low for use as a standard breeding technique. A *B. campestris* genotype has been identified recently that gives very high rates of androgenesis. This characteristic appears to be heritable. If this is correct, it should be possible to transfer the characteristic to other genotypes and species.

*Insects.* Winter sampling of adult flea beetles hibernating in groves of native parkland trees was investigated as a technique for estimating flea beetle abundance and for the possible threat to canola crops in the spring. Variation in beetle numbers was high between samples in a single grove and between groves. The beetles exhibited a clumped or aggregated distribution. Consequently, too many samples are required for this method to be practical for estimating flea beetle abundance over farm-sized areas.

It is not clear if the clumped distribution in groves results from variations in the microenvironment or from an innate tendency of the beetles to gather together. Intensive sampling

in one grove over a 3-yr period revealed overwintering densities per hectare ranging from 0.26 to 1.93 million for crucifer flea beetles, *Phyllotreta cruciferae* (Goeze), and 0.10 to 1.45 million for striped flea beetles, *Phyllotreta striolata* (F.). Thus, parkland groves can harbor an immense number of overwintering flea beetles.

In cooperation with eight agricultural representatives from the Saskatchewan Department of Agriculture, 36 canola growers in northeastern Saskatchewan each looked after two bertha armyworm pheromone traps. The total number of bertha armyworm moths captured in 1982 was approximately one-fifth of the number captured in 1981. Only pheromone traps at Love, Carrot River, and Zenon Park caught more than 15 moths per trap weekly between 5 and 25 July 1982. Larval surveys were taken in 12 fields near Zenon Park, Peesane, and Bjorkdale. The number of larvae obtained in 1982 was less than one-tenth of that obtained in 1981. No fields were located in which numbers of larvae approached economic levels of 20/m$^2$. No canola fields in northeastern Saskatchewan were known to require the application of insecticides to control bertha armyworm larvae in 1982. Thirty-one percent of the bertha armyworm larvae died of disease and 32% of parasitism.

The low population of bertha armyworms in all districts in 1982, and the natural mortality from parasites and disease, suggest that the threat of a Saskatchewan outbreak in 1983 has greatly diminished.

*Diseases.* Over the past few years, techniques have been developed for determining the susceptibility of canola lines to stem rot caused by *Sclerotinia sclerotiorum* (Lib.) de By. With the use of these techniques, it has been possible to show that certain introductions from Japan exhibit good tolerance for the disease, and that this tolerance can be transferred into lines suitable for use on the Canadian prairies. Unfortunately, the tolerant parents are very late in maturing. Thus, combining early maturity and tolerance is expected to take several years of selection and testing.

Resistance to black leg, *Leptosphaeria maculans* (Desm.) Ces. & de N., has been successfully incorporated into canola strains of *B. napus*. This material has shown good resistance to sclerotinia under heavy infection pressure in the field, where the nonresistant control variety Regent was destroyed. Under disease-free conditions, however, the resistant lines selected to date have been inferior to Regent and Westar in yield and other agronomic traits, and an overall improvement will be necessary before licensing of a black-leg-resistant cultivar can occur.

Damping-off, seedling blight, and foot rot diseases of cultivated canola have caused some concern in Western Canada. These are all manifestations of a single disease caused mainly by *Rhizoctonia solani* Kuhn. In the spring, if this disease is severe at the seedling stage, farmers may need to reseed their canola fields.

A reliable technique has been developed to screen canola genotypes for resistance to several isolates of *R. solani* at preemergence and postemergence stages. The test utilizes very high levels of inoculum at soil temperatures typical of early spring conditions in the northern part of the canola-growing area of Saskatchewan. None of the genotypes tested showed complete immunity. However, several *B. napus* and *B. campestris* genotypes have been selected on the basis of their superior resistance. Progenies of these genotypes were found to be more resistant than the standard Canadian canola cultivars. These genotypes will be field-evaluated in 1983.

Of the eight fungicides tested as seed treatments, none significantly affected plant densities or resulted in a reduction in the foot rot disease ratings of adult plants. However, the fungicide Rovral significantly reduced the severity of both damping-off and seedling root rot.

Black leg caused yield reductions that were economically significant in a number of canola fields in Saskatchewan in 1982. Yield losses of up to 30% were recorded in the central part of the province. However, the average yield loss was less than 5%. In the more heavily infected fields, 100% of the plants were diseased. It was found that the prevalence of black leg was a result of widespread ascospore production on stubble that was more than 1 yr old. It was also found that 40% of the canola fields contained canola stubble that was 3 yr old and that the pathogen continued to produce ascospores on 5-yr-old canola residue.

A long-term study was initiated on the rate of disappearance of canola stubble in farm fields. During the 1st yr following crop growth, the amount of residue on the soil surface declined by 50–60%. This is a much

slower rate than that reported in Australia. Attention is now being given to the identification of strains of *B. campestris* with blackleg resistance and to the incorporation of this characteristic into canola cultivars with resistance to white rust, *Albugo candida* (Pers. ex Lev.) Ktze.

### Mustard

Strains of pure-breeding brown mustard, resistant to all races of white rust prevalent in Western Canada, have been developed. These strains will be entered in cooperative trials for the first time in 1983. It is expected that the best one of these will replace the susceptible cultivar, Blaze.

### Sunflowers

*Insects.* Pheromone traps were placed at 12 farms to monitor the occurrence and abundance of the sunflower moth, *Homoeosoma electellum* (Hulst). Two sunflower fields were near Outlook, and 10 were in southern Saskatchewan, from Boharm in the west to Gainsborough in the east. The two-level jet winds from the Gulf of Mexico, which can carry moths from the sunflower fields in the southern United States, occurred only once during the growing season between 6 and 10 August according to D. J. Bauer of the Atmospheric Environment Service, Environment Canada, Saskatoon. No large influxes of sunflower moths were reported from the cooperating growers, and no sunflower fields had to be sprayed in Saskatchewan for the control of this pest during 1982. However, 1351 larvae of the sunflower moth were found in 1000 heads of wild sunflower, *Helianthus* spp., collected near Estevan on 5 August. Only 46 larvae emerged from a similar collection made on 18 August. Two other sunflower pests also emerged from the collected heads, the banded sunflower moths *Cochylis hospes* (Wlshm.) and *Cochylis* n.sp. and the sunflower seed maggot *Neotephritis finalis* Loew. The 5 August collection contained only 45 banded moths and 94 seed maggots, whereas the 18 August collection contained 408 banded moths and 56 maggots.

## CEREALS

### Wheat and barley

*Wheat breeding.* The objective of this program is to develop strains of white wheat with medium gluten, medium hardness, and medium protein that produce higher yields than the traditional hard red spring wheats. In 1982, 14 advanced lines from the Saskatoon program were included in the cooperative A, B, and C high-yielding trials.

*Hybrid wheat.* Studies were conducted in cooperation with Rohm & Haas toward the development of hybrid wheats. Forty selected cultivars sprayed with a chemical male gametocide were crossed with each of Neepawa, Glenlea, Fielder, and NB4O2. The level of induced male sterility varied but averaged about 90%, and seed set ranged from 35 to 96%. Major differences were apparent in the effectiveness of crossing between donor pairs. Significant yield increases and some decreases occurred in the resulting $F_1$ hybrids; other attributes remain to be assessed.

*Diseases.* Research to develop wheat lines with high resistance to common root rot and good agronomic attributes for use as breeding parents was advanced. Thirty-six of 38 lines that had been recurrently selected for resistance were significantly less diseased than Neepawa over two locations in 1982. Ten of these lines were chosen on the basis of their agronomic performance for more intensive testing in 1983.

Common root rot was more severe in wheat plants seeded conventionally than in those seeded directly with preseeding tillage in both a continuous and rotational cropping sequence at Scott. The difference in disease was related to a difference in depth of seeding; seed was planted deeper in conventional seeding than in direct seeding. It had been shown previously that disease increased with depth of seeding.

Potassium fertilizer reduced common root rot in Neepawa wheat grown on acid soil at Scott. The average magnitude of the reduction was about 30% over 8 station-years. Of two P sources tested for 3 yr, potassium chloride was slightly more effective than potassium sulfate.

The reaction of wheat cultivars to prematurity blight (crown rot) was determined under controlled conditions. Glenlea and Wakooma appeared to be resistant; Columbus, Coulter, Macoun, Neepawa, and

Sinton were intermediate; and Hercules, Napayo, Pelissier, and Wascana were susceptible. The procedure to induce blight involved subjecting plants infected with *Fusarium culmorum* to drought stress between the flag leaf stage and the flowering stage of development.

Twenty treatments of four chemicals, imazalil, nuarimol, etaconazole, and baytan, significantly reduced root rot readings in Cypress wheat. Emergence was not affected by any of the treatments. Of 20 treatments, four chemicals, etaconazole, nuarimol, triadimefon, and DPX H6573, reduced symptoms of root rot in Gateway 63 barley, but many of the treatments also reduced emergence. The yield analysis for both studies was not obtained because of severe hail and bird damage to the plots.

About 1400 advanced lines obtained from six barley breeders in Western Canada were screened for common root rot reaction, and a few promising resistant lines were saved. One hundred and twelve lines, identified as showing resistance in previous years, were screened in replicated trials, and 16 lines were saved because they rated lower than the most resistant commercial cultivar Bonanza.

Low numbers of soil amoebas, which feed by causing large perforations in conidia of *Cochliobolus sativus*, were widespread in agricultural soils in Saskatchewan. They occurred mainly near the surface in the 0–15-cm soil profile, but some were also present to a depth of 30 cm. A seasonal fluctuation in numbers occurred with a peak in the fall and with lowest numbers present in summer. During the frost-free period, numbers of amoebas were negatively correlated with temperature, and numbers were not correlated with soil moisture. These amoebas appear to be present in field soils in the active trophic form rather than in the cystic form.

*Agronomy*. Where adequate weed control has been obtained, crop yields in a zero-tillage cropping system have exceeded yields from conventional cropping systems. Wheat is well adapted to zero-till production because of the wide array of herbicides available for use on this crop. Weed control in zero-till canola is a problem because of the lack of herbicides for postemergence control of broad-leaved annual weeds. Yields of canola, when grown without tillage, have been reasonably good in spite of the weed competition.

Soil moisture conditions in the seed placement zone at seeding time have been better on the zero-tillage plots than on the conventional plots. This has resulted in more uniform crop emergence where dry conditions prevailed following seeding.

With wheat under zero tillage, the yield response was equal when N was deep-banded with narrow-chisel blades in the spring or broadcast in the spring. The deep-banding tillage resulted in drying of the seedbed, and crop emergence was less uniform. Seed placement was deeper over the bands than between them. Where the P was deep-banded at 45-cm spacings, yields in 1982 were lower than where the P was banded at narrower spacings or applied with the seed.

Results of studies conducted over the past 2 yr at two locations have shown that tillage practices that resulted in a firm seedbed prior to seeding resulted in the most uniform stands of rapeseed. Where treatments were applied that resulted in a loose seedbed, more uniform stands were obtained by broadcasting and harrowing than by seeding with a double-disc press drill. Direct seeding into soil that was not spring tilled also resulted in uniform stands. Yield differences between treatments have been small.

*Weed control*. In field tests, six herbicides (five postemergent, one preemergent) that control wild oats in wheat were evaluated. Over the course of the 7-yr study all treatments produced wheat yield increases. Yield increases ranged from 8% for benzoylprop ethyl to 23% for diclofop methyl, and 24% for a hand-weeded control.

In greenhouse experiments, the fresh weight of wild oats growing in the absence of crop competition was reduced 40% by barban, 76% by benzoylprop ethyl, 78% by difenzoquat, 97% by flamprop methyl, and 100% by diclofop methyl when each was applied at its recommended rate.

Canada thistle, *Cirsium arvense* L., is the most serious perennial weed problem in Canada. Because of its very competitive nature, top-growth control in crops is essential if major yield losses are to be avoided. 3,6-Dichloropicolinic has provided excellent control of both shoot and root growth of Canada thistle in a range of various crops.

It would be advantageous if 3,6-dichloropicolinic acid could be mixed with herbicides for the control of wild oat, *Avena fatua*, for broad-spectrum weed control with

one spray operation. Field studies were carried out to determine the influence of 3,6-dichloropicolinic acid on control of wild oat with barban, diclofop methyl, difenzoquat, and flamprop methyl. Control of wild oat was not affected when either diclofop methyl or difenzoquat was mixed with 3,6-dichloropicolinic acid. When barban or flamprop methyl was mixed with 3,6-dichloropicolinic acid, control of wild oat was reduced.

In a series of experiments, the effect of density and time of emergence of barley in canola was evaluated. Thirty and 90 barley plants per square metre reduced the yield of the canola cultivar Tobin by 26 and 50%. Higher barley densities did not result in further yield reductions.

Time of barley emergence produced significant effects on canola yield. When barley emerged 7 days prior to canola, yields were 40% less than when both species emerged on the same day; when barley emerged 7 days later than canola, yields were 94% more than for simultaneous emergence.

## FORAGES

### Legumes

*Legume pasture bloat research.* The major goal of this project is to breed a bloat-safe alfalfa cultivar by selection for a slow initial rate of digestion. A nylon bag technique is used to measure the digestibility of forage samples at 3–4 h. The second cycle of recurrent selection was completed during 1982, and polycross seed has been produced to initiate the third cycle of selection. Animal feeding experiments to evaluate the selected strains were initiated in 1982 and will continue for several years.

Whole leaves were subjected to sonification to determine relative strength of mesophyll cell walls as a measure of resistance to cell rupture. Most bloat-safe legume species had a greater resistance to epidermal or mesophyll cell rupture compared with the bloat-causing species. Electron micrographs showed that the bloat-safe legume species had thicker epidermal and mesophyll cell walls than the bloat-causing species. Similarly, alfalfa plants selected for slow initial rate of digestion with the nylon bag technique had stronger cell walls. Selection of alfalfa strains for high- and low-mechanical strength, as determined by the sonification procedure, is under way as a complement to the nylon bag technique.

The predisposition of rumen contents to the occurrence of bloat was investigated. When rumen fluid was collected just prior to feeding fresh alfalfa, cattle that subsequently became bloated had a higher concentration of chloroplast particles, a larger buoyant floc, and greater microbial activity than cattle that did not become bloated. This study was done in cooperation with the Kamloops and Lethbridge research stations.

### Grasses

Slender wheatgrass, *Agropyron trachycaulum* (Link) Malte, is a native prairie grass that has been developed into a cultivated forage crop. One of the rare self-pollinating perennial grasses, it is short-lived (3–5 yr) and offers good tolerance for salinity. Twenty-seven advanced lines (natives, reselections, introductions) were compared with Revenue, the only currently licensed cultivar, in identical trials at Scott (seeded 1977) and Saskatoon (seeded 1979). Based on 4-yr averages at Scott, 26 lines outyielded Revenue for hay by 11.4%, and for seed production by 19.7%. Based on 4-yr averages at Saskatoon (including the establishment year), 24 lines outyielded Revenue for hay by 9.5%, and 20 for seed production by 22.1%. Greenhouse studies indicated that some lines had superior salinity tolerance.

The experimental synthetic S-8800 of smooth bromegrass, *Bromus inermis* Leyss., was developed from two cycles of selection in the Magna cultivar for plants with good seed yields, better seed handling quality, and some resistance to the bromegrass seed midges. Hay yields in the provinces of Saskatchewan, Alberta, and Manitoba show yields and quality similar to those of Magna and Carlton. Seed yields were 24% above those of Magna and 17% above those of Carlton. A higher bushel weight of S-8800 relative to Magna and Carlton should facilitate seed cleaning and drilling of seed. It has been recommended for license.

### Corn

A number of new corn hybrids have been evaluated under 2200–2400 corn heat units at Outlook and Saskatoon. Some of the earliest maturing hybrids from Eastern Canada and France have produced 24% more silage dry matter than the older recommended hybrids. At present in Saskatchewan, the moisture

content of the grain is too high to make grain corn production feasible.

## INTEGRATED PEST MANAGEMENT

### Black flies

*Economic effects of outbreaks of Simulium luggeri.* Data on effects of black fly outbreaks on livestock are difficult to obtain because of the multiplicity of variables affecting production. One method used has been to compare productivity between protected and unprotected portions of single herds. Permethrin and fenvalerate, two pyrethroid chemicals, have shown promise in providing relatively long-term protection from black fly attacks. Fenvalerate-impregnated ear tags appear to provide good protection for 2 mo or more from black flies, especially *S. luggeri*, which attacks the head and upper body. Permethrin spray provides protection for up to 2 wk, but since cattle in large pastures are not readily rounded up for respraying, the use of ear tags is favored. In one split herd in 1982, 35 cows and five heifers each received two ear tags and 35 suckling calves received one tag. In the other portion of the herd, kept in an adjacent pasture, 27 cows, 3 heifers, and 25 suckling calves were not tagged. During a severe black fly outbreak in midsummer, sweep-netting showed there were about 5.5 times more black flies around the untagged herd than the tagged herd. Reweighing at the end of 48–51 days showed average gains for tagged cows, heifers, and calves of 0.97, 1.10, and 1.03 kg/day, and for the untagged herd, 0.51, 0.53, and 0.91 kg/day.

### Grasshoppers

*Control.* Several insecticides have been tested when applied on dry, edible baits for control of grasshoppers in Saskatchewan. At the rates tested in the field (based on $LD_{95}$ levels in laboratory assays), only dimethoate has proven effective as a bait in reducing grasshopper populations to acceptable levels. For example, a third-instar grasshopper population was reduced about 70% by dimethoate at an active ingredient (a.i.) rate of 70 g/ha on dry wheat bran bait. A higher dosage, with an a.i. rate of 130 g/ha, was needed to reduce an adult grasshopper population to the same level. Previously published data indicated that at least four times as much dimethoate would be required in a spray to reduce grasshopper populations to levels similar to those obtained with dry baits. Also, between four and six times as much dimethoate would be required as a liquid spray, and three to four times as much as dry bait, to raise the grasshopper mortality level from about 70% to about 85%. Unless the population density is very high, it would not be cost effective for growers to use that extra amount of insecticide. In many instances, a 70% reduction in the grasshopper populations would reduce them to levels that would not be of economic importance. There are other benefits in using dry baits for insecticides. Hazard from residue would be very slight with dry bran formulations because most of it is consumed by grasshoppers within a very short time. Treatment of forage crops with dry bait should greatly reduce the insecticide hazard to pollinating insects such as honey bees and alfalfa leafcutting bees. The hazard of insecticide drift also should be reduced with dry baits.

*Population forecasting.* A modified Leslie matrix model was developed to simulate the effect of weather on changes in the densities of eggs, nymphs, and adults of the three grasshopper species *Melanoplus sanguinipes* (Fabr.), *M. packardii* Scudder, and *Camnula pellucida* (Scudder) within a generation. Data to test the predictive power of the model were based on population samples taken from a grasshopper–alfalfa pasture in the parkland zone of Saskatchewan during 1974–1976. Appropriate data on initial egg density and age distribution and on weather data were used as input for simulations recapitulating events in the field. The model gave good estimates of peak density for early instars but overestimated densities of fifth-instar nymphs and adults. Biotic factors not included in the model, such as declining quality of food, dispersal, and the influence of natural enemies, were the cause of the discrepancies between observed and simulated densities of fifth-instar nymphs and adults.

*Damage.* Studies on acute grasshopper and acute simulated grasshopper damage to spring wheat, *Triticum aestivum* L., showed that the type and timing of damage and the amount of available soil moisture have a profound effect on growth response of wheat. Cutting at ground level resulted in the greatest reduction in plant biomass and yield. A less severe reduction in biomass and yield resulted from actual grasshopper damage or

from the artificial stripping of leaves. Although the relative growth rates were higher in damaged plants than in the controls, they were not able to recover lost biomass when the damage occurred any later than the early stages of tillering. The relative growth rates of the damaged plants increased with the increase of available soil moisture.

The most detrimental effect of damage on yield was the reduction of heads per plant and kernel weight. Differences in the number of seeds per head between damaged and control plants were rarely significant.

### Insect nutrition

*Mycotoxins.* Investigations confirmed that, as for many other organisms, diacetoxyscirpenol (a toxic sequiterpene structurally related to T-2 toxin, produced by several *Fusarium* species) is less potent than T-2 toxin for larvae of *Tenebrio molitor.* Penicillic acid at concentrations of up to 100 mg/kg had no effect on growth or survival of larvae of *T. molitor* that were fed diets that contained 2, 5, or 20% of dietary protein. Larval growth was reduced when diets contained 100 mg/kg of aflatoxin B, ochratoxin A, or rubratoxin B, except when rubratoxin B was included in a diet that contained 20% crude protein. Larval survival was unaffected by dietary mycotoxin or dietary protein level, although aflatoxin has been reported to be lethal to all animal organisms.

*Techniques.* A technique has been developed for the bioassay of mycotoxins in feeds with the use of larvae of the bertha armyworm, *Mamestra configurata.* These larvae were sensitive to 1 mg/kg of T-2 toxin included in an agar-base diet. Larvae of *T. molitor* in early experiments were sensitive to 64 mg/kg and mice to 20 mg/kg of dietary T-2 toxin. Thus, the larvae of bertha armyworm can be useful in testing contaminated feed samples or in determining toxicity of crude extracts containing mixtures of mycotoxins, without purification or separation of individual toxins.

*Amino acid nutrition.* Results of a study in which 10 holidic diets, varying in amino acid concentration or composition, were fed to larvae of *T. molitor* indicated that larval growth is influenced by qualitative and quantitative changes in the dietary amino acid mixture. These factors also influence the efficiency of food and of energy conversion by the larvae, either metabolically or in relation to phagostimulation.

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# Research Station
# Swift Current, Saskatchewan

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| I. Bos, Ph.D.<br>On sabbatical leave from 1 May 1982 to 23 October 1982, Wageningen University, Netherlands | Plant breeding |
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[1]Seconded from Systems and Consulting Division, Finance and Administration Branch.
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[3]On transfer of work to CSIRO, Canberra, Australia, from 1 July 1982 to 30 June 1983.
[4]Appointed on 29 November 1982.
[5]On educational leave, University of Saskatchewan, Sask., from 1 September 1982 to 31 May 1983.
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# INTRODUCTION

The diversified research program at the Swift Current Research Station emphasizes the improvement of cereal and forage cultivars and the development of technology to improve crop production and utilization practices. This is accomplished through a multidisciplinary approach to research in plant breeding, plant physiology, agronomy, soil and water management, salinity control, nutrition, agrometeorology, agricultural engineering, and energy. The results of this research are described very briefly in this report. More detailed information can be obtained from the publications listed at the end of this report or from individual scientists. Requests and correspondence should be addressed to the Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

W. L. Pelton
Director

## CEREAL PRODUCTION AND UTILIZATION

### Effect of nitrogen and phosphorus on stem solidness

Canuck wheat was given three fertilizer treatments (N and P at rates of 0 and 0, 10 and 40, and 100 and 20 kg/ha) at the time of seeding at each of four locations in southwestern Saskatchewan. The fertilizer treatments had no significant effect on the expression of stem solidness. Weather at a location had a greater effect on the development of pith in an internode than did the fertilizer treatments. The relative fluctuations of stem solidness were similar among internodes even though the absolute percentage of stem solidness differed significantly among internodes. Internode length increased progressively from the base of the culm to the peduncle without evidence of a relationship to the expression of solidness.

### Developing increased dormancy in white wheat

RL 4137, a spring wheat genotype with a long stable dormancy period and three genes for red seed color, was hybridized with a white-seeded line. Progeny were tested in the $F_3$ to $F_7$ generations using rain simulation techniques and germination tests. The results indicate that some of the dormancy of RL 4137 has been recombined with white seed coat color. The evidence suggests that RL 4137 has a genetic mechanism for dormancy associated with red seed color and one or more mechanisms not associated with seed color.

### Drought physiology

Leaf diffusive resistance, temperature, and osmotic potential were evaluated in three *Brassica campestris* and three *B. napus* cultivars under both irrigated and rainfed environments. These techniques differentiated between environments but not among cultivars within environments. Incorporation of $^{14}CO_2$ by stressed plants of two cultivars under rainfed conditions showed more promise as a means of differentiating among cultivars for drought response.

Three techniques were evaluated for screening for drought resistance in rainfed and irrigated wheats, that is, leaf diffusive resistance, leaf temperature as measured with a hand-held infrared thermometer, and drying rate of excised leaves. Yields under rainfed and irrigated conditions were used to characterize the drought resistance of 8 durum and 10 hexaploid cultivars of diverse origins. Neither diffusive resistance measurements nor leaf temperature showed differences among cultivars. There were marked differences in leaf temperatures between the rainfed and irrigated environments. Cultivar differences were detected in rate of water loss from excised leaves, which was lowest early in the season and increased markedly after anthesis. The drought-hardy durum cultivar Pelissier had the best water retention capability. Progeny of a Pelissier × Hercules cross showed a range of retention capabilities between the parental values. Visual rating of excised leaves identified the genotypes with superior water retention capabilities. It was concluded that measurement of water retention capability of excised leaves showed the

most promise of the three techniques evaluated.

Excised-leaf water retention was studied in 25 bread and 16 durum wheat genotypes, as well as in 52 lines from a cross of high- and low-retention durums. In the bread cultivars, Columbus lost water slowest and NB 112 lost water fastest; in the durums, Pelissier was slowest and Hercules was fastest. Fifty-two lines from a Hercules × Pelissier cross exhibited a low-order, but significant, positive correlation between yield and flag-leaf water retention.

**Growth regulators**

Roots and shoots of barley plants grown hydroponically in P-deficient Hoagland's solution on subsequent exposure to P-normal solution accumulated less $^{32}P$ than the control plants. The growth retardants CEPA and SADH restored the P sink activity of the shoots.

Indoleacetic acid inhibited $^{32}P$ accumulation. CCC, CEPA, and ancymidol increased $^{14}C$ assimilation in leaves of P-deficient barley. These results support the concept that a source-sink control mechanism, and not simply transpirational uptake and accumulation of P, was involved.

**Cold hardiness**

Alfa, a relatively nonhardy alfalfa cultivar, continued to accumulate on a dry weight basis fructose, $\alpha$- and $\beta$-D-glucose, sucrose, and maltose during the latter stages of cold hardening; Rambler, a hardier alfalfa cultivar, conversely showed a decrease in these soluble sugars with hardening. Frontier rye, a very hardy winter-habit cereal, showed decreases in these soluble sugars plus melibiose during the same hardening period. These results support the hypothesis that hardy cereals and alfalfa undergo a decrease in soluble sugars with hardening, whereas less hardy cereals and alfalfa continue to increase their content of soluble sugars.

**Nonstructural carbohydrate of wheat**

Nonstructural carbohydrate (NSC) levels of vegetative tissues were examined in two cultivars of wheat and of oats to determine the seasonal distribution patterns and amounts of NSC present in these crops when grown under the dryland conditions of southwestern Saskatchewan. The green-leaf carbohydrate levels were relatively stable throughout the growing season and did not fluctuate in response to seasonal rainfall. Carbohydrates accumulated in the stems to a maximum (25–48% of the dry weight) about anthesis and then declined toward maturity. The results support the concept that the stem may act as a temporary storage organ for NSC to correct a phase difference between the time of maximum photosynthate production by the plant and the time of maximum requirement for carbohydrate by the developing grain.

**Rye breeding and genetics**

Two cultivars of winter rye, Frontier and Musketeer, were registered with the Crop Science Society of America and are available to any breeder who would like to use them in a breeding program. Frontier is the most cold-tolerant winter rye under conditions encountered in Western Canada. Musketeer represents a combination of desirable traits. Winter survival of Musketeer has equaled that of the best controls, while combining high seed weight, test weight, and grain yield with early maturity and intermediate height and lodging resistance. Preliminary indications are that it has lower pentosan levels than other cultivars.

**Nutrition, sensory quality, and meat yield of turkeys**

The sensory quality of carcasses of 14-wk-old broiler turkeys fed Candle canola meal at 0, 73, 144, and 211 g/kg (four males and four females for each level) was evaluated by an experienced test panel. Except for a slightly increased frequency of off-flavors at the 73-g/kg level, no differences in flavor or off-flavors were associated with the level of canola meal in the diet.

The replacement of soybean meal by canola meal in turkey diets of equal protein content did not change liveweights at 42 days. Fish meal at either 60 or 120 g/kg increased the final liveweights by 5.3%, whether or not the diet included canola meal. No synergistic effect on growth occurred when canola meal was combined with fish meal.

Practical feeding programs for turkeys vary in the frequency with which the dietary protein concentration is reduced in accordance with the decreasing protein requirement of growing birds. The effect on performance of changing diets every 2 or 3 wk, every 6 wk, or only once, at about 12 wk of age, was determined. In addition, four dietary protein

regimes were provided within each feeding plan. The frequency of changes in dietary protein concentration had little influence on the rate of growth of turkeys fed adequate dietary protein. However, lower initial protein levels sufficed to maintain the maximum growth rate when the diets were changed less frequently. The frequency of diet changes did not influence the efficiency of feed or energy utilization, but frequent dietary adjustments promoted efficiency of protein utilization.

Carcass scores and meat yield of turkeys of two strains fed diets of varying protein contents, using different feeding schedules, were studied at 18, 20, and 22 wk of age. Dietary regimes that led to suboptimal protein intake reduced carcass and edible meat yields and increased proportions of skin and bone. The greatest effect of dietary protein was on the yield of breast meat. Carcass fat scores effectively predicted carcass finish but fleshing scores bore little direct relationship to meat yield. The more rapidly growing strain had greater eviscerated carcass yield and a lesser proportion of carcass bone.

### *Salmonella* contamination in broiler chickens

During a 2-yr period, 10 broiler flocks varying in size from 6200 to 14 000 birds were checked for *Salmonella* contamination during rearing and processing. Brooding equipment, feed, drinking water, and litter were also tested. Prior to initial operation of the processing plant, the processing equipment was sampled for *Salmonella*. No evidence of *Salmonella* contamination was observed in 4 of the 10 flocks. The incidence of *Salmonella* was lower when cloacal swabs were taken from 48-h-fasted chicks and tested than for the same groups of chicks when blended in nutrient broth. The blending of fasted chicks appears to be a more critical test. Commercial feed in crumble form was free from *Salmonella*. *Salmonella* was isolated from one sample of drinking water. The serotypes isolated from eviscerated birds were the same as those isolated from litter samples. Litter sampling may be a practical indicator for determing the *Salmonella* status of flocks. This would facilitate the processing of clean flocks prior to infected flocks. There was flock-to-flock variation in the incidence of *Salmonella* in eviscerated birds.

## ENGINEERING

### Trap strips for snow management

Research in northern Montana and at Swift Current has shown grass barrier strips can be used effectively to trap snow and increase soil moisture. Another concept developed in 1979 consists of leaving a strip of tall standing stubble that acts as a barrier to trap snow on stubbled fields. In order to leave such a strip, clipper- and deflector-type attachments mounted on a windrower were designed, developed, and tested. Both attachments were found to leave a stubble barrier that was effective for trapping snow. However, the deflector type was ranked superior because of its simplicity, low cost, and adaptability to any make of swather. Contingent on a number of climatic and soil factors, overwinter-stored water resulting from snow management varied from 1 to 14 cm.

### Soil salinity and crop yield under effluent irrigation

A catena containing the Orthic Regosol, Calcareous, Orthic, and Cumulic Orthic members of the Birsay Association of a Brown Chernozemic soil was seeded with alfalfa and irrigated. As the applied effluent had a mean electrical conductivity (EC) of 2.6 dS/m, soil salinity was a major concern. To prevent buildup of salt in the root zone, effluent was applied at rates 10–15% greater than crop demand to deliberately allow a fraction of applied water to leach through the root zone. Eight years of effluent irrigation has increased the soil salinity at the surface layer (0–60 cm) whereas at the bottom layer of the root zone, the $EC_e$ decreased substantially in the Orthic, Orthic Regosol, and Calcareous soils. Although the salinity profiles suggest that some yield reduction might be expected in the effluent-irrigated soils compared with yields from creekwater-irrigated soils, the yields were higher due to the higher nutrient loading in the sewage water. In the Cumulic Orthic soil the salt content throughout the profile increased from a very low initial level and failed to reach a steady-state condition after 8 yr of irrigation. Initially, alfalfa yields were considerably higher than yields on the other soil series; by 1980, however, yields were the lowest and had declined to about 80% of those on the Orthic soil.

### Equipment design

A new self-propelled plot seeder was produced for the Lacombe Research Station to do research in areas of zero tillage and soil fertility. Previously developed zero-tillage openers for placing seed and fertilizers were adapted to the Swift Current plot seeder. Narrow hoe openers that can be hydraulically adjusted from zero to mid-row distance from the seed are used to apply fertilizer. Depth of placement is also hydraulically adjusted, separate from the seed. Duplicates are being fabricated for Vegreville and Swift Current.

### Contract research

The agricultural engineering research and development (AERD) program continues to make progress in the field of mechanization. In the first production year of the "Depth Master," developed and produced by Inventronics, approximately 75 depth controllers have been sold. The controller has been well received and is meeting a need for most of the farmers who purchased one. However, some teething problems exist with some cultivator hydraulic systems employing master–slave cylinders. Another automatic depth controller produced by Senstek of Saskatoon employs ultrasonic sensing of tillage depth. A number of preproduction prototypes will be marketed and evaluated in 1983. This unit also has multiplexing capability where one controller can sequence independent control action to several implements or several hydraulic cylinders on the same implement.

## FORAGE PRODUCTION AND UTILIZATION

### Effect of cattle grazing on yield of fall rye

Grain yields of fall rye (*Secale cereale* L.) in southwestern Saskatchewan were reduced when the crop was grazed by cattle during the fall of the seeding year, the spring of the succeeding year, or both the fall and spring periods. Spring grazing reduced grain yield by only 10% and fall grazing by only 17%; grazing in both fall and spring reduced yield by 25%.

### Preference for alfalfa influenced by slender wheatgrass

Altai wild ryegrass and Russian wild ryegrass were seeded in a sandy soil in alternate rows with alfalfa, with an alfalfa–slender wheatgrass mixture, and with slender wheatgrass seeded in rows on either side of each row of alfalfa and 15 cm from it. The rows of Altai or Russian wild ryegrass and alfalfa were 45 cm apart. Cattle grazed the Altai or Russian wild ryegrass–alfalfa stands intensively but refused to eat slender wheatgrass or alfalfa grown in association with it.

### Composition of grasses as influenced by N fertilization and harvest date

The effects of three rates of N fertilizer and nine fortnightly dates of initial harvest on the N, P, Ca, Mg, and K concentrations and the K/(Ca + Mg) ratio of Russian wild ryegrass, Altai wild ryegrass, and crested wheatgrass were studied on irrigated land for 2 yr. The N, P, K, and K/(Ca + Mg) ratios declined with increasing maturity. N fertilization tended to increase the N, P, and K concentrations but appeared to have little influence on percentages of Ca and Mg and the K/(Ca + Mg) ratio. Altai wild ryegrass had higher N, P, Ca, Mg, and K concentrations and K/(Ca + Mg) ratio than Russian wild ryegrass which, in turn, had higher values than crested wheatgrass. Crested wheatgrass utilized prior to early June, Russian wild ryegrass utilized prior to late June, and Altai wild ryegrass utilized prior to early July had the suggested minimum level for lactating beef cows of 1.60% N. Only samples cut during May equaled the suggested minimum of 0.32% P. Supplementation with N and P may be required with rations or pastures using these grasses in June or later. The percentage of K was adequate on all sampling dates. The K/(Ca + Mg) ratio for crested wheatgrass did not exceed the suggested maximum of 2.2, but the ratio for Altai and Russian wild ryegrasses was above this maximum for May, June, and part of July, indicating there may be some danger of grass tetany with these grasses during the May–June period and supplementation with Mg or Ca or both may be required for good performance.

### Three-cut harvesting schedules for alfalfa forage

Alfalfa cultivars Roamer and Beaver grown under irrigation in southwestern Saskatchewan were compared over nine cutting schedules. A third cut of alfalfa could be harvested after 1 October without reducing the yield of the first cut in the subsequent year. The best three-cut system involved two

cuts at the recommended 10% bloom stage and a third cut after growth had ceased in October.

### Composition and processing effects on nutritive values of plant feeds

Heating of alfalfa increased the N contents of acid detergent fiber (ADF) and neutral detergent fiber (NDF). Increased NDF content was a consequence of binding of protein to the hemicellulose fraction of the fiber. Associated with increased NDF and increased N contents of both NDF and ADF was a reduction in organic matter digestibility by rumen bacteria, and in N digestibility by both rumen bacteria and pepsin digestion. In lower-quality roughages such as mature hays or cereal straw, a large proportion of total N was associated with NDF and ADF. Ammonia treatment decreased NDF content and increased both digestibility and intake of these roughages while at the same time increasing N content of both NDF and ADF. With rye grain, the pentosan (hemicellulose) fraction is of primary importance to feeding quality through interactions with protein, which reduced protein digestibility or amino acid availability, or both. Further investigations revealed that the component sugars of hemicellulose (pentosans) reacted readily with amino acids through Maillard-type reactions at physiological temperatures and these observations led to development of a molecular model that accounted for changes in nutritive value caused by processing of foods and feeds of plant origin.

### Distribution of plant species and plant communities in relation to climate

The distribution of plant species and vegetation types in the Prairie Provinces can be related to climatic phenomena. The ratio of summer to spring precipitation is most important, with temperature of less importance. Climatic areas can be outlined; within these areas differences in soils are important. The plant–climate relationship is of importance in the selection and domestication of introduced species. Particular attention must be given to the number of days from emergence to maturity for different parts of the Prairie Provinces. The dryland shrub communities of the Prairie Provinces have been classified and are shown to be closely related to similar communities in Eurasia, including Japan. One class with 2 orders, 4 alliances, 14 associations, and 12 subassociations is recognized and described. Several transitional communities, representing ecotones, are also described.

## SOILS AND ENVIRONMENT

### Loss of organic matter and potentially mineralizable N

Although it is known that considerable loss in total organic matter has occurred due to cultivation of prairie soils, there is little information on changes in the fertility-related fraction of the organic matter. Twelve prairie surface soils representing paired virgin and cultivated coarse, medium, and fine textured soils from the Brown, Dark Brown, and thin Black Chernozemic and Gray Luvisol soil zones were analyzed and used to assess changes in total C, N, and potentially mineralizable N. It was found that after 60–80 yr of cropping, not only have Saskatchewan soils suffered large losses of their organic N (31–56%) but their losses of the small active fraction of organic matter that replenishes the soil's fertility were even greater (55–67%). Losses were greater from sandy than from clay soils. These findings help to explain why a significant portion (>30%) of prairie soils now require N fertilizer even after being summerfallowed.

### Water retention equations, soil organic matter, and particle size distribution

Functional relationships between water content and soil water suction were examined and related to textural and organic carbon content data. Soil water retention curves between 5 and 10 000 kPa were determined on disturbed samples of 18 soil types representing various great soil groups in Saskatchewan. Correlation and regression analysis showed that texture was the main soil property influencing the shape and magnitude of the water retention curve. These soil water retention equations will allow researchers to describe the availability of soil water to plants and to model the movement of water and salts in an array of Saskatchewan soils.

### Factors affecting fertilizer response of wheat

Fertilizer tests using hard red spring wheat were conducted in the field from 1967 to 1979 on stubble and fallow land on the major soil

types throughout southwestern Saskatchewan. The yield, percentage of N and P in the grain, and kernel and volume weights of the grain were measured, and the responses of each of these characteristics to N and P fertilizer were determined. These responses were related to soil measurements of available $H_2O$, $NO_3$-N, $NH_4$-N, and sodium bicarbonate-extractable P, which were taken at seeding time at depths to 120 cm, and to the monthly rainfall during the growing season.

### Factors affecting N and soluble sugars in spring wheat

Disposition of N and soluble sugars in Manitou spring wheat was examined, as influenced by N fertilizer, temperature, and duration and stage of moisture stress. Nonstructural carbohydrate (NSC) content was reduced in proportion to the duration of moisture stress, as was N content (%N × dry wt); however, N content was not greatly influenced by temperature. N uptake during grain filling plays a significant role in determining protein level. The factors known to be related to high grain protein (such as high temperature, high N fertility, high moisture stress) were also the ones associated with greater transport of N to the grains. Those conditions known to favor greater grain yields (such as low or late moisture stress, low temperature, high N fertility) were found to be associated with greater NSC translocation from stems to heads.

### Long-term crop rotation study—yield and grain quality

Yield and quality of spring wheat in particular, and of flax, fall rye, and oat hay in general, in 12 rotations deemed feasible for southwestern Saskatchewan were summarized and discussed after the first 12 yr of study (1967–1978). The study was conducted on a Brown Chernozemic loam. The factors examined were the effect of rotation length, fallow substitute crops, and N and P fertilizer. On a crop-year basis, continuous wheat yields averaged 75% of fallow yields when recommended rates of N and P fertilizers were applied. Yield variability was lower for rotations that included high proportions of fallow than for continuous-type rotations. Fertilizer N applied at recommended rates increased yields of wheat grown on fallow by an average of 5% (from 1780 to 1860 kg/ha) and wheat grown on stubble by an average of 7% (from 1350 to 1455 kg/ha). Application of P fertilizer at recommended rates increased yields of wheat grown on both fallow and stubble by an average of 12%. Total wheat production (in kilograms per hectare on an annual basis) was inversely related to the frequency of fallow in the rotation. Thus, continuous wheat (N and P applied) outproduced wheat grown on fallow in the 2-yr rotation by 53% over the 12-yr period. Wheat yields were directly related to growing-season rainfall. Protein concentrations of wheat grown on fallow were high (average 15.9%) and generally greater than those of wheat grown on stubble (except for wheat grown on flax stubble).

### Economics of minimum tillage systems for summerfallow preparation

The economic feasibility of substituting herbicides for mechanical tillage of summerfallow was assessed under a spring wheat–fallow rotation at Lethbridge, Alta. Six minimum tillage and two conventional tillage treatments were evaluated over a 9-yr period for differences in resource requirements and overhead costs. Also, breakeven costs for herbicides that equate the cost of fallowing with minimum and conventional tillage systems were estimated at three prices for wheat and three prices for labor.

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# INTRODUCTION

The Northern Research Group, comprising the Research Station at Beaverlodge and the associated Experimental Farm at Fort Vermilion, Alta., continued its responsibility for research on agricultural problems of northwestern Canada. This report presents highlights of research for 1982.

Major accomplishments included the development of a technique to permit the determination of occupancy by *Rhizobium meliloti* strains and competitive ability in root nodules and strain identification in either single- or double-occupied small nodules.

Initiation of the urgently required research on tillage methods in the North was made possible by the addition of one biologist to the Fort Vermilion Experimental Farm.

Detailed information can be obtained from the publications listed in this report. Correspondence to individual research scientists should be addressed to the Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta. T0H 0C0; and the Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta. T0H 1N0.

L. P. S. Spangelo
Director

## APICULTURE

### Breeding

*Selecting superior colonies.* Sixteen colony characteristics were monitored in 391 honey bee colonies at three locations in Alberta from 1978 to 1980. Short-term (1–7 days) colony gain was the most significant characteristic to be correlated with honey production. The multiple correlation for predicting colony production was improved by using capped brood area, 24-h pollen collection, and 24-h weight gain. This is a new method for selecting superior colonies.

### Diseases

*Chalkbrood.* A comparison of the incidence of chalkbrood disease in selected wintered colonies and in package bee colonies showed that colonies developed maximum infection in early summer. Larval loss ranged from 0.04 to 4.0% and showed an inverse relationship with the amount of sealed brood. Honey production was not affected at these levels of infection. Feeding sorbic acid and sodium propionate in a pollen supplement reduced infection by about 50%.

*Nosema.* Sampling procedures for *Nosema apis* infection indicated that, compared with techniques of sampling individual bees, infection counts from composite bee samples are a reliable method of assessing the degree of infection in a colony.

### Varroa mite

*Morphological characteristics.* Electron microscope observations revealed that the idosoma of the female mite *Varroa jacobsoni* is highly sclerotized. The body is oval and dorsoventrally flattened. The legs are short and stout, with the pretarsus developed into a strong sucker. Long, stiff setae are observed on the legs, especially on the tarsal segments. The dorsal shield is covered with numerous branched setae and has a row of thick, short and curved setae at its lateral edges. The significance of these morphological features was related to the phoretic behavior of the female mite.

### Contract research

*Herring meal as a pollen substitute for honey bees.* Pacific herring meal on average contains 7.7% moisture, 71.6% protein, 7.9% fat, and 11% ash. It is low in two B-complex vitamins compared with natural pollen. When mixed 1:1 with brewer's yeast it meets the levels of amino acids and vitamins considered essential in honey bee nutrition. The palatability of the 1:1 formulation of herring meal and brewer's yeast plus 2.5 parts sugar compares favorably with other commercially available protein sources and the bees consume more of the mixture than when each is fed separately. The addition of 5–10% pollen increased consumption, and fructose, glucose, and lactic acid enhanced palatability. For brood production none of the formulations

tested performed as well as fresh bee-collected pollen. Compared with the brewer's yeast, the herring meal–brewer's yeast substitute increased total brood area by 37% and honey production by 45%. No flavor was imparted to the honey in colonies fed herring meal.

### Nectar source

*Nectar production in rapeseed.* Nectar yield per flower was 0.348 and 0.165 $\mu$L over 24 h for *Brassica napus* (Argentine-type rapeseed) and *B. campestris* (Polish-type rapeseed), respectively. All 28 varieties and breeder's lines of the two species of rapeseed secreted nectar. Andor, Regent, Tower (*B. napus*), and many breeder's lines produced a greater amount of nectar than Torch, Candle (*B. campestris*), and some other lines. The nectar of Regent and Candle contained 38.7 and 41.8% sugar and the sugar value (milligrams per flower over 24 h) was 0.177 and 0.64, respectively. The estimated sugar yield of blooming Candle was 13.3 kg over 24 h.

## CEREALS

### Breeding

*Disease resistance.* Sources of resistance to barley leaf scald, net blotch, and thrips were recorded from extensive replicated scald inoculation trials. Resistance to each pest was inherited separately but resistance to two of the three was identified in a few lines. Barley leaf stripe was found in 3% of fields throughout the Peace River region in both six-row and two-row cultivars.

### Diseases

*Chemical control.* Three years of testing EL228 as a seed treatment to control barley leaf stripe provided the main Canadian efficacy data supporting application for registration.

In Norstar winter wheat, yield increases of up to 220% were obtained with single foliar applications of snow mold fungicides applied in late fall. *Plenodomus* and *Myriosclerotinia* were dominants in the snow mold complex, but *Pythium* sp. was found to be significantly involved for the first time in the Prairies. *Gerlachia*, *Coprinus*, and *Typhula* were also involved.

*Sources of resistance.* Spring wheat was found to be affected by the same version of common root rot in the Peace River region as previously found for barley. It differs from the form in the rest of the prairies, and cultivars have different levels of resistance to the two versions. It is by far the most damaging disease for both wheat and barley in the Peace River region. A source of moderate resistance to speckled leaf blotch was identified.

At least 30 lines of *Brassica campestris* from a worldwide germ plasm collection were found to have significantly better resistance than either Candle or Tobin to brown girdling root rot. This root rot causes greater yield losses in rapeseed than all other diseases combined in the Peace River region.

## ENVIRONMENT AND SOILS

### Meteorology

*Effect of environment on activity of Megachile rotundata.* Research on the relationship of temperature, solar irradiance, and humidity to pollination activity of the alfalfa leafcutting bee, *Megachile rotundata*, revealed that air temperature establishes an environmental threshold for the initiation of pollination activity by the bee. Once this threshold is surpassed, activity is dependent on solar irradiance. Although pollination activity shows a strong relationship with relative humidity, this relationship falsely represents response to humidity. When the influence of temperature is incorporated, the effect of atmospheric vapor pressure on pollination activity is minimal.

### Nitrogen fixation

*Determining the competitive ability of Rhizobium strains.* A serological technique developed to identify and enumerate Canadian-developed strains of *Rhizobium meliloti* in commercial alfalfa inoculants was further refined to permit the determination of individual strains occupying alfalfa nodules. The enzyme-linked immunosorbent assay (ELISA) was successfully used to study the competitive ability of two strains of *R. meliloti*. The technique readily detected bacteroids as well as vegetative cells. Also, it was sensitive enough to permit strain identification in either single- or double-occupied nodules as small as 0.5 mm in diameter. The technique has application in studying the competitive ability of selected strains of *R. meliloti*. Its sensitivity and speed simplify the process of screening *R. meliloti* isolates with improved $N_2$-fixation potential.

### Plant survival

*Response of alfalfa cultivars to severe winter stress.* Tests to enhance field winterkill by removing the snow cover in December 1981 showed that Anik, Peace, Grimm, Trek, Rambler, Kane, Drylander, Heinrichs, and S7312 were superior in resistance to severe winter stress to Beaver, Vernal, Algonquin, Angus, Saranac, Chimo, and 10 other cultivars.

### Soil acidity

*Effect of fertilizers and lime on soil acidification.* Acidification of two soils was measured following treatment with various combinations of fertilizer and $CaCO_3$. High rates of nitrogen decreased the pH by 0.43 and 0.18, respectively, in 4–5 yr in an unlimed Donnelly (Gray Luvisol) and Josephine (Eluviated Gleysol) soil and increased the soluble Al content. Fertilizer and lime treatments increased the yield of barley, *Hordeum vulgare* L., but by the fourth crop on the Josephine soil, fertilizer failed to give a yield increase in the absence of lime due to declining soil pH and increasing soluble Al. In another experiment, the average loss of lime over an 8-yr period from six soils was equivalent to 495 kg of $CaCO_3$ per hectare annually. This was accompanied by a decline in pH of 0.48 unit in 8 yr. Increased yields of barley from liming were sustained over the period.

### Weed control

*Narrow-leaved hawk's-beard review.* Narrow-leaved hawk's-beard, *Crepis tectorum* L., occurs across most of Canada but is particularly abundant in the parkland zone of Alberta, Saskatchewan, and Manitoba. It is a serious problem in forage crop fields and has been increasing rapidly in many years.

*Effect of herbicides on timothy seed production.* The effects of 2,4-D and dicamba were evaluated on seed production of timothy, *Phleum pratense* L. Applications of 2,4-D at 0.5 kg/ha to timothy in late September of the year of seeding severely reduced yields the following year, or during the first year when applied before stem elongation in the spring. However, spring applications at the shot-blade or 5% heading stage did not reduce yields. 2,4-D at 1.0 kg/ha caused yield reductions at any of the above stages of crop development. Applications of dicamba at 0.15–0.60 kg/ha in late September of the year of seeding reduced yields the following year. Dicamba at the same rates reduced yields when applied in the spring before stem elongation or at the shot-blade stage. Yield losses due to dicamba increased with each advance in the stage of crop development at the time of herbicide application. 2,4-D had no significant effect on seed quality but dicamba applied in the spring reduced seed germination.

## FORAGE CROPS

### Utilization

*Crop and livestock productivity studies.* Summaries of a number of studies on herbage production and livestock pasturing are as follows: early seeding (before mid-June) was necessary for creeping red fescue and crested wheatgrass but was less critical for other major grass species; maximum crop yields were obtained from row widths of 50 cm for a range of forage species; the species most responsive to supplemental irrigation were meadow foxtail, timothy, crested wheatgrass, and alfalfa; pure stands of sainfoin outyielded sainfoin–grass mixtures; on average, beef gains of 250 kg/ha could be made by steers on grass–legume pasture in less than 130 days; a cattle stocking rate of 2.5 steer units per hectare could be maintained in years when rainfall was sufficient to keep forage growing; meadow foxtail could be grazed 1–2 wk earlier than bromegrass or fescue; bird's-foot trefoil, when seeded and grown without direct competition, provided good-quality, bloat-free grazing for at least four growing seasons; liveweight gain of cattle was best in early June, poor during July and August, and intermediate in September; acceptable grade A carcasses could be marketed directly from pasture without supplemental grain feeding.

### Diseases

*Fungicides to control snow mold.* Single foliar applications of snow mold fungicides in late fall resulted in seed yield increases of up to 300% in creeping red fescue. *Plenodomus* and *Myriosclerotinia* were dominants in the snow mold complex, but *Pythium* sp. and *Phaeseptoria* sp. were found to be significantly involved for the first time. *Gerlachia*, *Fusarium nivale*, and *Coprinus* (LTB) were also present. Sources of partial resistance to stem eyespot disease were identified, making possible a revival of the fescue breeding program.

# PUBLICATIONS

## Research


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# Research Station
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# INTRODUCTION

The Lacombe Research Station and the Soils and Crops Substation at Vegreville are responsible for regional agricultural research in the central Alberta parklands. Specifically, programs include: soil reclamation and development of cropping practices for Solonetzic soils of east-central Alberta; breeding new, high-yielding, disease-resistant feed barley and oat varieties for domestic use and export; and developing soil fertility, soil management, weed control, and cropping systems for barley, oat, and rapeseed production in the parklands. The Station has regional responsibility for production and disease research of annual forage crops, specifically screening and selecting species and varieties that will be used by beef and dairy farmers for silage and pasture to give optimum yield per hectare of digestible energy. The Lacombe program also includes research responsibility for regional and national programs in swine and beef cattle breeding; the technical research aspects of record of performance (ROP) beef cattle and swine testing programs; and major carcass evaluation research related to national departmental beef and swine carcass grading programs. The meats research includes work on the physical, chemical, microbiological, and sensory aspects of beef and pork quality in relation to pre- and post-slaughter conditions and carcass management, both at the meat-packing plant and retailer levels and with consideration given to cooking quality and other factors related to consumer acceptance of the final product.

This report summarizes the highlights of research completed in 1982. Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, Box 1420, Lacombe, Alta. T0C 1S0.

D. E. Waldern
Director

## ANIMAL BREEDING

### Beef cattle

*New breed averages and age-of-dam adjustment factors for birth weight of beef cattle.* The weight of a calf at birth is used in the calculation of preweaning average daily gains and adjusted weaning weights for all calves tested in the Canadian federal–provincial ROP program. But because actual birth weights are difficult to record under commercial management, they are provided for less than one-third of the calves in the ROP program. This means estimated birth weights must be used to calculate the preweaning performance of the remaining calves.

Lower birth weight of calves is also associated with easier calving and is used by many beef cattle breeders as a criterion of selection for calving ease. But because birth weight is influenced by the age of the dam, comparisons amongst the progeny of cows differing in age cannot be made without an appropriate age-of-dam adjustment.

For these reasons, a study was undertaken at the Lacombe Research Station to calculate mean birth weight and age-of-dam adjustment factors specific to the major breed-of-sire and breed-of-dam classes in the Canadian ROP beef population. Actual birth weight records for 191 535 calves from 7021 herd-years tested during 1971–1980 were selected from the ROP data files. These were used to calculate estimates of "breed-of-sire" specific mean birth weights for male and female calves produced by sires from any of 23 major beef breeds. Also, additive age-of-dam correction factors were estimated for male and female calves born to any of 12 major dam breeds or crosses.

Expressed as deviations from the birth weight of calves born to mature dams, the average (over all breeds of dam) adjustment factors for calves born to 2-, 3-, 4-, and 5-yr-old dams respectively were −2.7, −1.3, −0.4, and 0.0 for males, and −2.6, −1.3, −0.5, and 0.0 for females. The estimated breed average birth weights and the age-of-dam adjustment factors derived in this study are being used in the revised national beef cattle ROP program to improve the accuracy of comparisons for birth weight and preweaning growth performance of calves in Canadian beef herds.

*Causes of leg weakness in pigs.* Leg weakness in pigs reared intensively has long been recognized as a problem for producers. During the past 20–30 yr the incidence of leg weakness has increased. Although most producers will accept the view that the trend to increasing degrees of confinement management will explain much of this increase, many are also inclined to associate the problem with the improvement in genetic potential for lean tissue growth rate being developed by modern pig breeding programs.

In studies at the Lacombe Research Station, high-performance Lacombe pigs were reared in single confinement (one pig per 1.2 × 2.4 m pen), group confinement (four pigs per 2.4 × 2.4 m pen), and outside lots (12 pens per 9.1 × 20.1 m earth-surfaced outside lot). Subjective scores for locomotor soundness and elbow cartilage condition (following slaughter) were made separately for the forelegs and the hind legs when the pigs reached approximately 90 kg liveweight.

Single-confined pigs did not develop significantly more leg weakness than group-confined pigs, and gilts reared in outside lots did not differ significantly in the incidence of leg weakness from their confined counterparts. However, barrows reared outside suffered significantly less leg weakness, in terms of locomotor and cartilage damage scores, than barrows in either of the confined rearing treatments. Correlations between the various leg weakness scores and growth performance were sporadic and, where they existed, tended to associate leg weakness with depressed growth, presumably as a result of physical incapacity. There was no suggestion of a relationship between average back fat depth and leg weakness.

The results suggest that an increase in the incidence of leg weakness amongst barrow pigs is to be expected under commercial forms of confinement rearing. The view that leg weakness is associated with improved growth potential may arise from the fact that growth performance is improved by such management. There was, however, no evidence in this trial to support the view that leg weakness is associated with genetically superior growth potential and certainly no basis upon which to question continued selection for high lean tissue growth rate in Canadian swine herds.

**Slaughter technology**

*Effects of delayed chilling and altered carcass suspension on certain bovine muscle properties.* Suspension of carcasses from the aitchbone (hipbone) with the legs hanging free produced a substantially greater alteration of the histological properties of beef muscles than did delayed chilling. Such alterations resulted in longer top round (*semimembranosus–SM*) and loin-eye (*longissimus dorsi–LD*) sarcomeres, shorter tenderloin (*psoas major–PM*) sarcomeres, smaller top round and loin-eye muscle fiber diameters, larger tenderloin fiber diameters, fewer wavy fibers in the top round and loin-eye, more wavy fibers in the tenderloin, and shorter fiber fragments in the top round muscle. This type of carcass suspension (hip-free suspension) significantly reduced the amount of force required to shear samples from the loin-eye and top round, but had no effect on shear force values for tenderloin samples. Hip-free suspension also resulted in darker muscle color in the top round. Delayed chilling at two different temperatures (13 and 22°C) for 12 or 24 h had no effect on 2-h pH values taken in the top round or on 144-h pH values taken in any of the muscles evaluated. However, carcasses held at either temperature for 24 h had lower 24-h pH values than controls. When such delayed chilling treatments affected muscle color, treated sides had darker lean color than their conventionally chilled counterparts. Histological properties, textural properties (shear force values and taste panel tenderness ratings), and amount of expressible juice generally were unaffected by the delayed chilling treatments evaluated. Neither hip-free suspension nor delayed chilling produced consistent differences in the content, heat solubility, or histological properties of the intramuscular collagen.

**Biochemistry and physiology**

*Creatine phosphokinase and pork quality.* Levels of the enzyme creatine phosphokinase (CPK) in porcine blood serum have been shown to be useful for the prediction of porcine stress susceptibility (PSS). Since stress-susceptible pigs tend to produce a higher incidence of pale, soft, exudative (PSE) meat, it is plausible to expect that CPK levels may also be useful for the prediction of the PSE condition. Pigs classified by

breed (Lacombe, Pietrain × Lacombe), sex (boar, barrow), age (102, 116, 130 days), and stress treatment (no additional stress, exercise stress by an 80-m run around the barn) were used to test this hypothesis. Serum from blood removed from an ear vein at sampling times of 0, 6, and 24 h following stress treatment was used for analysis of CPK content. Of the above factors, breed, age, and sampling time affected CPK levels. The absence of a stress treatment effect may indicate that the exercise caused little additional trauma compared with that resulting from the taking of the blood. The pork quality attributes measured include pH at 1 and 24 h postmortem, subjective color/structure score, objective color, expressible juice, and percentage transmission. Color/structure scores ranged from extreme PSE to moderately dark, firm, and dry (DFD). Adverse quality was more predominant in the Pietrain × Lacombe than in the purebred Lacombe pigs. Quality measures, with the exception of the pH measured at 1 h postmortem, were highly correlated with each other ($r = 0.62$ to 0.84). However, no significant relationship existed between the CPK level at any age or sampling time and the various quality measures. On the basis of these findings, the use of porcine serum CPK levels for the prediction of ultimate pork quality is not recommended.

## CEREAL BREEDING, PATHOLOGY, AND FORAGES

### Cereal breeding

*Diamond barley.* A new barley cultivar was licensed and named Diamond in 1982 to mark the 75th anniversary of the founding of the Lacombe Research Station. Originating from the cross of Galt × Unitan made in 1972, Diamond is a six-row feed cultivar with a better yield-to-maturity index than any genotype in the Western Canada cooperative six-row barley test. Diamond matures 2–3 days earlier than Galt and Klondike, the two most popular six-row feed barleys in Alberta, and has consistently outyielded them since it was first tested in 1977.

Characterized by a very large kernel (about 44 g/1000) and a nodding spike, it has field resistance to scald and net blotch, but is susceptible to loose smut. Diamond barley's excellent yield-to-maturity index and good lodging resistance should make it a valuable cultivar for the short growing season and moist conditions normal to west-central Alberta.

### Cereal pathology

*Control of root rot in barley.* Common root rot is a major disease in barley, cutting yields by an estimated 10% across Western Canada each year. Researchers at Lacombe have found that losses from root rot can be significantly reduced through the addition of phosphate fertilizer. On stubble, the addition of phosphates dropped the number of plants affected from 76 to 56% and dropped yield losses from 40 to 30%. Nitrogen fertilizer had less effect. Neither N nor P fertilizers were effective in reducing losses in summerfallow.

Barley seeded shallow (3 cm) had significantly less root rot than deeper sown barley. Size of seed from four barley varieties had no effect on root rot severity.

## CROP MANAGEMENT AND SOILS

### Soil fertility

*Nitrogen fertilization of bromegrass.* Field experiments at four locations (Lacombe, Joffre, Stettler, and Rocky Mountain House) were conducted to determine the yield response of bromegrass to N fertilization. The experiments were established on fallowed soils in 1974 and N was applied as ammonium nitrate (34-0-0) until 1979 at N rates varying from 0 to 300 kg/ha. Each plot received a blanket application of P at 20 kg/ha. Fertilizer applications were made in early spring.

Average annual bromegrass yields varied from location to location as did the fertilizer N level at which maximum yield was obtained, depending upon the soil-climatic zone in which it was grown. At Lacombe (Black soil), the forage yield increased substantially with increasing rates of N up to 200 kg/ha; while at Stettler (Dark Brown soil) the optimum rate of N was between 50 and 100 kg/ha. At Rocky Mountain House (Luvisolic soil) there was increased forage yield up to an N rate of 100 kg/ha. In general, forage yield was doubled by applying the optimum rate of N. The average annual yield per hectare of forage at optimum rate of N was 6040 kg at Stettler, 8750 kg at Joffre, 9130 kg at Rocky Mountain House, and 11 920 kg at Lacombe. The forage yields with one high-rate application of N were lower than with the same total

amount of N applied over 4 yr. The carry-over effect of N at high initial rates lasted for 2–3 yr.

Accumulation of nitrate, at levels toxic to animal health, in forages when fertilized with heavy rates of N have been reported. Forage samples from the above tests will be analyzed to find if toxic nitrate levels in bromegrass could be associated with the high rates of N used in these experiments.

### Weed research

*Selective control of false cleavers in rapeseed with benazolin.* Under field conditions, control of false cleavers in rapeseed with three formulations (dimethylamine solution, ethyl ester emulsifiable concentrate, or ethyl ester wettable powder) of benazolin applied at 0.5 kg/ha was good. The ester formulations provided better control of false cleavers than the dimethylamine. There were no differences in degree of control following application of the dimethylamine formulation at the one-, three-, or five-leaf whorl stage in the field. Under greenhouse conditions control of false cleavers and tolerance of rapeseed for benazolin dimethylamine at 0.25–0.75 kg/ha at the one-, two-, or three-leaf whorl were good. Slight to moderate rapeseed injury in the form of stunting or thinning was observed 2 wk following application of benazolin under field conditions. The dimethylamine and emulsifiable concentrate formulations caused more injury than the wettable powder formulation. At harvest, these injury symptoms had disappeared. Control of false cleavers with benazolin did not result in an increase in yields of rapeseed over those of a weedy control.

*Influence of several herbicides for broad-leaved weed control on the phytotoxicity of paraquat.* Paraquat at 0.28 kg/ha provided excellent control of barley, wheat, and oats when applied at the four-leaf stage of growth. Combination of paraquat in tank mixtures with ester formulations of 2,4-D, MCPA, bromoxynil, or bromoxynil/MCPA did not affect paraquat activity when mixtures were applied on the grasses. Tank mixtures of paraquat with dimethylamine formulations of 2,4-D and MCPA resulted in a permanent reduction of paraquat activity on the annual grass species. Sequential applications of 2,4-D amine or MCPA amine in relation to paraquat did not reduce paraquat activity on the annual grass species. Control of rapeseed with paraquat at 0.28 kg/ha was not acceptable and was variable. However, excellent control of rapeseed was obtained when one of several herbicides for broad-leaved weed control were combined with paraquat.

## SOILS AND CROPS SUBSTATION VEGREVILLE

### Soil research

*Effect of soil management on some chemical, physical, and biological properties of a Solonetzic soil.* The comparative effects of wheat–fallow, continuous wheat, and an 8-yr cereal–grass rotation on the chemical, physical, and biological properties of a Solonetzic soil were determined after 22 yr of cropping. Differences in chemical properties were characterized by enhanced levels of extractable Na in the upper layers of the soil of the wheat–fallow compared with the other two systems. The Na adsorption ratio and soluble Na percentage of the saturation paste extract from the Bnt horizon were significantly lower under the cereal–grass rotation. Extractable Na was negatively correlated with various physical properties such as water infiltration, soil strength, and aggregate stability. Organic C and N levels, when expressed on either a concentration or an area basis, increased from wheat–fallow to the cereal–grass rotation. For the latter system, a friable consistence of the Bnt horizon was related to enhanced levels of organic matter. Generally, biological properties such as microbial biomass C and N, and N mineralization potentials, reflected the above change in organic C and N. Labile organic matter and N-supplying power of the Ap horizon were enhanced under both continuous wheat or the cereal–grass rotation, compared with the wheat–fallow. The study provides an example of possible improvement, over time, in the agronomic properties of some Solonetzic soils due to improved soil management.

*Growth and mineral composition of barley and wheat across sequences of Solonetzic soils.* The growth and mineral composition of barley and wheat were measured across closely associated sequences of Solonetz and Solod soils. Growth of both species, along with root penetration, was reduced on the Solonetz compared with the Solod soil. Mineral composition of the foliage and roots

indicated that a Na–K interaction was present for the barley across the Solonetz–Solod sequences. Such factors were considered to be characteristic of soil–plant relationships on Solonetzic soils.

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# Research Station
# Lethbridge, Alberta

## PROFESSIONAL STAFF

| | |
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| D. B. Wilson, B.Sc., M.S., Ph.D. | Acting Director |
| T. G. Atkinson, B.S.A., M.Sc., Ph.D. | Assistant Director |
| S. B. Arnason, B.S.A. | Head, Administration |
| C. G. Schoening | Finance Officer |
| M. J. McCormick, B.A. | Personnel Officer |

### Scientific Support

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| G. K. Honey, B.S.A. | Technical Information Officer |
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| R. B. Peveril,[2] B.Sc. | Computer System Manager |
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| J. L. Shipp, B.Sc., M.Sc., Ph.D. | Black fly ecology |
| W. G. Taylor, B.S.P., Ph.D. | Pesticide chemistry |
| J. Weintraub, B.A., M.S. | Cattle grub ecology |
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| G. H. Coulter, B.Sc., Ph.D. | Reproductive physiology |
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| R. Hironaka, B.Sc., M.Sc., Ph.D. | Animal nutrition |
| J. E. Lawson, B.S.A., M.S.A. | Beef cattle breeding |
| G. J. Mears, B.Sc., M.Sc., Ph.D. | Animal physiology |
| R. C. Phillippe, B.Sc. | Bacterial culture collection |
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| B. D. Hill, B.Sc., M.Sc., Ph.D. | Residue chemistry |
| K. W. Richards, B.Sc., M.Sc., Ph.D. | Insect pollinators |
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| D. L. Struble, B.A., M.A., Ph.D. | Insect attractants |
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| K. J. Degenhardt, B.Sc., M.Sc., Ph.D. | Smuts and oilseed diseases |
| D. A. Gaudet, B.Sc., M.Sc., Ph.D. | Snow molds |
| H.-C. Huang, B.Sc., M.Sc., Ph.D. | Forage and special crops diseases |
| G. A. Nelson, B.Sc., M.Sc., Ph.D. | Potato and bacterial diseases |
| D. W. A. Roberts, B.A., Ph.D. | Cold-hardiness physiology |

## Plant Science

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| M. R. Hanna, B.S.A., M.S.A., Ph.D. | Forage legume breeding |
| M. S. Kaldy, B.Sc., M.S., Ph.D. | Food science |
| G. A. Kemp, B.Sc., Ph.D. | Vegetable breeding |
| D. R. Lynch, B.Sc., M.Sc., Ph.D. | Potato breeding |
| M. D. MacDonald, B.Sc., Ph.D. | Corn breeding |
| W. H. Mains, B.Sc. (Eng.) | Forage systems engineering |
| D. J. Major, B.Sc., M.Sc., Ph.D. | Crop physiology |
| K. W. May, B.Sc., M.Sc., Ph.D. | Barley breeding |
| R. J. Morrison, B.Sc., Ph.D. | Spring wheat breeding |
| J. R. Moyer, B.Sc., M.Sc., Ph.D. | Weed control |
| H.-H. Mündel, B.S.A., M.S., Ph.D. | New crops |

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|---|---|
| J. B. Thomas, B.Sc., M.Sc., Ph.D. | Winter and soft white spring wheat breeding |
| E. D. P. Whelan, B.S.A., M.S.A., Ph.D. | Wheat cytogenetics |
| W. D. Willms, B.S.F., M.Sc., Ph.D. | Rangeland ecology |

### Soil Science

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| D. C. MacKay, B.Sc., M.S., Ph.D. | Head of Section; Plant nutrition |
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| J. B. Bole,[3] B.S.A., M.Sc., Ph.D. | Plant nutrition |
| J. M. Carefoot,[4] B.S.A., M.S.A. | Chemical analyses |
| C. Chang, B.Sc., M.Sc., Ph.D. | Soil physics |
| J. F. Dormaar,[5] B.S.A., M.S.A., Ph.D. | Organic chemistry |
| S. Dubetz, B.Sc., M.S. | Irrigation agronomy |
| N. Foroud, B.Sc., M.Sc., Ph.D. | Irrigation engineering |
| R. M. N. Kucey, B.Sc., Ph.D. | Soil fertility |
| C. W. Lindwall,[6] B.Sc., M.Sc. | Agricultural engineering |
| R. J. Rennie, B.S.A., M.Sc., Ph.D. | Soil microbiology |
| T. G. Sommerfeldt, B.Sc., M.S., Ph.D. | Drainage engineering |

### Departures

| | |
|---|---|
| R. W. Barendregt, B.Sc., M.Sc., Ph.D.<br>Resigned 17 July 1982 | Irrigation engineering |
| S. Freyman, B.Sc., M.S.A., Ph.D.<br>Resigned 13 November 1982 | Dryland agronomy |
| W. D. Gould, B.Sc., M.Sc., Ph.D.<br>Resigned 23 October 1982 | Soil denitrification |
| J. M. Hardman, B.Sc., M.Sc., D.I.C., Ph.D.<br>Transferred to Research Station, Kentville, N.S., 8 July 1982 | Grasshoppers |
| E. H. Hobbs, B.Sc. (Eng.)<br>Retired 30 October 1982 | Irrigation engineering |
| R. G. L. McCready, B.Sc., M.Sc., Ph.D.<br>Resigned 19 June 1982 | Biophysical chemistry |
| W. A. Nelson, B.Sc., M.Sc., Ph.D.<br>Retired 31 December 1982 | Parasitology |

## VISITING SCIENTISTS

| | |
|---|---|
| P. E. A. Asea, M.Sc.<br>International Atomic Energy Agency training fellow, July 1982 to June 1983 | Plant nutrition |
| H. Kudo, D.V.M., M.V.S., Ph.D.<br>Postdoctorate fellow, September 1981 to September 1983 | Rumen microbiology |

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|---|---|
| W. S. Procunier, Ph.D.<br>Postdoctorate fellow, May 1982 to April 1983 | Cytogenetics |
| R. Scarth, Ph.D.<br>Postdoctorate fellow, February 1982 to December 1982 | Wheat physiology |
| P. J. Scholl, Ph.D.<br>Seconded from United States Department of Agriculture to the Canada/USA sterile insect release project on warble flies, March 1982 to February 1987 | Integrated pest management and warble fly ecology |

[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]Seconded from Systems and Consulting Division, Finance and Administration Branch.
[3]On leave of absence to International Atomic Energy Agency, Vienna, Austria, January 1980 to June 1982.
[4]On educational leave, University of Alberta, September 1982 to August 1985.
[5]On transfer of work to the Institut für Pflanzenernährung und Bodenkunde (FAL), Braunschweig, West Germany, March 1981 to March 1982.
[6]On educational leave, Iowa State University, Ames, Iowa, August 1980 to August 1983.

# INTRODUCTION

The Research Station at Lethbridge, in southern Alberta, is located at the center of one of the most diverse agricultural regions in Canada. A wide variety of crops is grown on both dry and irrigated land and a major part of Canada's beef cattle industry is established on the farms and ranches within and around the region.

Station scientists conduct fundamental and applied research in six disciplines to support 13 Research Branch programs. In addition to the 500-ha site at Lethbridge, the Station conducts research at a 20 000-ha ranch and beef cattle breeding station near Manyberries, a 500-ha ranch near Stavely in the foothills of the Rocky Mountains, and a 150-ha irrigation substation at Vauxhall.

New research projects are continually initiated, to replace completed ones and in response to new problems, in the quest for new knowledge and improved, more economical production practices. As agricultural production problems become more complex, their solution demands more sophisticated research involving the most recent advances in scientific knowledge and equipment. Examples are the refinement of selection criteria for breeding for improved growth rates in livestock; understanding the roles of the myriad of microorganisms that contribute to the digestion of feed in ruminant animals; identifying, assessing, and controlling little-known but debilitating plant pathogens and insect pests; and developing biological methods to make nutrients more freely available to plants and to control livestock pests. At the same time, some long-term projects are continuing. Four dryland cropping rotations completed their 73rd, 72nd, 32nd, and 5th yr, and an irrigated rotation completed its 72nd yr. A stocking rate study on native rough fescue grassland completed its 33rd yr. These studies are yielding practical information on the long-term effects of certain agricultural practices. The results can be used in formulating current recommendations and will provide a valuable resource for future investigations by scientists in related disciplines.

During 1982 there were several new appointments to the professional staff and several long-term staff members retired or resigned during the year, including Dr. W. A. Nelson, animal parasitologist, Mr. E. H. Hobbs, irrigation engineer, and Dr. S. Freyman, dryland agronomist.

The short reports that follow give results of recent research and illustrate the types of studies that are under way. Further information may be obtained from publications listed at the end of the report or from the scientists. Correspondence or requests for reprints should be addressed to the Research Station, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

D. B. Wilson
Acting Director

## ANIMAL PARASITOLOGY

### Biting flies

*Mosquitoes.* The Utah strain of *Coelomomyces*, a parasitic fungus of mosquito larvae, has been tested in the laboratory as a biological control agent against *Aedes aegypti, A. vexans, A. dorsalis, Culiseta inornata,* and *Culex tarsalis.* Infection was induced in *A. aegypti* and in *C. tarsalis.* The infection in *C. tarsalis* is significant because this is the first time that an infection by a strain of *Coelomomyces* has been confirmed in a medically important mosquito. The infection in *Culex tarsalis* occurs at a high, consistent rate in both laboratory-reared and field-collected larvae.

*Black flies.* The establishment of a procedure for sampling population levels of adult black flies is the initial step in the development of a model for predicting when to apply repellents to cattle for protection from black flies. Six different traps were evaluated to determine which one collected the most adults of each black fly pest species attacking cattle in central Alberta. Silhouette traps, sticky traps, and suction traps, with and without dry-ice bait, were used. Traps were evaluated on a 20-ha pasture on a farm near Grassland, Alta.

Although nine black fly species were collected, population levels were sufficient to allow statistical analysis only for *Simulium arcticum* Malloch, *Simulium decorum* Walker, and *Simulium venustum* Say–*verecundum* Stone & Jamnback group. Dry-ice-baited silhouette traps collected the most *S. arcticum* and *S. venustum–verecundum* ($P \leq 0.05$) and *S. decorum* ($P \leq 0.01$).

### Chemical control

*Pesticides*. A subcutaneous injection of ivermectin, a wide-spectrum parasiticide, was almost 100% effective for systemic control of both species of cattle grubs, *Hypoderma lineatum* (Villers) and *H. bovis* (Linnaeus). Unlike the organophosphorus compounds commonly used for control of cattle grubs, ivermectin did not cause esophagitis in animals harboring *H. lineatum* larvae in the esophagus. During the post-treatment period of 239 days, the yearling steers treated with ivermectin gained 5.9% more weight than the untreated steers, which were infected with an average of 60 grubs per head.

*Repellents*. A gas chromatographic method was developed for determining 3-acetyl-2-(2,6-dimethyl-5-heptenyl)oxazolidine (Johnson Wax R-69 insect repellent) in analytical standards, technical material, and microsomal suspensions. Under optimum conditions of high-resolution capillary gas chromatography, two main components with a 45:55 peak area ratio were detected. The identical mass spectra of the two components were attributed to the existence of isomeric (diastereomeric) forms of this insect repellent. Effective methods for preparing alcohol, aldehyde, and acid derivatives of citronellal ethylene acetal were also developed. These compounds were isolated with both the *E* (*trans*) and *Z* (*cis*) geometry and are important for elucidating the metabolic pathways of citronellal-based insect repellents.

## ANIMAL SCIENCE

### Beef cattle

*Performance of dairy crosses with the Hereford in a range environment*. The performance of Brown Swiss-, Holstein-, and Hereford-sired calves produced in a specific Hereford cow herd over 2 yr was evaluated in a southern Alberta range environment. Holstein × Hereford heifers exceeded Brown Swiss × Hereford and Hereford heifers in 200-day weight and 365-day weight, and lost less weight during the winter. Crossbred bull calves were heavier than Herefords in initial feedlot weight and 365-day weight and had heavier and longer carcasses at the same age. Although the crossbreds consumed about 15% more digestible energy (DE) than the Herefords during the 168-day feedlot period, the three groups did not differ in the digestible energy consumed per kilogram of gain. Holstein × Hereford bulls had the highest feedlot average daily gain and the least fat cover over the *longissimus dorsi* muscle. Brown Swiss × Hereford bulls had more lean, less marbling, and the highest cutability percentage. This study demonstrated the hardiness of crossbred heifers derived from a Hereford cow herd well adapted to the tough range environment.

*Postpartum anestrous interval in crossbred beef cows*. The postpartum anestrous interval was determined in 10 $F_1$ crosses including the Hereford × Angus and those by Charolais, Limousin, and Simmental bulls out of Angus, Hereford, and Shorthorn cows. All cows were in drylots from October to March and then on range. About half of the lactating cows were returned to drylots from mid-June to weaning in October. In the drylot, and on range until grass was available, cows were fed alfalfa–straw cubes (70:30). The ration was adjusted to achieve an average backfat of about 5 mm per breed cross. For portions of the drylot period, feed intake of the various crosses ranged from 30 to 55% above National Research Council (USA) recommendations. Cows calved in April–May, and all showed estrus by the 2nd wk in August. The mean postpartum anestrous interval was 56 days and breed crosses did not differ. The interval was similar for cows on range and in the drylot (55 versus 56 days) and it decreased by 4 days for every 10 days advance in calving date (day of year).

*Environmental and genetic effects on preweaning performance of calves from first-cross cows*. Effects on preweaning traits were evaluated in calves out of first-cross dams under small-farm (Brandon, Man.) and range (Manyberries, Alta.) conditions. Calves were sired by Chianina (Chi), Charolais (C), Limousin (L), and Simmental (S) bulls. The dam crosses were Hereford × Angus (HA) and those produced by mating C, S, and L

Location did not affect calving ease or birth weights. But, at Brandon, postnatal mortality, particularly of males, was less and preweaning growth rate was 10–13% greater. The L terminal sires produced the highest proportion of unassisted births and the lowest incidence of difficult births. Calves of C sires had the highest and of L the lowest postnatal mortality rate. Progeny of Chi had the heaviest birth weights, while those of Chi, C, and S had a more rapid rate of preweaning growth than L. Breed of dam's dam (H, A, N) had no influence on calving ease or mortality, but H and N exceeded A in birth weight of calves and N, H, and A resulted in similar preweaning growth. For breed of dam's sire (C, L, S), progeny from L-sired dams had the highest incidence of both unassisted births and postnatal mortality, with S exceeding C, and C surpassing L for calves' postweaning growth.

*Energy requirements for maintenance and gain.* Digestible energy (DE) intake and weight data from four experiments with Hereford steers fed all-concentrate diets were used to estimate energy requirements for maintenance and gain. The steers weighed about 200 kg initially. They were marketed at about 475 kg in three experiments and at about 390, 430, and 475 kg in the fourth experiment. The experimental period was divided into two periods of 12 wk each and a final period of variable length to market the cattle at the desired weight. Feed was offered to obtain a low (L), medium (M), or high (H) rate of gain in each period so that combinations of LMH, LLH, MMH, MHH, HHH, MMM, HML, and LHH were used in the three periods. The relationship between average daily gain (G) in kilograms and mean daily DE intakes in kilocalories was examined for each feeding period using the exponential model $k^G = (1/a)\ DE/W^{0.75}$, where W is the mean body weight (kilograms) for the feeding period and $k$ and $a$ are parameters fitting the data to the general form of the exponential equation above. The equations for each period were:

Period 1. $2.4279^G = (1/118.958)\ DE/W^{0.75}$
Period 2. $2.164^G = (1/115.459)\ DE/W^{0.75}$
Period 3. $1.8326^G = (1/140.804)\ DE/W^{0.75}$

Estimates of maintenance DE requirements using the model agree closely with published values of maintenance requirements for cattle derived from calorimetry studies.

*Rumen microbiology.* The colonization and digestion of NaOH-treated, $NH_3$-treated, and untreated barley straw by mixed natural rumen populations (in vitro and in vivo) and by mixed and single pure cultures of rumen bacteria were examined by both scanning electron microscopy (SEM) and transmission electron microscopy (TEM). *Bacteroides succinogenes* was recognized by its peculiar morphology and by its intimate adhesion to plant cell wall fragments. Pure culture experiments showed that this cellulolytic bacterium may be the most important single species in straw digestion. Cells of this adherent organism autolyze and fragment during the digestive process and the fragments remain adherent on the cellulosic substrate. Two other important cellulolytic organisms, *Ruminococcus flavefaciens* and *R. albus*, are also recognizable by their unique morphologies. The former is seen in close association with plant cell wall materials while the latter is always seen at a distance from these cellulosic substrates. The more closely associated bacterial species (*R. flavefaciens*) is more cellulolytic in single-species digestion tests. Ovine rumen populations contain more distinct and structurally elaborate morphotypes than bovine rumen populations. No clear morphological distinctions could be seen between the natural rumen bacterial populations on treated and untreated straw. Nevertheless, both NaOH-treated and $NH_3$-treated barley straws tended to be more avidly colonized by the cellulolytic species in natural rumen populations of both sheep and cattle.

*Microbial degradation of nitrite and aliphatic nitrotoxin.* Rumen bacteria have been shown to detoxify nitrotoxins and to metabolize nitrite and thus reduce levels of these toxic compounds. Preliminary results indicate that feeding nitrate and other chemical inducers enhances these detoxification activities in ruminants. Sixty-three pure strains of rumen bacteria representing 17 genera were tested for their ability to metabolize nitrite. Twenty-three of the strains belonging to nine genera (*Anaerovibrio lipolytica*, *Bacteroides ruminicola*, *Clostridium* sp., *Coprococcus* sp., *Lactobacillus* sp., *Megasphaera elsdenii*, *Peptostreptococcus* sp., *Selenomonas ruminantium*, and *Veillonella alcalescens*) were capable of metabolizing nitrite and all showed growth on a medium containing nitrite. Nitrite metabolism was not observed in the remaining 40 strains, nor did these grow in the presence of nitrite. Bacteria capable of nitrite reduction and growth in the presence

of nitrite were also able to degrade aliphatic nitrotoxins such as 3-nitropropionic acid and 3-nitropropanol, toxic forage constituents found most abundantly in certain rangeland species of legume.

### Dairy cattle

*Crossbreeding.* One of the expected advantages of crossbreeding in dairy cattle is improved reproductive efficiency. Analyses of calving records of 1154 Holstein (H), 598 Ayrshire (A), and 764 crossbred (HA and AH) cows showed that the percentage of normal births and of cows with normal postpartum uterine conditions was higher for the crossbreds (88 and 89%) than for the purebred Holsteins (81 and 87%) and Ayrshires (85 and 84%).

### Sheep

*Light control to increase lamb production.* Seven consecutive production cycles, each lasting 240 days, were completed with half-Finnish Landrace and half-Dorset ewes maintained in three groups (A, B, and C). Group A was maintained under natural light and ewes were exposed to rams once a year in the fall. Group B was also maintained under natural light but ewes were exposed to rams every 8 mo. Ewes in group C were also exposed to rams every 8 mo but were maintained under an artificial light regime. The half-Finnish ewes and half-Dorset ewes in group A annually produced 221 and 185 lambs per 100 ewes exposed to rams. Corresponding values for group B were 215 and 171 and for group C, 279 and 204. These results confirmed earlier observations indicating that the lamb production in group C was greater than that in groups A and B. However, overall productivity of group C ewes was not as great as initially expected, because of the larger preweaning losses compared with those of groups A and B. Mortality of lambs from half-Dorset ewes was 12.5% for group A, 10.0% for group B, and 14.7% for group C. Corresponding values for half-Finnish Landrace ewes were 26.7, 22.1, and 30.3%.

*Microbial inoculation of newborn lambs.* Eight newborn lambs orally inoculated with 38 strains of beneficial bacteria and eight uninoculated controls were challenged with a highly pathogenic strain of enterotoxigenic *Escherichia coli*. Three lambs from the control group developed scours and died, while only one lamb from the treated group developed this fatal diarrhea. These results indicate the possibility of reducing postnatal mortality by artificially establishing at birth a beneficial digestive tract microflora.

## CROP ENTOMOLOGY

### Forage crop insects

*Seed crops.* Sampling of alfalfa seed fields during 1982 indicated that population levels of lygus and alfalfa plant bugs were higher than in 1981, with some fields in the Brooks area requiring control. Alfalfa weevil populations were generally low, which had a negative effect on the parasite and predator populations of this species.

*Odynerus dilectus*, a solitary wasp, has been shown to be a predator of third-instar or later stages of alfalfa weevil larvae. With culturing and management, this insect may have a potential for biological control.

Fall and spring burning of alfalfa seed fields, for partial control of plant bugs, increased seed yields over those of unburned plots. Yields were further increased if burned fields were treated with insecticides when pest populations again approached economic thresholds.

The driedfruit moth has increased in importance as a predator of alfalfa leafcutting bees and honey bees in Alberta and British Columbia. Female moths deposit eggs in cracks of leafcutting bee hives in early spring while the hives are still in overwinter storage and also in the hives after they have been placed in the field. Larvae enter the uncapped tunnels, and eat the pollen–nectar provisions in incomplete cells and destroy bee larvae in complete cells within the tunnel. More cocoons were destroyed in hives with pine-grooved tunnels than those made with polystyrene, but the latter sustained more damage to tunnel walls by larval feeding. When hives are removed from the field and placed in winter storage, most mature larvae leave the tunnels on completion of feeding and aggregate in spaces between the hives where they pupate. Second-instar larvae, fed various diets with food available in the cells and hives, had significantly better survival on diets that contained a high proportion of pollen and nectar or live bee prepupae than the other diets tested.

*Forage crops.* Feeding of adult *Sitona sissifrons* (Say), the alfalfa curculio, has

caused delayed emergence and reduced production of cicer milk-vetch in the foothills area of Claresholm and Nanton for the 2nd yr.

The spotted alfalfa aphid, *Therioaphis maculata* (Buckton), was recovered in late summer surveys from irrigated alfalfa at Vauxhall, Seven Persons, and Lethbridge, but not in dryland areas in central and northern Alberta. Greenhouse experiments with Grimm alfalfa have shown that the pea aphid can significantly reduce mean height, fresh and dry weight, and fiber content of this aphid-susceptible variety. However, there were only minor changes in the quality of the alfalfa. There were no differences in the percentage of protein, fat, total sugar, reducing sugar, dry matter, and nitrogen-free extract between infested and noninfested plants. Potassium was significantly reduced in infested plants whereas calcium, magnesium, and phosphorus content were increased. With the exception of isoleucine, the amino acid composition was similar in infested and noninfested plants.

*Chemical control.* Spring (16–26 May) applications of fenvalerate and deltamethrin for alfalfa weevil control resulted in more effective pest management and less exposure of leafcutting bee pollinators and other beneficial insects to the insecticide. Although alfalfa weevil populations were significantly reduced by spring application, pirate and lygus bug populations increased after 6 wk. Applications of these insecticides in late June (when pollinators are normally introduced) significantly reduced alfalfa weevils, plant bugs, and aphids but also reduced lacewing and pirate bug predators and threatened leafcutting bee survival.

Simulated rain (3 cm) at 1 h after application of cypermethrin (emulsifiable concentrate) and dylox (liquid) to alfalfa for lygus bug and alfalfa weevil control did not adversely affect the efficacy of cypermethrin but treatments with dylox gave unsatisfactory control.

### Cutworms

*Sex attractants.* Two two-component sex attractants were developed for the striped cutworm, *Euxoa tessellata.* This insect has been reported as a pest of corn and flax in the midwestern United States. The blends were developed by systematically testing combinations of synthetic compounds under field conditions. The two optimized blends consisted of (*Z*)-5-tetradecenyl and (*Z*)-7-hexadecenyl acetates at a ratio of 2.5 and 500 $\mu$g per dispenser or (*Z*)-5- and (*Z*)-7-hexadecenyl acetates at 500 $\mu$g each per dispenser. Initial monitoring in Alberta and Saskatchewan, utilizing (*Z*)-5-tetradecenyl and (*Z*)-7-hexadecenyl acetate blends, showed that this species was more abundant than expected from previous light trap catches.

*Population monitoring.* Density levels of male adults of eight noctuid species were recorded using sex attractant traps at 81 locations in a 13 000-km$^2$ region of southern Alberta for the 5th yr. Catches of *Leucania commoides*, clover cutworm, army cutworm, bertha armyworm, and variegated cutworm were 24, 33, 49, 64, and 97% lower, respectively, than those recorded in 1981. Male adult populations of pale western, darksided, and redbacked cutworms increased 43, 97, and 150% over those trapped the preceding year.

Pale western cutworm populations increased to a regional mean of 150 moths per trap, with catches at five locations exceeding 250 moths. The threshold level for this species appears to be 250–300 moths per trap. Above this level, larval infestations can be expected in susceptible fields if spring weather is favorable (warm and dry) for larval survival.

Redbacked cutworm moth counts increased to a regional mean of 641 per trap with catches at six locations exceeding 1200 per trap. Although the threshold level for this species is high (>1000 per trap), it is probable that localized infestations will occur near the locations with high counts if 1983 spring conditions are favorable for larval survival.

*Chemical control.* Laboratory tests on the contact toxicity of synethetic pyrethroids to sixth-stage larvae of the army cutworm have shown that permethrin, fenvalerate, cypermethrin, BAY FCR 1272 (Bayer AG), and deltamethrin were 5, 7, 18, 36, and 300 times more toxic, respectively, than either endrin or chlorpyrifos and have a good potential for cutworm control.

### Grasshoppers

*Population studies.* In 1982, the grasshopper survey in Alberta was expanded beyond latitude 55°N to include the Peace River district; 138 621 km$^2$ was the total area covered by the survey, up from 98 330 km$^2$ in 1981. In general, grasshopper populations have

increased in Alberta for the 3rd yr. The area with normal infestations (grasshopper numbers at $<1/m^2$) decreased from 70% of the area surveyed to 59%. Lightly infested areas ($1–2.5/m^2$) increased from 15 to 19% and moderately infested ($2.5–5.0/m^2$) increased from 11 to 18% of the total area. Severely ($5–10/m^2$) and very severely infested ($>10/m^2$) categories remained at 3 and 1% of the area surveyed, comprising 4852 and 1620 $km^2$, respectively. In the northern and central regions of the province the lesser migratory and clearwinged grasshoppers were the dominant species. In the southern half of the province the roadside and Packard grasshoppers were the dominant species.

*Chemical control.* Oral and contact toxicity of five synthetic pyrethroid insecticides to fifth-stage nymphs of *Melanoplus bivittatus* were established in the laboratory. As oral poisons, fenpropanate, Pay-off® (American Cyanamid), fenvalerate, and deltamethrin were four- to two-fold more toxic than dimethoate or cypermethrin, whereas, as contact poisons, the pyrethroids increased in toxicity four- to eight-fold and dimethoate decreased in toxicity two-fold. Fenpropanate was the most toxic pyrethroid tested against this species.

### Row crop pests

The European corn borer has become established in the Medicine Hat area of Alberta. In 1982, the number of infested fields increased there as well as in the Bow Island area. No infestations were recorded from Brooks, Tilley, Rolling Hills, Hays, Taber, or Lethbridge.

Populations of the sugarbeet root maggot, *Tetanops myopaeformis* (Röder), increased in 1982. Approximately one-third of the sugar beet crop area was treated at seeding with granular insecticides. A survey of 24 fields in the Taber–Cranford area in July indicated severe damage to roots with 40% stand losses despite chemical control practices.

### Insecticide residues

An analytical method was developed to determine deltamethrin residues in soils. Recoveries by this method were 91–100% at fortification levels of 1–100 $\mu$g/kg. The method was used in two studies to determine the persistence of deltamethrin in Lethbridge clay loam. In an indoor incubation experiment, residues declined in an exponential manner ($r = 0.981$) with a half-life of 4.9 wk. Under field conditions, in a microplot experiment, deltamethrin had a half-life of 6.9 wk. Residues from a June application declined to 24% of that applied by October. By March the following spring, residues were 15% of that applied. At 1 yr after treatment, only 7% of the applied deltamethrin remained in the soil.

## PLANT PATHOLOGY

### Cold hardiness of wheat

Long exposure of cold-hardened winter wheat to a 0.5°C temperature in the dark resulted in a gradual loss in hardiness. Long exposure to –7.5, –10, and, possibly, –5°C killed the plants or reduced their hardiness. In contrast, plants exposed for up to 20 wk at –2.5°C still retained their hardiness. These results indicate that field-grown winter wheat, which is not killed by exposure to temperatures of –15°C for 2 days, will be damaged by exposure for 16–20 wk at –7.5 or –10°C. They also explain why plants transferred in January, February, or March from the field to a growth chamber at 3°C lose their hardiness but those left in the field normally do not, because they remain at temperatures just low enough to prevent loss of winterhardiness but not low enough to damage the plants.

### Cereal diseases

*Ergot of cereals.* Yields of individual spring wheat spikes containing sclerotia of the ergot fungus *Claviceps purpurea* were compared with those of nearby, ergot-free spikes of similar maturity and stem length. From 3 to 25 such pairs were collected in 1979 from each of 15 commercial fields in Alberta. Ergot reduced spike yield by 16%. This reduction resulted from fewer kernels in the ergoty spikes. Weight of individual seeds did not differ significantly between the two groups. The equation that relates ergot severity to yield is:

$$\text{yield loss } (\%) = 0.16x$$

where $x$ is the percentage of ergoty spikes in the field. Hard red spring wheat produced in fields with 0.23–0.44, 0.45–1.77, and 1.78–3.01% ergoty spikes was estimated to be downgraded from No. 1 CWRS to No. 2 CWRS, No. 3 CWRS, and Canada Feed, respectively, resulting in price reductions to the producer that averaged 3.8, 8.5, and 18.6% from 1972 to 1981.

*Common bunt of wheat.* Cool temperatures (<15°C) at the seedling stage have previously been recognized to determine whether wheat becomes infected by the common bunt fungi *Tilletia foetida* and *T. caries*. In a recent study on the effects of temperature on symptom expression, inoculated winter or spring wheat was germinated at 15°C to assure infection and then placed at temperature intervals of 5°C up to 35°C until the kernels were formed. Plants grown at temperatures above 25°C developed no bunt and those at temperatures from 25 to 15°C expressed progressively more infected spikes, demonstrating that the temperature to which wheat plants are exposed after infection is also an important factor in determining the frequency of bunted spikes. These results explain year-to-year differences in bunt levels encountered in field experiments with plants sown in cool soil to assure that infection occurs. This suppression of symptom development by high temperatures may also be the major reason why wheat is more frequently bunted in the cooler northern and western regions of the prairies than in the warmer southern and eastern regions.

*Black point of wheat.* Fields of soft white spring wheat in the irrigated regions of southern Alberta and Saskatchewan were surveyed for the incidence and severity of kernel black point. The average incidence of discolored kernels from fields in southern Alberta declined from 17.9% in 1981 to 5.3% in 1982. This decline in severity appeared to be due to drier conditions during flowering to ripening. In Saskatchewan, rainfall was much higher during this period and black point severity averaged 22.7%. All fields sampled in Saskatchewan had high levels of black point, while in many fields in southern Alberta the disease was not detected.

Black point in both years was caused almost entirely by *Alternaria* spp. *Helminthosporium* and *Fusarium* spp. were only rarely isolated from diseased seeds.

*Stem smut of fall rye.* From 1977 to 1981 commercial fall rye fields in Alberta were surveyed annually to determine the distribution and severity of stem smut. Based on these surveys, the yield loss from stem smut for the 5-yr period was estimated at 0.75% (7455 t), with a cash value of $1.25 million. This loss occurred because many growers continue to grow the highly susceptible variety Cougar, even though a moderately resistant cultivar and a seed treatment fungicide are available to control the disease. Stem smut did not occur in central and northern Alberta where 20% of Alberta rye is produced.

**Forage crop diseases**

*Verticillium wilt of alfalfa.* Verticillium wilt has become an important new disease of alfalfa in Canada, particularly in the southern part of British Columbia, Alberta, and Ontario. A new research project was initiated in 1982 to support the Station's ongoing efforts in developing disease-resistant cultivars and to investigate the pathology, survival, epidemiology, and control of the disease. Results of a study in an irrigated field with hay alfalfa showed that numerous spores of the verticillium pathogen were produced on diseased plants. In this field pea aphids, an important pest of alfalfa, were found to carry and transmit the spores onto healthy alfalfa, thereby causing verticillium wilt. This discovery implies that insects such as pea aphids may play a significant role in the spread of verticillium wilt of alfalfa.

**Potato diseases**

*Latent infection caused by ring rot bacteria.* Potato plants grown in 1979 from Russet Burbank seed pieces inoculated with 30 or 300 cells of the ring rot bacterium, *Corynebacterium sepedonicum*, were symptomless but yielded tubers that, in 1980, produced some plants with symptoms and many with latent (symptomless) infection. Tubers from these plants sown in 1981 produced more plants with symptoms and fewer with latent infection. Plants originating from seed pieces inoculated with three cells of the pathogen developed no detectable symptoms or infection in three successive tuber generations. Pathogenic ring rot bacteria were recovered from potato plants classed as latently infected.

## PLANT SCIENCE

**Sorghum potential in Alberta**

The potential of sorghum in southern Alberta has been studied at the Lethbridge Research Station since 1972. Early-maturing,

adapted genotypes and the agronomic practices necessary for optimum production have been identified. Sorghum does not show greater drought resistance than barley or wheat in Alberta. The main problem remaining to be resolved is that of poor stands caused by chilling injury and by pathogens.

### Cereals

*Early seeding of cereals in southern Alberta.* Yields of cereals sown in southern Alberta between January and early June declined when seeding was delayed past late April. Snow and soil conditions frequently permitted sowing of cereals as early as January, usually without decreasing yields. Winter wheat could be successfully vernalized by sowing by early March, and subsequent yields were comparable to those of early-sown spring wheat.

*An efficient barley breeding technique utilizing a controlled environment.* A procedure has been developed for breeding barley in a controlled environment using high plant density and split nitrogen application. This procedure allows an accelerated generation cycle (three generations per year), large populations, low mortality during vegetative growth, and an environment where loss due to natural selection is minimized.

### Amino acid composition and protein quality of selected winter wheat cultivars

The protein content of Alberta-grown winter wheat varied among four cultivars and between whole wheat and milling fractions. Lancota whole wheat had the highest protein content and Norstar, a progeny of Winalta and Alabaskaya, had the lowest. Lysine was highest in shorts, followed by bran, screenings, whole wheat, and flour. Bran, screenings, and shorts contained more tryptophan than whole wheat and flour; shorts contained the most. Norstar had higher protein quality than either its parents or Lancota for whole wheat, flour, and screenings. Lancota had the highest protein quality in bran and shorts. The first limiting amino acid in whole wheat, flour, and screenings was lysine and in bran and shorts, isoleucine.

### Potatoes

*Development of new varieties for the prairie potato processing industry.* The potato breeding project at Lethbridge is designed to develop varieties with good processing quality, superior yield, early maturity, and other desirable characteristics. Selection procedures emphasize tuber quality characteristics, such as high dry matter content and a light golden color of the fried product, demanded by the French fry and chipping industries. Material from established breeding programs is also being evaluated for production potential under prairie conditions.

*Early generation selection of potato seedlings.* Agriculture Canada supports a major breeding program at Fredericton, N.B., where hybridization and preliminary selection are carried out for cooperative breeding projects at other locations in Canada. An evaluation of the efficiency of this system was required with the advent of a new breeding project at the Lethbridge Research Station to serve the prairie region of Canada. Two groups of seedlings from the first field generation of the Fredericton breeding program were compared. One group was composed of seedlings obtained at random and the second of seedlings obtained through the normal selection procedures used in Fredericton. Ten crosses were sampled in 1979 and 12 in 1980. Results of the study provide evidence that preselection of the first clonal generation at Fredericton improves the maturity, yield, and tuber traits of these seedlings grown in Alberta, yet does not cause a major reduction in the variability of traits. These results support the current philosophy of operating regional potato projects in Canada.

### Special crops

*Safflower varieties becoming a reality.* Safflower cultivars currently available are too late maturing to ensure a crop in the southern prairies. The selection program started at Lethbridge in 1978 shows promise of resulting in agronomically acceptable early-maturing cultivars. At Lethbridge in 1982 the best-yielding early selections have outyielded standard cultivars currently grown in the adjoining USA and have matured 10–14 days earlier. Intensified yield testing needs to be carried out during the next few years. Maturity levels are adequate to ensure a crop prior to a killing fall frost. When such a high-yielding cultivar becomes available, safflower, with its deep tap roots, could become a dryland crop alternative to the cereal grains. This would help intensify dryland agriculture by the reduction of summerfallow.

## Forage

*Walsh western wheatgrass.* Walsh is the first cultivar of western wheatgrass, *Agropyron smithii* Rydb., a hardy and long-lived native perennial species, to be released in Canada. It was developed at the Lethbridge Research Station and licensed in 1982. Walsh is especially adapted to heavy clay soils that may receive spring flooding or irregular irrigation. The name "Walsh" recognizes the locality in southeastern Alberta where the need was first identified for a forage crop that could be used in regrassing clay and clay loam soils. The district was named after Superintendent James Morrow Walsh of the North-West Mounted Police.

*The effect of stocking rate on the productivity of fescue grassland.* A study was begun in 1949 to examine the long-term effects of four stocking rates on the productivity of rough fescue rangeland. The four stocking rates were light, 0.8 ha/AUM (animal unit per month); moderate, 0.6 ha/AUM; heavy, 0.4 ha/AUM; and very heavy, 0.2 ha/AUM. After more than 25 yr of grazing, forage production was not affected by moderate stocking but decreased 25 and 50% in the heavily and very heavily stocked fields, respectively. This corresponded to a decline in the composition of rough fescue and an increase in the composition of the less productive species. An increase in the stocking rate was associated with a decrease in the weight gain of individual animals but an increase in cattle gains per unit area. The field stocked at a very heavy rate could not support cattle for the entire grazing season.

## Aquatic plants

*Seasonal aquatic plant control in irrigation canals.* Until recently, the only available aquatic herbicide for use in the moving water of irrigation canals was the contact herbicide acrolein. Acrolein was injected into the canal water three or four times during the growing season at rates up to 5 $\mu$L/L. Research in the Eastern Irrigation District near Brooks, Alta., has shown that the 1:1 mixture of diquat and paraquat (Reglone A and Gramoxone S, Chipman Chemicals, Ltd.) at 2.24 kg/ha will give seasonal emergency control of rooted submergent aquatic plants. After canal water velocity was reduced to 0.084 $m^3/s$, a herbicide mixture diluted 1:10 with clean water was surface-sprayed over the weed-infested canal. Forty-eight hours later the canal was flushed with irrigation water. The canal was free from aquatic vegetation within 10 days. Sago pondweed, common water-milfoil, and Richardson pondweed were controlled until late September. By November some regrowth was evident. No visible damage was evident to bank vegetation or to rooted submergent aquatic plants outside the plot area. No residue was detected in the canal-bed soil after flushing.

*Long-term vegetation control in irrigation canals.* Diuron applied in the fall to the canal bottom and inner banks of irrigation canals will give 5 yr of total vegetation control in southern Alberta. Applied at 31.3 kg/ha, the herbicide requires winter moisture and 3 mo to bind to the soil particles. The canals must be flushed in the spring and the flush water disposed of. Total grass and broad-leaved weed control existed for 3–4 yr with regrowth appearing in the 5th yr. Retreatments with diuron at 15.6 kg/ha are usually applied in the 6th to 7th yr after initial treatment. Commercial applicators must ensure uniform application to all canal surfaces to avoid spotty vegetation control.

Aerial application of fenac at 11.2 kg/ha in late fall to drained irrigation supply canals (21–42 $m^3/s$ capacity) gave excellent seasonal control of all native rooted aquatic plant macrophytes. Sparse reinfestation occurred in late November, but no retreatment was planned until the 3rd yr. Some control of broad-leaved species was achieved on the inner banks of the canal but no drift occurred beyond the top of the canal bank. No control was visible outside the plot area or from spring flush water.

*Irrigation water quality of the upper Oldman River basin.* The upper Oldman River system serves as the major source of irrigation water for southern Alberta. Soluble salts, pH, conductivity, and total solids were measured in late spring and summer of 1963 and the water was found to be of excellent quality for irrigation. The water quality studies were repeated from 1979 to 1982 by measuring total solids, total inorganic solids, silt, organic content, soluble salts, phosphorus, nitrate, and trace elements biweekly over the entire year. Summer aquatic vegetation surveys during water sampling trips were conducted on the various tributaries in the east slope watershed of the Rocky Mountains.

During the past 18 yr there has been less than 5% change from 1963 values in yearly

pH, conductivity, total solids, and soluble salts levels of the irrigation water of headwaters of the Oldman River basin. Seasonal water quality variations as high as 40% in total solids levels did occur due to changes in surface runoff patterns brought on by variations in snow pack levels, rate of spring thaw, and frequency of heavy summer precipitation.

Although foothills dugouts contain a wide variety of native rooted submergent aquatic plants, the rivers of the east slope watershed lack infestations completely. However, numerous isolated infestations of algae were found. *Cladophera* sp. (a green alga), *Batrachospermum* sp. (a freshwater red alga), and *Nostoc commune* (Vauch.) (a blue green alga) were the most common. These infestations were generally associated with man-induced environmental alterations such as logging roads, patch-cut forestry operations, or grazing of cattle. None poses a serious problem for potential spread to downstream irrigation storage reservoirs.

### Weeds

*Legume establishment as affected by weed control.* Alfalfa established where annual broad-leaved weeds and grasses were controlled yielded approximately 4 and 3 t/ha more in year 1 (establishment year) than alfalfa established with a cover crop and without weed control, respectively. Alfalfa yields were slightly greater in year 2 where weeds were controlled in year 1, but yields were similar for all treatments by year 3. Competition from weeds in the establishment year had a similar effect on sainfoin yields. Legumes were seeded at Lethbridge with various levels of weed control and harvested for 3–5 yr to determine the long-term benefits of the treatments. The project was partially funded by the Alberta Department of Agriculture through the farming for the future program.

## SOIL SCIENCE

### Soil–crop relations

*Availability of subsoil sulfur to crops.* The application of elemental or sulfate-sulfur at S rates of 0, 26, and 52 kg/ha had no effect on the yields of barley in a series of 10 field experiments. The soils contained low levels of available S (most <10 kg/ha) in the top 15 cm but higher levels (6–39 kg/ha) at depth (15–30 cm). In a controlled environment experiment with a soil containing 2 $\mu$g/g of $SO_4$-S, deficiency symptoms in rape were alleviated and yields increased by placement of $SO_4$-S fertilizer at depths of 36 cm and more. Elemental S was somewhat less effective than the sulfate form.

*Effect of N and P fertilizers on winter wheat survival.* The recent development of winter-hardy cultivars (Norstar, Sundance) has extended winter wheat production into areas where winter survival is relatively more hazardous. The results from experiments conducted under controlled environment conditions and in the field showed that plants receiving high rates of N fertilizers were less hardy than those receiving P. There was also evidence that in the presence of P the deleterious effects of N were less pronounced. These results suggest that where these nutrients are required, growers should apply P at seeding time but that they should consider delaying the application of N until the following spring.

### Soil chemistry and microbiology

*Superior $N_2$ fixation in field beans.* Western Canadian soils do not contain *Rhizobium phaseoli*, the bacterium that fixes atmospheric $N_2$ in field beans (*Phaseolus vulgaris* L.). Thus, to ensure adequate growth of beans without the addition of costly fertilizer N, the rhizobium must be added by inoculation. In a 2-yr experiment with two cultivars, $N_2$-fixation by 15 pure strains and two commercial inoculants varied from 0 to 121 kg/ha. One strain produced nodules but was consistently ineffective for $N_2$-fixation. Most strains and the two commercial inoculants were effective $N_2$-fixers and, in general, inoculation resulted in bean yields comparable to those from heavy fertilization.

*Solubilization of rock phosphate by mycorrhizal fungi.* Soil microorganisms were rated for ability to solubilize precipitated calcium phosphate in agar plates and unprocessed Idaho rock phosphate in solution culture. Many varied conditions of growth were imposed so as to select the organism best suited for use in a biotechnological phosphate fertilizer system. Tests were conducted on a variety of carbon materials as a food source; the phosphate-solubilizing (PS) activity utilizing "waste" carbon materials; PS activity at 20°C and at 4°C as might be encountered in early spring; PS activity in small batches incubated for short periods and in large batches incubated for a long time; and PS

activity under moisture conditions of soil field capacity. Based on the results of these experiments, five fungal isolates, all *Penicillium* spp., were selected which have the potential to solubilize phosphorus at rates sufficient to supply plant uptake needs. These isolates will be subjected to further testing including soil–plant growth experiments.

*Seasonal contribution of grass roots to soil organic matter.* Blue grama grass, *Bouteloua gracilis* (H.B.K.) Lag., was grown in containers which separated the shoot and root spheres by an air-tight seal. Four successive light and temperature regimes simulated different seasonal conditions: (*1*) day (14 h) and night temperatures of 25 and 15°C, respectively, in a $^{14}CO_2$ atmosphere during the last 3 l of the 55 days from germination to seed set; (*2*) 21 days of a 14°C day (10 h) and 3°C night regime; (*3*) 29 days of continuous −5°C; and (*4*) 26 days of the original temperature and light conditions. Distribution of the assimilated $^{14}C$ at the end of period *1* was: 33% in roots; 23% in soil organic matter; and 22% released as $CO_2$. The ratio of washed root mass to root-derived soil organic matter originating from labeled $^{14}C$ was 60:40. A root mass decrease of 45% during the cool and freezing periods changed this ratio to 23:77. Polysaccharides and 0.1 *N* NaOH-extractable organic matter decreased while potential dehydrogenase activity and total organic P increased during this same period, thereby confirming field-related observations. Measured dehydrogenase activity over winter may have two distinct origins. As total C content of the soil did not increase under the conditions of the experiment, it was postulated that a portion of the observed increase in total C in the field over winter was of inorganic rather than organic origin.

**Irrigated soils**

*Salinity of irrigated soils.* A recent 2-yr salinity survey showed that the percentages of land with a salinity level exceeding 4 dS/m (decisiemens per metre) within the western block of the St. Mary River, Lethbridge Northern, and Taber irrigation districts were 7, 8, and 10%, respectively. This condition is not as serious as was suggested in a consultant's recent report to the Alberta government. The salinity level of the soil at each site was found to vary with its location, clay content in the 0- to 120-cm depth, distance from canal, water table level, and slope.

*Control of seepage from irrigation canals.* Seepage from canals is a common cause of waterlogging and salinity in the irrigated soils of southern Alberta. These soils are frequently layered with coarse and fine textured materials and "bridging" of groundwater across a drain is not uncommon. Installation of a vertical plastic barrier, in conjunction with an interceptor drain and a gravel envelope at 1.4- to 1.8-m depth, effectively controlled the water table at drain depth throughout the irrigation season. Prior to drainage the water table depth varied from 0.4 to 1.0 m. By the slope of the water table draw-down curve, it was evident that the plastic barrier was effective in preventing bridging of the groundwater. This concept of interceptor drainage with a plastic barrier to prevent bridging could have wide usage along many of the seepage-prone canals in Alberta.

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# Research Station
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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On transfer of work to University of California at Davis, CA, August 1982 to August 1983.
[3]On a Canadian International Development Agency (CIDA) assignment to Sri Lanka, from July 1982 to November 1984.

# INTRODUCTION

This report refers to some of the major research achievements in 1982. The Station has a broad mandate for investigation of problems in animal and crop production for the region and for the nation.

Some highlights of 1982 research include the discovery that sorghum could be satisfactorily substituted for wheat in diets of laying hens; Haida and Willamette raspberry cultivars did not become infected with raspberry bushy dwarf virus; a combination of metribuzin and metolachlor provided good control of grasses and broad-leaved weeds for production of processing peas; marked differences were observed between Kentucky bluegrass cultivars in resistance to diseases and in the effects of shading.

Dr. C. G. Kowalenko has been seconded to the Canadian International Development Agency to work on soil fertility problems in Sri Lanka.

Additional details concerning the research program and results achieved may be obtained by requesting copies of the listed publications and other informal reports. Requests should be directed to the Research Station, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0.

J. E. Miltimore
Director

## ANIMAL SCIENCE

### True availability of dietary copper for dairy cows

Tracer techniques were used to investigate quantitative aspects of copper (Cu) metabolism in dairy cows and to determine the effects of high, subtoxic dietary levels of selenium (Se) on Cu metabolism. Six dairy cows in early lactation were assigned in groups of three to an Se-adequate diet or the same diet with additional Se. Animals were dosed intravenously with $^{65}Cu$ (a stable isotope) equivalent to about 10% of whole-body Cu content. Samples of plasma, milk, urine, feces, and liver were obtained at intervals over 252 days and analyzed for Cu and Cu stable isotope ratio. Liver Cu increased during the trial for both treatments, indicating a change in Cu status. $^{65}Cu$ enrichment decreased in liver with first-order kinetics up to 140 days, yielding a biological half-life for Cu of 108 ± 25 (standard error of the mean) days after correction for changes in Cu status. Absorption of Cu from the gastrointestinal tract was estimated from whole-body Cu turnover and found to be 6.9 ± 1.0% of dietary Cu. Dietary Se level did not affect liver Cu, biological half-life of Cu, or absorption of dietary Cu during the first half of lactation. However, high dietary Se appeared to accelerate body Cu turnover after 140 days of the trial.

### Carcass characteristics of steers finished on corn or grass silage

Forty Hereford steers were reared on grass–legume pasture for 211 days. Ten were then slaughtered. The remaining 30 were divided into two feedlot groups and finished on grass hay at 2 kg/day plus (ad libitum) grass silage supplemented with 9% dehydrated beet pulp or corn silage containing 0.5% feed-grade urea. The five heaviest steers of each group were then serially slaughtered after 42, 84, or 126 days. Gains on pasture were 0.47 kg/day whereas feedlot gains were 0.71 and 0.30 kg/day for steers on corn and grass silage, respectively. Two steers from pasture and two that received grass silage graded B1 for insufficient fat cover but the remaining steers graded A1 or A2. Steers fed corn silage averaged less carcass fat coloration (2.9) than those fed grass silage (3.6) when evaluated on a scale of 1 (white) to 9 (amber).

Agriculture Canada graders do not downgrade amber carcasses. However, meat packers begin to discriminate against carcasses reaching 5 in the amber scale. One carcass from the grass silage group reached a carcass amber rating of 7 and would probably have been downgraded by the packers.

In addition, steers fed corn silage had more carcass weight (5%), rib fat depth (30%), marbling (9%), rib fat (27%), and offal fat

(47%), a higher grade measure (52%), and less rib lean (6%) and rib bone (16%) than steers fed grass silage.

### Substitution of sorghum for wheat in hen diets

Interest has recently been shown in growing sorghum as an alternative grain crop on the Canadian prairies. Yields in southern Alberta have been shown to be comparable to wheat and barley. In Western Canada, wheat is the primary grain source used in diets for laying hens, but if sorghum becomes available it could replace some wheat. Comparisons of wheat and sorghum in laying diets, however, had not been previously reported. An experiment was conducted to compare sorghum and wheat in laying diets where sorghum replaced wheat at 0.0, 25, 50, 75, and 100%. The diets were maintained at 16% protein by adjustments in the amount of soybean meal used (wheat 13.5% protein, sorghum 10.7% protein). Egg production, egg weight, feed consumption, body weight, and hatchability of eggs from Single Comb White Leghorn hens were not affected by the proportion of sorghum in the diet.

### Early growth of rabbits

It had been shown that additional milk during the suckling period could double the growth of young rabbits. To capture this growth potential, growers have attempted to creep-feed young rabbits, but the creep feeds used are high in milk products and therefore expensive. Preliminary research at Agassiz showed that the accelerated growth of conventional creep feeding systems could not justify the extra labor cost. Creep feeding improved survival at 49 days by 18% and feed conversion by 7%, but labor and feed costs reduced revenue per animal by $0.14. The reduced revenue represents only about 4% of the total sale value of the average fryer, so that it should be possible to develop an economical creep feeding system.

## CROP SCIENCE

### Raspberry bushy dwarf virus

Raspberry bushy dwarf virus causes symptoms that adversely affect fruiting and growth in susceptible red raspberry cultivars and selections. Symptom expression may vary among plants and the virus has been implicated as the causal agent of yellows disease in some susceptible plants. The virus is seed- and pollen-borne. Field spread has been observed in initially virus-free plants of susceptible cultivars and selections. Virus-free plants of six cultivars of red raspberry were graft-inoculated with infected scions. Inoculated plants were established in a field trial and their performance was compared with noninoculated plants for 4 yr. The cultivars Haida and Willamette did not become infected with the virus either by graft inoculations or by pollen transmission. The other cultivars, Creston, Canby, Lloyd George, and Meeker, were infected by both means.

### Control of fruit rot in strawberries

The fungicides captan, meclozolyn, and iprodione were evaluated for control of pre- and post-harvest fruit rot in Totem and Tyee strawberries. The incidence of fruit rot in the field for the unsprayed plots of Totem was 31.3% and for Tyee, 33.8%. All treatments significantly reduced preharvest fruit rot. There was no effect of treatment on berry size. The yield of sound berries was increased by all treatments. All fungicides significantly reduced total postharvest rots. *Botrytis* was the main agent of rots and all fungicides reduced its presence. No treatment reduced *Rhizopus* and only captan and iprodione reduced *Penicillium*. Considerable rot (3–24%) caused by a bacterial complex was identified; no fungicide controlled it.

### Control of postharvest fruit rot of raspberries

Field sprays with the fungicides captan, UBI 2342, iprodione, meclozolyn, and anilazine were evaluated for control of postharvest fruit rot in Willamette and Haida raspberries. *Penicillium* was the major contributor of postharvest fruit rots, followed closely by *Botrytis*. All treatments except UBI 2342 reduced *Penicillium* in both Willamette and Haida. *Botrytis* was reduced by all treatments in Haida and all except UBI 2342 in Willamette. No treatment reduced *Cladosporium* in Willamette but in Haida, where the incidence of the rot was much higher, all treatments except UBI 2342 caused a reduction. *Rhizopus* infection was too low for accurate assessment.

### Preplant treatments for weed control in processing peas

Metribuzin was tested at 0.21 and 0.42 kg/ha alone and in mixture with metolachlor at 1.68, 1.92, and 2.64 kg/ha as preplanting, soil-incorporated treatments for weed control in the processing pea cultivar Improved Laxton's Progress. Metribuzin alone gave poor control of barnyard grass, annual bluegrass, and large crabgrass. In addition, redroot pigweed and lamb's-quarters showed some tolerance for metribuzin. Weed competition was reflected in yield reduction. The metribuzin–metolachlor mixture, as in the previous year, controlled grass and gave acceptable to good broad-leaved weed control. Crop yields from these plots were not different from those of the weeded control plots.

### Disease resistance in Kentucky bluegrass cultivars

During 1981–1982, disease incidence was monitored in a test of 56 Kentucky bluegrass cultivars established in 1978 and 100 cultivars in two tests established in 1981. The diseases that caused appreciable damage were leaf spot (melting-out) in early summer and stripe rust in late fall. Apparent response to these diseases varied from highly resistant (less than 5% damage) to highly susceptible (50% or more damage). Among 21 licensed cultivars represented in the tests, seven (Baron, Birka, Bristol, Enmundi, Merion, Nugget, and Touchdown) were highly resistant to leaf spot. Seven cultivars (Banff, Bristol, Fylking, Geronimo, Majestic, Sydsport, and Victa) were highly resistant to stripe rust.

In a shade tolerance trial established in spring 1982, 20 cultivars of Kentucky bluegrass were evaluated for resistance to powdery mildew. The licensed cultivars America, Birka, Bristol, Eclipse, Glade, Nugget, Touchdown, and Trampas were highly resistant to the disease and this was closely related to satisfactory establishment in shade.

### Witloof–a new vegetable for British Columbia

More than 30 witloof (chicory) cultivars were grown at Agassiz and in a cooperator's field over a period of 4 yr. Forcing was done in controlled environment chambers and in a commercial facility. Of the cultivars tested, Zoom gave the greatest yield of chicons as well as the best quality.

Forcing was done either by the traditional method using soil and straw to cover the roots or by the more modern soilless method. The soilless method required less labor and cost less, and gave greater yield and better quality.

### Sewage increases base metal content of radishes

Radishes were grown in lysimeters and an industrial sewage sludge was added to half of the drums. With minor modifications, the experiment was carried through a 2nd yr with further additions of sludge to the drums that had received the treatment previously. The concentrations of several base metals were determined in the roots.

The 2-yr average concentration of copper was not affected by the sewage treatments. Zinc concentrations increased from an average of 52 to 122 mg/kg, manganese from 40 to 110 mg/kg, cadmium from 0.6 to 3.4 mg/kg, and nickel from 3.4 to 5.2 mg/kg. There was no significant effect on the lead concentrations in the roots and the overall average was 1.5 mg/kg.

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# Research Station
# Kamloops, British Columbia

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[2]On education leave.
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# INTRODUCTION

The research programs at the Kamloops Range Research Station and at the Experimental Farm, Prince George, serve the diverse rangelands of interior British Columbia, which vary from true grasslands to forested range to wet meadows. Research is focused on servicing the beef industry through development and transfer of technology on forage crops and beef production, as well as studies on bloat, poisonous plants, drought, and winterhardiness. The staff utilize their expertise in chemistry, biochemistry, plant physiology, soil science, plant ecology, range management, forage agronomy, and animal science to provide knowledge and technology to the scientific and producer clientele.

Two of the staff are increasing their expertise on transfer of work or education leave in 1982. The director was on assignment from 16 July to 16 August in the People's Republic of China on behalf of Agriculture Canada.

As these are only highlights of completed research during 1982, anyone wishing for further information is encouraged to contact the director or the scientists at Agriculture Canada, Range Research Station, 3015 Ord Road, Kamloops, B.C. V2B 8A9, or the Experimental Farm, R.R. No. 8, R.M.D. No. 6, Prince George, B.C. V2N 4M6.

J. D. McElgunn
Director

# RANGELAND STUDIES

### Seeding pastures

A new bulletin, *Seeding Grassland Ranges*, specific to conditions of the British Columbia interior was published. The bulletin summarizes the research and technology developed by several research studies. The contents include a description of the grasslands and detailed information on when to seed, how to seed, and what to seed as well as supplying data on feed values, competitive ability yields, management, and fertilization.

### Nitrate accumulation of forage grasses

Three grasses (timothy, reed canarygrass, meadow foxtail) of importance to the province's interior were fertilized at five rates of N application ranging from 0 to 360 kg/ha. All three species responded with more than twofold yield increases but all three accumulated nitrate to various degrees. Timothy did not accumulate nitrate to a level that could be deemed unsafe for cattle feed (less than 0.15% $NO_3$) at any rate of N fertilization. Reed canarygrass contained enough nitrate at the 180-kg rate to be of possible toxicity (above 0.15% but less than 0.30% $NO_3$). Meadow foxtail must be regarded as a nitrate accumulator and possesses the greatest potential for nitrate poisoning. At rates of 90 kg/ha or greater, the feed contained 0.25% nitrate, which increased as the N fertilizer increased.

### Native versus seeded pastures

Three seeded grass–legume pastures were compared with three native pastures in the Peace River region of British Columbia using a cow–calf system. No differences in weaning weight of calves and only small differences in cow weights occurred in favor of cultivated pastures. The superiority of seeded pastures was manifested in greater stocking rates on seeded pastures as compared with native pastures.

### Feed additives: Avoparcin, Bentonite

Performance of steers receiving either hay or whole-crop cereal silage with or without Bentonite or Avoparcin was measured. No differences in average daily gain or feed conversion efficiency were found. Average daily gain of the control was 0.42 kg/head and feed conversion expressed as gain to weight of dry feed was 1:15.8.

In a grazing study with steers, Avoparcin did not improve average daily gain over the control treatment.

### Crude protein and digestibility of meadow foxtail and timothy

Crude protein, digestible dry matter, and digested protein of meadow foxtail and timothy were determined over time. All three factors declined with time in both species. All three factors were consistently higher in

meadow foxtail than in timothy and the rates of decline of each factor were not different in the two grasses. Despite these results, some of the preliminary grazing studies comparing the two grasses have shown greater average daily gain and more gain per hectare from timothy than from meadow foxtail. These results may be attributable to yield or intake differences.

### Fencing

An improved fence at substantially less cost was the result of a joint project of Agriculture Canada and the University of British Columbia's Bioresources Engineering Department. The criteria used to guide the project were: to optimize material usage; to reduce the time and motion required to build a fence; and to design, construct, and test fencing devices and techniques that increase the overall efficiency of fence construction. After studying traditional fences we found that they were overdesigned and used considerably more labor and materials than required to build a sound fence. Through the use of wider post and dropper spacings, snap-on droppers, and properly designed line and end braces, a saving of 40% can be made over traditional fence costs. The use of smooth wire as opposed to barbed wire gives additional efficiency and further reduces the cost by 20%, in that there is more wire length per equivalent weight than for barbed wire, smooth wire is easier to handle, and all strands of a fence can be installed at the same time. Not only does this new fencing technology reduce the cost of a fence, experience shows that it produces a better fence.

### Timber milkvetch poisoning

Affected cattle are usually detected in advanced stages of poisoning or dead, when it is too late to do anything. We injected steers, heifers, and cows with toxin and observed them closely for early signs of change, which developed as follows: (*1*) a small elevation in heart and respiration rate occurred (not observable in the field); (*2*) animals became placid, stupified, and tractable; (*3*) most animals had partially closed eyes and ears moved continually in a random twitching manner; (*4*) the gait was elongated, relaxed, and slower than normal; (*5*) there was excessive frothy salivation and increasing placidity; (*6*) animals became unstable and continually shifted weight from one hind leg to the other; (*7*) if an animal was forced to move, there was a distinctive high-headed carriage and eyes were partly closed.

If these signs are observed in grazing cattle, the afflicted animals should be removed and pastured or fed in fields that do not contain timber milkvetch.

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# Saanichton
# Research and Plant Quarantine Station
# Sidney, British Columbia

## PROFESSIONAL STAFF

### Administration

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| J. M. Molnar, B.S.A., M.Sc., Ph.D. | Director |
| G. Blair | Administration Officer |

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| M. A. Watson,[1] B.A., M.Lib. | Librarian |

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| R. G. Atkinson, B.S.A., Ph.D. | Plant pathology |
| A. W. Chiko, B.Sc., M.S., Ph.D. | Viruses |
| C. J. French, B.Sc., Ph.D. | Woody ornamentals |
| W. C. Lin, B.S., M.Sc., Ph.D. | Floriculture |

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| H. Hartmann, B.Sc. (Agr.), M.Sc., Ph.D. | Plant pathology |

### Plant Quarantine

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| R. C. Johnson,[2] B.S.A. | Head of Section; Grape viruses |
| D. Thompson,[2] B.Sc. | Tree fruit viruses |

## Departures

| | |
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| N. V. Tonks, B.S.A., M.S. | Entomology |

[1]Seconded from the Libraries Division, Finance and Administration Branch.
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# INTRODUCTION

The Saanichton Research and Plant Quarantine Station has a dual responsibility. First, it is the research center for ornamentals and greenhouse vegetables in British Columbia, and second, it is responsible for the national post-entry quarantine program for Canada.

The Station's research programs are oriented to solving problems and giving direct service to the ornamentals and vegetable industry. Emphasis is being given to nutritional and physiological problems in floriculture, plant propagation, postrooting development of nursery plants, eradication of viruses, rapid multiplication of grapes and ornamentals by tissue culture, and control of pests and diseases in vegetables and ornamentals. The Station is also responsible for research in energy conservation utilizing solar energy, thermal blankets, and a computerized climate control system.

Requests for information or publications should be addressed to the Saanichton Research and Plant Quarantine Station, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

J. M. Molnar
Director

## ORNAMENTALS

### Breeding

*Release of Alstroemeria 'Alsaan'.* This new cultivar was obtained by crossing *A. aurantiaca* D. Don and *Alstroemeria* 'Orange Beauty'. It is being released through the Canadian Ornamental Plant Foundation. Alsaan was selected for cut flower production in low-temperature (13°C) greenhouses.

*Release of Rieger Elatior begonia 'Saanred'.* This cultivar originated through X-ray-induced mutation of Rieger Elatior begonia 'Renaissance' and is being released through the Canadian Ornamental Plant Foundation. Saanred plants are compact in growth habit and grown as pot plants.

### Management

*Alstroemeria flowering affected by low soil temperature and high-intensity lighting. Alstroemeria* 'Regina', which typically ceases flowering in the fall, was planted in four ground beds. Two beds were equipped with a water cooling system (+ cold) and the other two were not (– cold). Each soil temperature regime was further divided into two lighting conditions: with high-pressure sodium light (+ HPS) or without (– HPS). During the 1st yr, soil cooling increased the number of flowering shoots from 451 (– cold) to 721 (+ cold) under HPS light and from 590 (– cold) to 928 (+ cold) without HPS light. This improvement in flower production due to soil cooling was even more evident during October to March: flowering shoots increased from 15 (– cold) to 233 (+ cold) under HPS light, and from 40 (– cold) to 188 (+ cold) without HPS light. It appeared that soil cooling is the primary factor in improving productivity of the cultivar Regina.

*Gerbera flowering affected by high-intensity lighting and soil warming.* The data obtained from bed-grown *Gerbera* in 1981–1982 indicated that daily 16-h high-intensity lighting with HPS lamps during the low light period of November–March increased the number of flowers by 65% and 118%, without and with soil warming to 24°C, respectively. There was no or little effect of HPS light and soil warming on productivity during March–August.

*Propagation of English holly (Ilex aquifolium) cultivars using $CO_2$-enriched mist and HPS light in fall and spring.* In fall propagation (2 November to 15 January), $CO_2$-enriched mist promoted rooting in cultivars Brethour and Italian, inhibited rooting in Silver vag. Standard, and had no effect on Wilsonii, Shortspra, or Pinto. In the spring, $CO_2$-enriched mist strongly promoted rooting in Silver vag. Standard and Italian, inhibited rooting in Wilsonii, and had no effect on Shortspra or Pinto. In the fall HPS light inhibited rooting in Silver vag. Standard and Shortspra and had no effect on the other four cultivars. In the spring, HPS light stimulated rooting in Italian, showed a positive interaction with $CO_2$ in Wilsonii and Silver vag. Standard, and had no effect on Brethour,

Pinto, or Shortspra. The results indicate that even closely related cultivars show marked differences in response to HPS light and $CO_2$-enriched mist during propagation. Also, $CO_2$ and HPS light appear to be more beneficial in spring propagation than in the fall, presumably due to differences in the physiology of the stock plants.

*Effects of high-pressure sodium (HPS) light on growth of rooted cuttings.* HPS light used as a supplementary night-break treatment (2000–0400 h) stimulated total shoot growth (terminal and lateral) of *Ilex aquifolium* cultivars Wilsonii, Silver vag. Standard, and Shortspra compared with growth under natural daylight. HPS light had no effect on Brethour or Pinto. Low-intensity incandescent (INC) lighting (2000–0400 h) had no effect on the growth of any of the cultivars. A combination of HPS and INC light stimulated growth of Silver vag. Standard and Shortspra and had no effect on the other cultivars. The results indicate that the effects of HPS light are variable and depend on the cultivar. Low-intensity incandescent night-lighting was ineffective in promoting growth in any of the cultivars tested.

### Diseases

*Viruses infecting tuberous begonia and Daphne.* A spherical virus isolated from tuberous begonia was identified serologically as cucumber mosaic virus. The normal lengths of particles of two flexuous rod-shaped viruses isolated from *D. odora* 'Leucanthe' were 773 and 789 nm and the mean particle widths were 13–14 nm. Although these particle sizes were characteristic of potyviruses, tonoplast aggregates were the only potyvirus-type inclusion observed in sections of cells infected with either isolate.

## SMALL FRUIT

### Management

*Effect of the size of culture vessel on the in vitro shoot proliferation of grapevine in a liquid medium.* One 2-cm shoot from actively proliferating in vitro cultures of *Vitis vinifera* 'Liemberger' was placed in each of 12 126-mL Erlenmeyer flasks, 12 250-mL Erlenmeyer flasks, and 12 473-mL (pint) Mason jars containing 7.5 mL of proliferation medium. These explants were transferred into fresh media every 2 wk. After 4 or 6 wk of proliferation under the same conditions of temperature and illumination and at the same rate of mechanical agitation, the explants were weighed and the shoots obtained were counted and measured. The final mean fresh weight of the explants in jars was significantly less than that of the explants in the flasks. Thus the size of vessel used influenced the in vitro proliferation of grapevines in liquid culture.

*Kiwi fruit.* Kiwi fruit, *Actinidia chinensis* Planch, was first planted on the Station some 7 yr ago and it has now been firmly established that the local conditions are quite suitable for its cultivation, provided that the site selected is well drained and protected from the wind. The results of the Saanichton experiment indicate that a kiwi fruit industry could be established on Vancouver Island. Fruit can be harvested in the 4th yr after planting and full production is attained in the 7th yr. The fruit is extremely rich in vitamin C (105 mg/100 g sample), much more so in fact than citrus fruit. It can be stored for long periods at cool temperatures and the juice can be consumed directly or mixed with other fruit juices.

### Diseases

*Effect of ribavirin on in vitro cultures of leafroll-infected grapevines.* Ribavirin was added at concentrations of 0, 10, 20, 30, 40, and 50 mg/L to the culture medium of grapevine leafroll-infected *Vitis vinifera* 'Liemberger'. After the cultures had been exposed to the drug for 30, 60, and 90 days, shoots 2 cm long were excised and placed on drug-free rooting medium.

Plants derived from the control cultures (no ribavirin) exhibited typical leafroll symptoms 37–41 days after the shoots had been excised for rooting. Plants derived from drug-treated cultures showed symptoms 75–110 days after shoot excision. For the concentrations tested, this significant delay in the onset of symptom expression was independent of drug concentration, and a 30-day treatment was as effective as a 90-day treatment.

## VEGETABLES

### Management

*Overwintering cauliflower.* The 12 most promising cultivars from the 1980–1981 trials were seeded on both 15 and 30 July and

transplanted to the field on 19 August and 3 September, respectively. The numbers of heads harvested for the two plantings were not significantly different. The average head weight for the first planting varied from 722 to 1198 g. The second planting produced heads with an average weight between 477 and 769 g.

*Tipburn in butterhead lettuce cultivars.* The incidence of tipburn in butterhead lettuce cultivars grown in a system that used nutrient film techniques (NFT) has been investigated during the past 2 yr. It has been established that the problem is most prevalent in lettuce seeded between March and July. Cultivar trials are conducted continuously to determine the most suitable cultivars for production during the summer months. Eight of the 40 cultivars included in the trials are exhibiting acceptable tipburn levels during the summer. Further work indicates the incidence of tipburn is not reduced by raising the humidity in the greenhouse. It was also found that raising the calcium level in the nutrient solution after transplanting gave mixed results, depending on the cultivar being examined.

*Tomatoes grown by a nutrient film technique.* The performance of four tomato cultivars grown both in sawdust culture and by NFT was tested. During the 20-wk harvest period (18 April to 13 September), the number of fruit produced by the four cultivars was an average of 10% higher for the plants grown by NFT than in sawdust (range 2–19%). At the same time, the NFT system resulted in an average of 23% more fruit by weight per plant than the sawdust (range 16–34%). This was because the NFT system gave rise to an average of 21% more large fruit than the sawdust (range 16–26%). Early fruit production (the first 6 wk) was not different in the two growing systems but was dependent on the cultivars.

### Diseases

*Biological control of cucumber powdery mildew.* Fifteen species of fungi have been tested for effectiveness as agents for biological control of powdery mildew. The organisms were tested both as protectants, applied before the pathogen was introduced, and as eradicants, once powdery mildew had established itself. All tests were carried out on the cucumber cultivar Marketer. Eight of the organisms have shown considerable promise as control agents, achieving up to 95% control of powdery mildew under test conditions.

*Chemical control of powdery mildew on cucumber and gray molds on tomatoes in greenhouses.* The experimental compounds fell into two categories—pesticides developed and provided by the chemical pesticide industry, but still in the experimental stages, and compounds with low environmental hazard potentials such as those used to prevent spoilage of food products.

The pesticides provided by the industry have proven effective under the test conditions. The other compounds tested varied from slightly effective (soybean lecithin) to damaging (sodium propionate).

## GREENHOUSE ENERGY CONSERVATION

From September 1981 to April 1982, electrical energy inputs and propane fuel consumption were measured on a unit floor area basis in the experimental solar shed and the conventional control greenhouse. The solar shed required 34% less propane and 29% less total energy, resulting in a predicted annual total energy savings of 40%.

Two new solar-heated greenhouses equipped with earthen thermal storage systems are now completed. Heat is exchanged by circulating interior air in alternating directions through 10-cm polyvinyl chloride (PVC) pipes buried in subgrade soil beds running the entire length of the houses. Energy reductions of 45% are expected in both the glass gable house and its polyethylene-covered Quonset counterpart.

Thermal curtains have been retrofitted into the solar shed, control house, and glass-covered earthen thermal storage house. Heat load reductions of 30–50% are estimated.

## PLANT QUARANTINE

In 1982, 114 tree fruit and 26 grape varieties were received for virus indexing including some new Czechoslovakian peach and almond cultivars, a variety of ornamental *Prunus* species, and promising new peaches and apricots from Ontario. Six varieties were released from the heat therapy program and two pear varieties added to the repository. A total of 51 678 buds were distributed to 10

countries from the repository of virus-tested material.

Completion of a 744-$m^2$ greenhouse complex is expected to allow more extensive controlled-environment indexing of woody plants and significantly reduce the delays experienced with field indexing.

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# Research Station
# Summerland, British Columbia

## PROFESSIONAL STAFF

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| G. C. Russell, B.S., M.S., Ph.D. | Director |
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| R. D. McMullen, B.Sc., M.Sc., Ph.D. | Head of Section; Bionomics of pear psylla |
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| F. L. Banham, B.A. | Stone fruit insects |
| V. A. Dyck, B.A., M.Sc., Ph.D. | Management of codling moth |
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| H. F. Madsen, B.A., Ph.D. | Apple pest management |
| W. J. McPhee, B.Sc., M.Sc., Ph.D. | Tree fruit fungus diseases |
| J. T. Slykhuis, B.S.A., M.Sc., Ph.D. | Stone fruit virus diseases |
| R. S. Utkhede, B.Sc. (Agr.), M.Sc. (Agr.), Ph.D. | Tree fruit fungus diseases |

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### Pomology and Viticulture

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| N. E. Looney, B.S., M.S., Ph.D. | Pomology, plant physiology, growth regulators |
| M. Meheriuk, B.Sc., B.Ed., M.Sc., Ph.D. | Fruit storage and biochemistry |
| H. A. Quamme, B.S.A., M.Sc., Ph.D. | Orchard management, hardiness |

### Soil Science and Agricultural Engineering

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| D. S. Stevenson, B.S.A., M.S., Ph.D. | Head of Section; Soil moisture |
| A. P. Gaunce, B.Sc., M.Sc., Ph.D. | Pesticide and environmental chemistry |
| P. B. Hoyt, B.Sc., M.S., Ph.D. | Soil chemistry and management |
| A. L. Moyls, B.A.Sc., M.S., Ph.D. | Agricultural equipment—development and assessment |
| G. H. Neilsen, B.Sc., M.Sc., Ph.D. | Soil fertility, plant nutrition |
| P. Parchomchuk, B.A.Sc., M.S. | Agricultural equipment—development and assessment |

## VISITING SCIENTISTS

| | |
|---|---|
| O. L. Lau, B.S., M.S., Ph.D.<br>B.C. Tree Fruits Research Associate since July 1976 | Pomology, viticulture |
| C. H. Klaren, B.Sc., M.Sc., Ph.D.<br>Natural Sciences and Engineering Research Council postdoctorate fellow from November 1980 to November 1982 | Pomology, viticulture |
| N. Kobayashi, B.S.<br>Assistant Manager of Research and Development, Kikko Foods Co., Tokyo; September 1982 to January 1983 | Food processing |
| J. C. Yanez, B.S.<br>Professor, Universidad Nacional del Sur Bahia Blanca, Argentina; November 1981 to November 1982 | Food processing |

[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On transfer of work to Universidad Polytecnica, E.T.S.I.A., Valencia, Spain, from October 1982 to September 1983.

# INTRODUCTION

The Research Station at Summerland is the center for tree fruit research in Western Canada and also has a major role in research with grapes. Only a portion of the current research is included in this report, as its purpose is to indicate the scope and diversity of the program.

A number of staff have been involved in international studies. Dr. N. E. Looney returned to Summerland in August after a profitable year at the East Malling Research Station in England where he was involved with research on growth regulators and other aspects of pomology. Dr. A. J. Hansen left Summerland in September on a transfer of work to Universidad Polytecnica, E.T.S.I.A., Valencia, Spain, where he will study basic aspects of virus diseases of tree fruits.

Products named in this report are not necessarily recommended for use, nor is there an implication that they have preference over other products which may be used for the same purpose.

Requests for details of research activities or for reprints should be made to individual scientists or to the Research Station, Research Branch, Agriculture Canada, Summerland, B.C. V0H 1Z0.

G. C. Russell
Director

# ENTOMOLOGY–PLANT PATHOLOGY

## Resistance of fruittree leafroller to azinphos-methyl

During the 1980 and 1981 seasons, orchardists in the East Kelowna district of the Okanagan valley reported poor control following the use of azinphos-methyl as a petal-fall spray for fruittree leafroller control. Overwintering eggs from the above orchards were collected and hatched in the laboratory and the larvae used in laboratory tests to determine if resistance had developed in this area. Compared with a susceptible leafroller strain, the larvae from East Kelowna showed an eightfold greater tolerance for azinphos-methyl. A similar degree of tolerance for other organophosphate compounds including diazinon and parathion and methomyl, a carbamate compound, was also present. The orchards where resistance has been reported are restricted to one area in East Kelowna, but field evidence indicates the problem is increasing in nearby areas.

Methidathion, azinphos-methyl, and methomyl also failed to provide satisfactory control in field experiments. The pyrethroid insecticides permethrin, fenvalerate, and WL-41706 also gave poor control. The *Bacillus thuringiensis* formulations Dipel and Thuricide, applied at the pink bud stage, gave the best control but applications at full bloom or at petal fall were considerably less effective. A combination of Dipel and azinphos-methyl was not better than Dipel alone.

## Mating disruption with codling moth sex pheromone

Codlemone, a synthetic sex pheromone of codling moth, at an hourly release rate of 10 mg/ha was evaluated as a method for controlling codling moth by male mating disruption. Pheromone emitters with three release rates were used in order to vary the number of release sites per plot; 13.3 $\mu$g/h (284 dispensers per plot); 6.6 $\mu$g/h (698 dispensers per plot); 3.3 $\mu$g/h (1285 dispensers per plot). Plot size was about 0.35 ha. During flight activity of first-brood moths, pheromone-baited traps caught an average of only 0.44 moth per trap weekly in the plot with 1285 dispensers compared with 12.31 moths per trap weekly in the untreated control plot. In the plots with 698 and 284 dispensers, traps caught an average of 2.08 and 5.27 moths per trap weekly. In July, following flight activity of first-brood moths, a large sample of apples from each of the plots was examined for codling moth larval infestation. There were no significant differences in the percentage of infested apples between the control and the

mating disruption plots. The level of infestation was approximately 50% in all plots.

In a separate experiment, rubber tubing was impregnated with 35 mg of codlemone and the release rate determined as 13.3 $\mu$g/h. A 0.5-ha block of trees was established as a mating disruption area which contained enough rubber tubes to achieve an hourly release rate of 10 mg/ha. Pheromone-baited traps in the mating disruption plot caught no moths, compared with 18.0 moths per trap weekly in the untreated control plot during flight activity of first-brood moths. In July, an evaluation of infested apples showed no differences between the mating disruption area and the control area. In both experiments, perfusion of the orchard environment with synthetic sex pheromone significantly reduced the ability of male moths to orient to sex pheromone in traps but did not prevent orientation of males to females and mating.

**Codling moth control on apples by sterile-insect release**

From 1976 to 1978, codling moth was controlled in 526 ha of apple and pear orchards in the Similkameen Valley by mass release of sexually sterilized codling moths. The degree of codling moth population suppression was sufficient that no additional control measures were required in 1979 and 1980. Continued monitoring of codling moth populations in the controlled area indicated the need for insecticide sprays for control of codling moth in approximately 20% of the orchards in 1981 and 80% of the orchards in 1982. The remaining orchards will probably have to be treated in 1983. The benefits and costs of control of codling moth by the sterile insect release method may therefore be amortized over a period of 4–6 yr depending upon the degree of initial population suppression and isolation from reinfestation.

**New insecticides for control of pear psylla**

SN 72129 50 WP at active ingredient levels (a.i.) of 250, 500, and 700 g/ha applied to pear trees on 10 and 24 June and 8 July provided excellent control of pear psylla and remained effective until leaf fall in October. The two lower rates had no effects on predators of pear psylla but the highest rate reduced numbers of predators by 50%. Two applications 23 July and 5 August with a.i. at 100, 150, and 200 g/ha provided excellent control at the highest rate but there was a marked decrease in effectiveness at the two lower rates. This suggests an optimum a.i. rate of 200–250 g/ha. Ripcord 20 WP applied with a.i. at 500 g/ha on 10 and 24 June and 8 July provided excellent control of pear psylla but the control persisted for only 4 wk after the last application and predators of pear psylla were almost totally eliminated. Three applications of BAY SIR 8514 on the above dates with a.i. at 500 g/ha provided poor control of pear psylla and also markedly reduced numbers of pear psylla predators.

**San Jose scale control**

Current control methods for San Jose scale usually include a dormant oil application at tight cluster bud stage followed later by diazinon sprays for control of emerging males and then crawlers. These measures have not proved to be completely satisfactory under typical orchard conditions because of the zero tolerance for this insect on apples destined for certain export markets.

Applications of methidathion 25 EC alone and in combination with dormant oil were compared with the standard dormant oil spray on Red Delicious and Winesap apple trees at the 15-mm green tip growth stage. Fruit infestation at harvest indicated that all rates of methidathion gave significantly better control ($P < 0.05$, Student–Newman–Keuls) than oil alone. Rates of application and mean percentages of infestation were as follows: oil (90 L/ha), 14.4%; methidathion (5.6 L/ha) and oil (45 L/ha), 0.58%; methidathion (11.2 L/ha) and oil (45 L/ha), 0.23%; methidathion (5.6 L/ha), 2.70%; methidathion (11.2 L/ha), 0.60%; and control (no treatment), 74.5%.

**Mite growth regulators for integrated mite control**

Two new acaricides, NC 21314 and BAY SLJ 0312, with growth regulatory properties were assessed on apple for control of European red mite and for effects on phytoseiid and stigmaeid mite predators. Applications were made at the tight cluster bud stage, at petal fall, and during the summer and compared with standard recommended treatments of dormant oil at the tight cluster bud stage and cyhexatin during the summer. All applications of BAY SLJ 0312 and NC 21314 (a.i. at 560 and 280 g/ha, respectively) provided effective control of European red mite. A single application of NC 21314 provided season-long control of

European red mite whereas dormant oil did not. As summer sprays, the growth regulators caused significantly less mortality of predaceous mites (SLJ 0312, 76%; NC 21314, 66%) than cyhexatin (94%).

### Control trials against resistant green peach aphids

One post-petal-fall spray of the synthetic pyrethroid insecticides deltamethrin 2.5 EC with a.i. at 15 g/ha or fenvalerate 30 EC at 125 g/ha effectively controlled organochlorine–organophosphate resistant green peach aphid on Early Redhaven and Fairhaven peaches. The above treatments were as effective as an application of Pirimor 50 WP, a carbamate, with a.i. at 500 g/ha. CGA 73102 40 EC, also a carbamate, with a.i. at 100 g/ha was less effective and at 50 g/ha gave poor control. The treatments were applied by hand gun sprayer in 2250 L of water per hectare against apterous and alate aphids. Respectively, these treatments reduced the numbers of aphids on leaf cluster samples by 96.5, 99.2, 99.7, 82.4, and 62.3% 7 days after treatment. None of the treatments adversely affected mite predators of European red mite or peach silver mite and none were phytotoxic.

### Apple replant problem

With the advent of second- and third-generation apple orchards in the Okanagan valley of British Columbia, many orchardists have experienced problems with orchard renewal. Poor growth of apple trees planted at sites of old trees is caused by growth-suppressive organisms associated with the old roots and lack of sufficient available phosphate. The most effective remedial treatments in field trials were fumigation with methyl bromide (680 g per site) or with a chloropicrin-containing mixture (Telone C 17 R at 30 g per site), or drenching with formalin (150–300 mL in 5–10 L water per site). Growth was further increased in all treatments by incorporating superphosphate fertilizer (100–200 g) in the soil at each site before planting.

### Biological control of crown rot of apple

Twenty-one strains of *Bacillus subtilis* were tested for antagonism to six strains of *Phytophthora cactorum* on cornmeal agar. All the *B. subtilis* strains produced diffusible antibiotics antagonistic to growth of *P. cactorum*. The 21 bacterium strains were further evaluated for ability to control crown rot infection by four of the *P. cactorum* strains on McIntosh seedlings grown in soil. Five of the bacterium isolates provided a marked degree of protection against infection by all four of the *P. cactorum* strains.

## FOOD PROCESSING

### Natural fruit spreads

In spite of the declining market for jam, there is considerable industry interest in fruit spreads that do not contain refined sugar or highly processed products such as high-fructose corn syrups. Tests using malt and honey as sweeteners have shown that at the normal soluble solids of jam (66–68%), the flavor of the sweetener overpowers the fruit. Reducing the soluble solids to the range of 50–55% and using honey as sweetener gives an acceptable product. Malt is not acceptable at any level, not only because of the flavor, but also because the high content of amino compounds leads to accelerated nonenzymic browning. Standard commercial pectin gives satisfactory gel at the lower solids level only if the pH is lowered to about 2.8; alternatively, a low-methoxyl pectin specially formulated for 50% solids can be used. Because of the low solids the product cannot be labeled jam and must be hot-filled and held under refrigeration after opening. Commercial production of apricot, raspberry, and strawberry spreads will commence shortly.

### Winemaking trials for evaluation of new grape varieties and selections

Wines from all the major experimental grape plantings in British Columbia are prepared at the Summerland Research Station. During an annual workshop, members of the wine industry participate in a 2-day evaluation of experimental wines, followed by a discussion of the horticultural and vinification characteristics of the most promising cultivars. From the Research Station plots of 1981, selections 65, 180, 347, 123, and 82 produced attractive wines. The plots of the British Columbia Ministry of Agriculture and Food produced the Vineland cultivars 53263 and 5020l, which were rated well for their neutrality. The best-received wines from the "Becker" experiment of the Association of British Columbia Grape Growers were Riesling, Ehrenfelser, Gewurtztraminer, Schoenberger, and Weissburgunder.

### Flame sterilization

Direct flame sterilization of canned food products holds considerable promise as a processing technique. However, process setting and monitoring present a problem with regard to sensing of the internal temperature in individual cans. A system was developed that is capable of accurate center temperature measurement in an ongoing process. A unique gland system was designed to introduce thermocouple leads into sealed cans. Testing against a system accepted by the industry, the Ecklund thermocouple gland at the laboratory bench indicated that the Agriculture Canada discontinuous contact system yielded center temperatures in excellent agreement with the standard. Without adjustment, agreement was essentially within 1°C and after statistical adjustment values obtained were ±0.1°C. The system was specifically designed for use with the Steriflamme Cooker, which is used in North America for processing mushrooms. The unit is undergoing field testing at a Canadian processing facility.

## POMOLOGY AND VITICULTURE

### Flesh browning of Delicious apples

The results from a 4-yr study indicated that flesh browning in controlled-atmosphere (CA) stored Delicious apples is a low-temperature storage injury. Incidence of the disorder was very low or absent in fruit stored at 3.3°C. However, injury in low-temperature CA storage could be reduced by certain prestorage treatments. Reduced incidence of flesh browning was obtained when apples were left at 20°C for 10 days, were dipped in a $CaCl_2$–Keltrol solution, or were subjected to a heat treatment before storage in standard CA conditions. A factorial trial with calcium, diphenylamine, and gibberellic acid dip solutions showed a beneficial effect from calcium on the reduction of the disorders. The $CO_2$ content in the storage atmosphere had no effect at the higher storage temperatures but at lower temperatures less browning was observed with reduced $CO_2$ levels. Flesh browning was more prevalent with advanced maturity of the fruit and regression analysis of parameters evaluated at harvest showed fruit size and, to a lesser degree, the presence of watercore to be important factors.

### Winterhardiness of peaches

The mechanism of seasonal fluctuation in hardiness of peach flower buds has been determined. The flower primordia within the overwintering peach bud survive in the supercooled state throughout the winter. At some critical temperatures the supercooled tissue suddenly and lethally freezes. The supercooling depends on the bud water content. When the temperature is below freezing, water is lost to preferred sites of freezing within the flower bud scales and by sublimation to the environment. The supercooling point drops and the flower bud hardens. At temperatures above freezing the flower primordial tissue regains turgor by water transfer from other parts of the plant, the supercooling point rises, and hardiness is lost. The flower primordia remain supercooled because a dry region forms within the vascular tissue which prevents the spread of the ice boundary in the supercooled region. The supercooling response also explains differences in varietal response. The flower primordia of Siberian C (a hardy cultivar) had a lower supercooling point than Redhaven (less hardy) at equivalent moisture content.

### Use of gibberellic acid to thin de Chaunac grapes

Vine sprays of gibberellic acid ($GA_3$) applied at the 80% full bloom stage reduced berry set in 1981 and 1982 experiments. The remaining berries were heavier and higher in total soluble solids content. Sprays applied 1 wk later were much less effective. This procedure reduced vine yields in 1981 but not in 1982. Testing continues with the aim of developing an inexpensive and reliable chemical thinning technique for wine grapes.

### Calcium uptake by apples as influenced by growth activators

One-year-old Spartan and Delicious apple trees on four clonal rootstocks were cut to three scion nodes and transferred to an aerated Long Ashton full nutrient solution containing $^{45}Ca$. Treating the axillary buds with 6-benzyladenine plus gibberellic acid (6-BA + $GA_3$) resulted in a small increase in number, fresh weight, and total length of new shoots. Total area of new leaves per tree was unaltered. The 6-BA + $GA_3$ treatment significantly reduced the $^{45}Ca$ content of the new shoots fraction and the total amount of $^{45}Ca$ absorbed by the treated trees.

Spartan apple absorbed and transported more $^{45}Ca$ than Delicious. Of the rootstocks, MM 111 was less efficient than M 26, M 7, or MM 106 in transporting $^{45}Ca$ across the graft union to either scion cultivar. Growth regulator-treated trees on M 26 roots absorbed significantly less $^{45}Ca$ than comparably treated trees on MM 106 or MM 111 roots.

**Pollenizers**

Crab apples were selected in 1981 with the objective of obtaining a series of pollenizers for apples which would bloom at dates ranging from early to late. Those chosen and the commercial variety they bloom with are: for McIntosh—Dolgo, Garry, Garnet, Strathmore; for Golden Delicious—*Malus baccata*, Mandschurica, Flame, 55-74-02; for Red Delicious—Makamik, Hopa, *Malus scheideckeri*, Leslie. As part of the same project and to investigate the importance of pollenizers, apples were collected from throughout the producing areas. Fruit size and seed numbers were correlated. The results showed that when good pollination (eight seeds per apple) had been achieved, average yield was increased by 25% compared with yield when marginal pollination (three seeds per apple) was achieved because of increased fruit weight. The correlation, however, accounted for only 15% of the variability.

**Orchard soil management and soil temperatures**

A long-term trial with apple trees under five orchard floor management systems has indicated that soil temperatures are strongly influenced by the soil cover. Temperatures have been recorded continually at 20 and 100 cm under a grass sod, a surface kept free from vegetation with herbicides, a surface tilled frequently, and a black plastic mulch. During June 1982, when the warmest soil temperatures were recorded, the average temperature at 20 cm under plastic mulch was 3.9°C higher than under the grass sod. Temperatures under the chemically treated surface and the tilled surface were 2.2 and 2.3°C warmer, respectively, than under the grassed surface. At the 100-cm depth, the average temperatures were 3.2°C higher under plastic, 2.6°C higher under chemically treated soil, and 2.1°C higher under tilled soil than under the grassed surface. During the month with the coldest soil temperatures, January 1983, the average soil temperature at 20 cm was 0.15°C under plastic, 0.8°C under the surface kept clean with chemicals, 1.5°C under the tilled surface, and 2.6°C under the grass sod. At 100 cm the differences between the four treatments were small.

A lower winter soil temperature and a higher initial cost appear to be the main disadvantages of the black plastic mulch as an orchard soil management system which otherwise offers several distinct advantages, namely removal of competition from weeds without the potential hazard of chemicals, greater soil moisture conservation leading to lower irrigation need, and reduced leaching of nutrients and higher root zone soil temperatures for better root growth.

**Peach tree training**

Early Redhaven peaches on Siberian C seedling rootstocks were planted in 1974 to compare the effects of angle planting and palmette training with standard vertical planting and open-center training. Both were spaced 3.7 m × 4.8 m (560 trees per hectare). Cumulative marketable yields from 1974 to 1981 were 73.4 t/ha for angle-planted trees compared with 66.6 t/ha for the open-centered trees. Mean tree height was 2.5 m for angled trees, with new growth and fruiting wood well distributed over the entire tree, to 4.0 m for the open-centered trees, with new growth and fruiting wood restricted to the canopy area from 1.5 m from the ground to the tops of the trees. All operations such as pruning, thinning, and harvesting are convenient from the ground in the angled trees, whereas ladders are becoming essential in the open-centered trees.

## SOIL SCIENCE AND AGRICULTURAL ENGINEERING

**Grape growing under plastic mulch**

Statistically independent of N fertilizer treatments, yields of Foch grapes were 9.1, 6.4, and 3.4 kg per vine grown in plastic-mulched, herbicide-treated, and grassed ground, respectively. Using grass cover as the base level, the yields translate into 2.6 times as high for the plastic cover, and 1.8 times for the herbicide. Yield from the plastic treatment was 1.4 times that from the herbicide treatment. Yield from plastic-mulched soil with the lowest level of N was 1.6 times the yield from the grass with the highest level of

N. The independent effects of N on yields were not significant. The ground cover treatments had no significant effects on berry quality but the higher levels of N lowered the berry quality for wine making. The significance of these results is the possibility of improving grape yields without the use of heavy applications of N fertilizers which tend to reduce the quality of the fruit.

**Drainage flows in irrigated lysimeters**

For the year 1 October 1981 to 30 September 1982, irrigation water was applied to lysimeters at 100% of normal for Summerland (previous years have been at less than 100%). Irrigation for the season was at 1352 mm on the sandy loam and 1448 mm on the silt loam. Precipitation for the year was 359 mm.

Drainage from the sandy soil increased to almost 50% of the irrigation water and to about 37% of irrigation plus precipitation. The recent lack of difference between drainage from grassed and cultivated surfaces with the now-mature trees continued, in sharp contrast to earlier years when considerably more water appeared as drainage from cultivated plots than from grassed ones. The effect of the grass has largely disappeared.

For the first time drainage from the silt soil became substantial and averaged about 28% of the irrigation or 20% of irrigation plus precipitation. For some unknown reason, two of the lysimeters with silt soil still produced very little drainage. Also, for reasons as yet not explainable the grassed lysimeters produced significantly more drainage than the cultivated ones. That result may be the effect of grass on infiltration rates, but the return flows for the year were 24% under grass and 15% under cultivation.

**Foliar zinc applications**

In a series of laboratory experiments, open-pollinated McIntosh apple seedlings were grown in zinc (Zn) free Long Ashton solution and growth responses were measured after foliar application of chelated and $ZnSO_4$ sprays. No significant growth differences were measured between any form of Zn when equal amounts of elemental Zn were applied. The amount of Zn applied was thus more important than its chemical formulation, foliar sprays containing Zn at 4000 $\mu$g/mL being sufficient to support adequate seedling growth for a month whereas 500-$\mu$g/mL foliar sprays were not. Midterminal dry-weight leaf Zn was not a good measure of seedling response, since no significant differences were measured between leaf Zn content of deficient and vigorously growing seedlings.

**Variation in orchard soil pH**

Soil pH variation was examined in 23 British Columbia apple orchards. Soil pH tended to increase as distance from the tree trunk and depth from the soil surface increased. However, pH variation from tree to tree was frequently significant both for widely separated trees in orchards where pH was expected to be variable and for adjacent trees in orchards expected to have uniform soil pH. Tree-to-tree soil pH variations as high as 3.3 units were measured in some orchards. Therefore, to sample orchards adequately for measurement of soil pH, emphasis should be placed upon collecting samples from 10 or more trees widely separated within an orchard rather than detailed sampling around a few trees. Nevertheless, the possibility of decreased soil pH near trees cannot be ignored in sampling individual trees (which might be exhibiting poor growth). For these trees, compositing 5–10 samples at the 0–15-cm depth within 2.5 m of the tree trunk around the tree should be sufficient to characterize the pH of the main tree rooting zone.

**Cherry picker**

A hand-held cherry picker adapted from a sheep shearer underwent harvest trials at the Research Station. The 2-kg unit was electrically driven and required an orchard machine (Girette) for a power source. It made possible a picking rate about twice as fast as hand picking but was fatiguing to use and caused five times as much leaf loss. It sheared the stems individually, eliminating the need for a cluster cutter in the packinghouse. Overall, the machine functioned reliably with no breakdowns.

**Tree injection**

Analysis of apples from the 1981 trunk injection trials showed marginal increases in Ca that were not significant at the 0.5 level. In 1982 more concentrated (5%) $CaCl_2$ solutions were tried but again the effects were not significant. The surprising increase in Zn found in the 1981 injections was not present in the 1982 trials in which Zn levels were

generally high in all the fruit. The concentrated injections used in 1982 were hard on the trees, causing considerable leaf burn and fruit loss. Injection times were found to correlate well with wood density. A gravity feed injection technique worked well, introducing a large amount of a dilute solution into the tree over a 1-wk period and causing only minor leaf burn and fruit loss.

### Electrostatic sprayer evaluation

A commercial air blast sprayer which imparts an electrostatic charge to spray droplets was evaluated to determine whether the charging had any effects upon droplet size distribution, quantity of deposition, or uniformity of spray distribution within leaves or within trees. Two separate tests using a fluorescent dye to trace the spray deposits failed to reveal any consistent differences between spraying with and without charged droplets.

Subsequent measurements of the electrostatic charge being imparted to the spray cloud revealed that the charge was substantially lower than required for effective electrostatic spraying and persisted for only a short period after the beginning of sprayer operation.

Electrostatic spraying has been shown to increase spray deposition effectiveness dramatically when used with ground crops in other areas. This method has a tremendous potential for use with orchard sprayers but improvements to the present apparatus are required.

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# Research Station
# Vancouver, British Columbia

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| S. Y. S. Szeto, B.Sc., M.Sc. | Pesticide chemistry |
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# INTRODUCTION

This 20th annual report of the Vancouver Research Station summarizes aspects of our dual function, as national center for plant virus research, and responsibility for regional problems in plant pathology and entomology.

In the new program of biotechnology, production of monoclonal antibodies will result in more accurate diagnosis of bacterial ring rot of potato and the major virus diseases of several crops. Research on complementary DNA will facilitate diagnosis of diseases caused by viroids such as potato spindle tuber. These new methods should enable us to retain or regain access to export markets for these crops.

Dr. Robert Martin has joined our staff to continue research on virus diseases of strawberries. Dr. H. Daubeny spent several months in Australia, helping to establish a small-fruit breeding program. Dr. H. Pepin is on a year's transfer-of-work in Scotland. Foreign scientists working at the Station included Dr. S. Marco from Israel, Mr. G. Guy from Australia, and Dr. G. Naumann from West Germany.

Further details of research, or reprints of this report or publications listed can be obtained from the scientists or the Research Station, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub
Director

# VIRUS CHEMISTRY AND PHYSIOLOGY

## Biotechnology

Monoclonal antibodies were prepared for strain differentiation and for detection of fine structural relationships among viruses.

Eight monoclonal antibodies against the type bean strain of southern bean mosaic virus (SBMV-B) were tested in indirect enzyme-linked immunosorbent assay (ELISA) experiments in which the plates were coated with SBMV-B in the form of native virion, swollen virion, and dissociated protein. Three of these antibodies reacted predominantly with the protein and two were equally reactive with all three antigens. The three remaining antibodies reacted predominantly with the native virion. These last three antibodies were the only ones that reacted in gel diffusion tests, and in these tests they were specific for native virions of strains infecting beans (type-, Mexican-, Arkansas-strain); they did not react with native virions infecting cowpea (type-, Ghana-strain).

## Physical, chemical, and serological properties of viruses in vitro

The amino acid sequence of the coat protein peptides of SBMV were determined and the information was supplemented by a 2.8-Å-resolution electron-density map, which enables assigning absolute positions to each peptide. Four amino acids and the placement of one heptapeptide near the amino terminus of the protein were interpolated by comparison with the partially known southern bean mosaic virus RNA sequence. The subunit is heavily lined with basic residues on the side facing the RNA. Subunit–subunit interactions are hydrophobic and ionic. The calcium site on the quasi-threefold axis has three glutamic residues as ligands. There is a disulfide bond, between Cys 168 and 176, within a sequence which is almost identical to that of the tomato bushy stunt virus. This portion is a helix nesting between the "$\beta$-barrel" subunit structure and the RNA interior.

SBMV was swollen by treatment with EDTA at pH 7.5 and dissociated into RNA and protein in 1 *M* NaCl. Aliquots of this preparation were diluted in varying concentrations of NaCl. When the NaCl molarity exceeded 0.6 *M* the preparations contained RNA with approximately six protein subunits per SBMV RNA molecule. At 0.5–0.1 *M*, protein content increased from 30 to 145 protein subunits per RNA molecule. Similar components were assembled when preparations of RNA and protein dissociated from SBMV by dialysis in neutral buffers containing EDTA and 1 *M* NaCl were diluted to

lower NaCl molarities. When SBMV was swollen by treatment with EDTA and dissociated in various concentrations of NaCl, the components formed were similar to those obtained by assembly in the same NaCl molarities. Preparations in the pH 7.5 buffer contained single components with specific sedimentation constants.

**Virus infections**

So far, the most potent, naturally occurring inhibitors of virus establishment seemed to be restricted to a single taxonomic plant group, Engler's order Centrospermae. Although present in widely different species within this group, these components constitute a separate class of small proteins (see Report 1975). We now have isolated an inhibitor from *Begonia*, in the order Violales, which on the basis of its mode of action, composition, molecular weight, active group, and lysine content must also be placed in this class, although its proline content is considerably higher.

**Biological properties of viruses**

Replication of the cowpea strain (CP) of SBMV in inoculated primary leaves of French bean, cultivar Pinto, a host considered immune to the virus, was detected by infectivity assay and serologically specific electron microscopy (SSEM) of leaf extracts. No obvious symptoms were induced in French beans. However, local necrotic lesions were induced by SBMV-CP in this host when primary leaves were inoculated simultaneously or sequentially with the legume strain of tobacco mosaic virus.

The host range of the hypertrophic mitochondrial virus (HMV) originally obtained from Virginia crab apple was previously restricted to *Chenopodium quinoa* and *C. amaranticolor*. A systematic search expanded this range to five additional species in three plant families, including two suitable for propagation, French bean and *Nicotiana benthamiana*, and one effective local lesion host, *C. capitatum*.

**Ultrastructural responses to virus infections**

The cytopathological effect of HMV, which gave rise to its name, has so far been reported only in mesophyll cells that eventually become necrotic. It is now established that nonnecrotizing cells of stem tissue of HMV-infected *C. quinoa* plants also contain giant mitochondria. In addition, giant mitochondria, predominantly of the pleomorphic or branched type, were found in infected tissue from three of the five new hosts established for this virus. These tissues also contained x-bodies with large accumulations of electron dense, viroplasmlike material. Particles of HMV were detected in the plasmodesmata of two species.

**Virus transmission by seed and pollen**

Infectivity and serological assays of washings of pollen produced by necrotic ringspot virus (NRSV)-infected sweet cherry indicated that the virus was present on the surface of the pollen. Further evidence of surface contamination was provided by the observation that pollen from infected trees tended to adsorb latex particles conjugated with NRSV antibodies, whereas little or no adsorption of conjugated latex was observed on pollen from virus-free trees. The role of the surface-borne virions in the tree-to-tree transmission of NRSV is being investigated.

**Aster yellows disease**

Calli prepared from explants infected with aster yellows (AY) from British Columbia were compared (in Vancouver and in California) with calli from infected material from California. The former consistently failed to produce in vitro the "AY spiroplasma" described by Maramorosch and Kondo and by Raju et al. However, calli from the California material produced in vitro cultures of spiroplasms. This confirms Bove's assumptions that "AY spiroplasma" may be either *Spiroplasma citri* or one of its mutants, carried as a contaminant by the AY vector in California. The possibility also exists that the structures reported by us earlier as having been isolated and cultured from AY-infected tissue may be the disease agent.

**Little cherry disease**

The procedure to isolate phloem-bound filamentous particles associated with little cherry disease (LCD) directly from cherry leaves and a number of physical–chemical properties of the purified viruslike particles (VLP) were published. Subsequently, the small amounts of purified VLP available were used to establish a buoyant density of 1.34

g/mL, which supports a nucleoprotein composition, and to produce a homologous antiserum in mice with a titer of 1200, based on SSEM tests.

The development of a silver stain method for detecting ds-RNA following polyacrylamide gel electrophoresis, coupled with an improved isolation procedure, has resulted in reproducible recovery of small amounts of ds-RNA from LCD cherry tissue. Its association with LCD was further strengthened by the finding that the ds-RNA of apple chlorotic leaf spot virus, a common virus in cherry, was distinctly different. A comparison with ds-RNA of prunus necrotic ringspot virus, another common cherry virus, is in progress.

## PLANT PATHOLOGY

### Virology

The double sandwich ELISA (DSE) and the indirect ELISA (IE) were compared for their sensitivity and specificity in detecting potato leafroll virus (PLRV) and beet western yellows virus (BWYV). Using either pure virus preparations or plant extracts in DSE, detection of both viruses could be achieved by using their homologous antisera but not when the heterologous antisera were used. A higher sensitivity of IE as compared to DSE was observed with purified PLRV. It was also possible to detect purified BWYV by using PLRV antiserum but no detection of PLRV could be achieved with BWYV antiserum.

The ELISA technique was used to index about 400 *Prunus* trees at the University of British Columbia budwood orchard for the presence of prunus necrotic ringspot virus during 1982. The test was successful in detecting eight infected trees. The same technique was used to test the F12/1 understock at a major nursery in British Columbia. Of 760 samples tested, 23 were infected.

### Virus-free potatoes

The current virus-free collection consists of 112 named cultivars and 53 numbered seedlings. Visual inspections and laboratory tests confirmed freedom from all known viruses and viroids. The following number of samples were distributed as indicated in 1981–1982: British Columbia (42), Alberta (8), Manitoba (35), Ontario (30), New Brunswick (66), Prince Edward Island (14), USA (77), Australia (6), Peoples Republic of China (3), and Korea (4).

The 1982 survey for PVX and PVS involved 47 ha of Elite seed on four farms in Cariboo and 168 ha of Elite and Foundation seed on 20 farms in Pemberton. Two farms (23.5 ha) in Cariboo and 18 (157.8 ha) in Pemberton were free from both viruses. All four farms in Cariboo were free from PVX, one had up to 2.2% and the other had up to 41% PVS. In Pemberton, one farm had 3.4–9.7% PVX in 4 ha and another had up to 2.2% PVS in 6.4 ha.

A survey of fields in the Fraser Valley and Kootenay areas that had been planted with seed grown in Cariboo or Pemberton in 1981 revealed very low incidence of PVX and PVS. Six fields (13 ha) planted with Cariboo seed had 0–1.2% PVX and 0–11.0% PVS. Eleven (58.5 ha) of 12 fields (59.5 ha) planted with Pemberton seed were free from both viruses; the other had 0.8% PVS.

### Small fruits

*Strawberry.* Limited field surveys by aphid transmission to virus indicators of aphid-borne strawberry viruses in the Fraser Valley have shown that strawberry mottle virus (SMV), strawberry veinbanding virus (SVBV), and strawberry mild yellow-edge virus (SMYEV) occur in the Fraser Valley. Of 35 field-grown strawberry plants indexed, 30, 8, and 4 were infected with SMV, SVBV, and SMYEV, respectively. We have not found strawberry crinkle virus in the limited survey.

In the strawberry breeding program, five new selections were made from about 2000 seedlings. These selections are now being indexed for virus content, and heat treatment combined with meristem culture will be used where required to obtain virus-free clones. The selection under code number 69-5-34 is now being propagated on a commercial basis. It is expected to be an alternative to Totem, with as much or more virus tolerance, winter-hardiness, and an earlier ripening season than Totem. Adaptation to machine harvesting is being investigated on two progenies and one appears to be promising in both Pacific northwest and eastern conditions.

*Raspberry.* In a survey of commercial plantings, raspberry bushy dwarf virus (RBDV), tobacco streak virus (TSV), and tomato ringspot virus (TomRSV) were detected in one or more fields in Washington. RBDV was not detected in commercial plantings in British Columbia, but one planting with TSV and another with TomRSV were

detected. Another virus, as yet unidentified, was detected in both Washington and British Columbia. Raspberry cultivars and selections at Puyallup, WA, and Abbotsford, B.C., were surveyed for sap transmissible viruses. The three viruses that were isolated and identified were raspberry bushy dwarf, tobacco streak, and black raspberry necrosis. One clone, Brandywine, contained a sap-transmissible virus that has not yet been identified.

### Bacteriology

*Erwinia carotovora* populations were monitored in Pemberton potato fields during 1981 and 1982. The results indicate that populations of this bacterium in potato field soil are generally low during the growing season but develop into high levels after vines are top-killed. Populations continued to increase after tubers were harvested and the bacterium could be isolated from potato field soil samples obtained during the winter months. A single serotype of *E. carotovora* was also isolated from the Lillooet River in the Pemberton Valley but the serotype did not correspond to any found on potatoes in Pemberton.

In an attempt to develop monoclonal antibodies that can be used in a serological test for detection of all *E. carotovora* strains, the presence of common protein antigens was studied by polyacrylamide gel electrophoresis. Several common proteins were observed but monoclonal antibodies produced toward one of these did not react serologically with whole cells.

An agar immunodiffusion procedure was evaluated as a confirmatory test for bacterial ringrot diagnosis in potato and found to be as satisfactory as immunofluorescence but simpler to perform. Certain laboratory strains that have non-mucoid colony morphologies and have not been found in naturally infected samples in British Columbia did not react in immunodiffusion, however.

### Nematology

The interaction of the alfalfa stem nematode *Ditylenchus dipsaci* and a wilt fungus, *Verticillium albo-atrum*, on alfalfa is being studied. Greenhouse experiments indicate that nematode infection increases the severity of wilt symptoms on a wilt-susceptible cultivar, Vernal, but not on a wilt-resistant cultivar, Maris Kabul. Multiplication of nematodes and severity of nematode damage were not increased in presence of the fungus. Field experiments are under way to determine the extent of this interaction. The response of 14 commercial strawberry cultivars to infection by root-lesion nematode, *Pratylenchus penetrans*, was studied in the greenhouse. Hood and Tyee showed a degree of tolerance, whereas Rainier and Micmac were relatively resistant. A field study with 18 cultivars has been initiated.

Chemical control studies of root-lesion nematode infecting raspberry plants showed that drenches of oxamyl with active ingredient (a.i.) at 1 kg/ha, three times in the fall at 1-mo intervals, and once in March with a.i. at 3 kg/ha, achieved significantly better control than one application of granular aldicarb with a.i. at 8 kg/ha in a mature planting. Greenhouse experiments showed that dipping raspberry roots in solutions of phenamiphos, oxamyl, or carbofuran was a very effective preplant treatment and achieved over 95% nematode control in the roots. The efficacy of the granular formulations of the same compounds in the field at planting time is being assessed.

## ENTOMOLOGY

### Vectors

*Little cherry disease.* There were 195 transfer tests of LCD-associated inclusions done with over 3500 individual apple mealybugs. Of the 90 receiver trees assayed so far by electron microscopy, only one tree was positive for transfer of inclusions and two were possibles.

Evidence was obtained by bioassay that LCD occurs in the Chilliwack area of the lower Fraser Valley. Two trees from that area indexed to bearing Lamberts in 1981 showed suspicious fruit symptoms in 1982, produced red-leaf symptoms on "Sam" indicator trees, and had LCD-associated inclusions in their leaf petioles.

*Aphid survey.* New records brought the number of known aphid species in British Columbia to 341. Aphids have now been collected from 709 different host plants and the total number of aphid–host plant associations is 1298.

The lettuce aphid, *Nasonovia ribisnigri* (Mosley), is now a serious pest of lettuce in the Cloverdale area of British Columbia,

where growers continue to suffer severe economic losses (up to 25% of the plantings).

*Morphology and fine structure.* The histology and fine structure of the mouthparts, salivary glands, and gut were studied in a continuing search for LCD-associated inclusions in the putative vector, the apple mealybug.

Examination of the capitate trichoid sensilla of the strawberry aphid by scanning and transmission electron microscopy indicated that they are chemoreceptors.

*Aphid ecology.* The rate of hatch of field-collected eggs of the strawberry aphid was determined in the laboratory, a requisite to developing a model to predict the time of egg hatch in the field. The rate of development, fecundity, weight gain, and longevity of *Fimbriaphis fimbriata* Richards were determined at various temperatures. Methods of sampling the aphids and their natural predators were developed for monitoring purposes and to gather field data to be used to validate the models of the population dynamics of these vectors of strawberry virus diseases.

*Aphid vector–virus relationships.* New isolates of beet western yellows virus (BWYV) from sugar beet were transmitted by the green peach aphid to virus-free Netted Gem potato and back to the indicator *Physalis floridana* with good symptom expression. Enzyme-linked immunosorbent assays (ELISA) using antisera from California and Germany verified the presence of BWYV in the sugar beets and indicator plants, and ELISA for potato leaf-roll virus (PLRV) using antiserum from Vancouver were negative for PLRV in the indicator plants.

**Pest control**

*Pests of small fruits.* Two more species of leafrollers were identified from blueberries; one of these, *Archips rosanus* (L.), was common and injurious. Sprays applied against the leafroller complex on blueberries showed that permethrin, decamethrin, parathion, azinphos-methyl, and diazinon are more effective than malathion, carbaryl, and methoxychlor.

Post-blossom sprinkler applications of diazinon with a.i. at 3.4 kg/ha significantly reduced the numbers of cranberry girdler moths caught in pheromone traps. Canopy sprays of permethrin, decamethrin, cypermethrin, and carbofuran also controlled second-generation larvae of the blackheaded fireworm.

*Lettuce aphid.* Control of the lettuce aphid was achieved with a preheading foliar spray of methamidophos or demeton. The unregistered compound pirimicarb also gave adequate control. Disulfoton applied as a granular treatment or soil drench at seeding did not provide adequate control, but when a preheading foliar spray was applied, control was excellent.

*Asparagus aphid, Brachycolus asparagi Mordvilko.* In 1981, asparagus plots treated three times with methamidophos or once with disulfoton to control asparagus aphids had up to 32% higher yields than the untreated plots. Field experiments in 1982 again showed that disulfoton and oxydemeton-methyl were the best insecticides tested when applied with a.i. at 1.12 kg/ha. Residue analyses of the disulfoton-treated plants showed no carryover into the following year's spears.

*Pests of brassica crops.* Of the three insecticides currently recommended for control of cabbage maggots in British Columbia, only chlorfenvinphos gave season-long protection from cabbage maggots on cauliflower and broccoli. Experimental chemicals with efficacy equivalent to that of chlorfenvinphos were BAS 263, CGA 73102, chlorpyrifos, and FMC 35001.

Of seven insecticides tested, dimethoate and the unregistered aphicide pirimicarb gave the best control of green peach aphids on Brussels sprouts. Pirimicarb and dimethoate did not, however, control caterpillars. Decamethrin and BAY FCR 1272 did not control aphids but gave the longest lasting control of caterpillars.

*Weeds.* A study on the effect of the weevil *Rhinoncus pericarpus* (L.) on the weed curled dock was initiated. The larvae feed on the roots and crown and in heavy infestations will kill the plant. In laboratory tests, plants with six to eight leaves were killed with as few as 10 larvae. Eleven plants from a pasture averaged 4.5 larvae per root. Laboratory tests confirmed reports that this weevil will breed on rhubarb. Counts of tansy ragwort plants and eggs and larvae of the cinnabar moth at the Nanaimo release site showed that both plant and insect populations had declined for the 2nd yr. Although many hatched eggs were

found, no larvae were present, indicating heavy predation of the larvae. *Longitarsus jacobaeae* (Waterh.), whose larvae mine the roots and crowns, is well established at this site. The average number of larvae per plant was 17, a threefold increase over the number found in 1981.

### Residue chemistry

Gas chromatographic methods were developed to determine residues of dimethoate, pirimicarb, and their toxic metabolites in asparagus and lettuce resulting from the use of these insecticides for aphid control.

In asparagus, foliar sprays of dimethoate with a.i. at 1.0 kg/ha and pirimicarb with a.i. at 0.5 kg/ha were applied to control the asparagus aphid. Dimethoate was partially oxidized to dimethoxon. The total residues including the oxon persisted for about 20 days and decreased to less than 0.1 mg/kg after 40 days. Pirimicarb metabolized partially to its toxic methylamino-analogue. The total residues including toxic metabolites persisted for about 14 days and became negligible (<0.1 mg/kg) after 20 days.

In lettuce, foliar sprays of dimethoate (with a.i. at 0.15 and 0.30 kg/ha), pirimicarb (with a.i. at 0.14 and 0.28 kg/ha), and methamidophos (with a.i. at 0.45 and 0.90 kg/ha) were evaluated against the lettuce aphid. The residual life in descending order was methamidophos > dimethoate > pirimicarb. After two foliar applications at the high rates, the total residues in marketable heads were trace (<0.01 mg/kg), 0.14 mg/kg, and 0.23 mg/kg for pirimicarb, dimethoate, and methamidophos, respectively.

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# PROGRAM STRUCTURE OF THE RESEARCH BRANCH

## Departmental aim

The basic aim for Agriculture Canada, within the framework of overall government objectives and in cooperation with provincial governments, is to develop and assist the Canadian agricultural and food system, to provide for the needs of Canadians, for export markets, and for international aid commitments in a manner that ensures: (*a*) a dependable supply of safe, nutritious food at reasonable prices to consumers; and (*b*) equitable returns to producers and processors.

## Objectives and subobjectives

### LAND RESEARCH

To assist in ensuring the maintenance, availability, and better utilization of agricultural land to meet current and future agricultural and food production needs.

**1 Soil management and conservation**

To obtain an understanding of the properties that limit the productivity of selected soils.

**2 Land inventory and evaluation**

To obtain a reliable inventory of Canadian soils and to develop improved methods for their characterization, classification, and evaluation.

### WATER RESEARCH

To assist in more effective and efficient utilization of water resources for agricultural production.

**1 Irrigation, drainage, and desalinization**

To improve water management, irrigation, and drainage on Canadian soils in order to increase productivity.

**2 Agrometeorology**

To increase the use of climate resource information.

### ENERGY RESEARCH

To assist in the conservation, production, and utilization of energy throughout the food production system.

**1 Energy**

To improve on-farm production and the use and conservation of energy.

### ENVIRONMENTAL QUALITY RESEARCH

To minimize environmental hazards associated with agricultural production and practices.

**1 Environmental quality**

To develop agricultural management practices consistent with production and environmental requirements.

### ANIMAL PRODUCTION DEVELOPMENT RESEARCH

To improve the efficiency of production and the quality of animals in support of market development.

**1 Beef cattle**

To improve the efficiency of beef production and the quality of beef products.

**2 Dairy cattle**

To improve the efficiency of milk production.

**3 Swine**

To improve the efficiency of swine production and the quality of pork and pork products.

**4 Poultry**

To improve the efficiency of production of eggs and poultry meat and the quality of poultry products.

**5 Sheep**

To improve the efficiency of sheep production and the quality of mutton and lamb products.

**6 Other animals and bees**

To improve the efficiency of production of other animals and bees, and the quality of their products.

## CROP PRODUCTION DEVELOPMENT RESEARCH

To improve the efficiency of production and the quality of crops in support of market development.

**1 Wheat**

To increase production, protection, and utilization of wheat through multidisciplinary research.

**2 Other cereal crops**

To increase production, protection, and utilization of other cereal crops through multidisciplinary research.

**3 Oilseed crops**

To increase the efficiency of production, adaptability, and quality of oilseed crops and their products through multidisciplinary research.

**4 Forage crops**

To increase the efficiency of forage crop production systems and the quality of forage crops through multidisciplinary research.

**5 Horticultural crops**

To improve the efficiency of production and the quality of horticultural crops through multidisciplinary research.

**6 Field crops**

To improve the efficiency of production and quality of field crops such as tobacco, field peas, buckwheat, new crops, and field beans.

## PRODUCTION SUPPORT RESEARCH

To ensure the availability and development of basic support services necessary for food and agricultural production.

**1 Supportive research and development**

To provide research information on crops, animals, and soils.

**2 Protection**

To provide new general research information on the protection of crops from diseases, insects, and weeds.

**3 Biosystematics**

To clarify the taxonomy of and provide identification services for vascular plants, insects, arachnids, nematodes, and fungi found in Canada.

## FARM INPUT SUPPLY RESEARCH

To assist in ensuring the availability and quality of basic inputs to the food and agricultural production system.

**1 Machinery and structural research**

To provide information and technology needed for improving and better utilizing farm structures and machinery.

## INTERNATIONAL DEVELOPMENT

To assist developing countries, directly and through international organizations, in becoming more self-reliant in food supplies and to provide assistance during food crises.

## REGIONAL DEVELOPMENT

To facilitate development of the agri-food sector in each region—in accordance with its market potential—in collaboration with provincial government departments, federal departments, and nongovernmental organizations.

## PROCESSING RESEARCH

To promote increased technological innovation and efficiency in the processing sector.

**1 Processing technology**

To develop new food processing technology and to improve the efficiency and effectiveness of food processing systems, including background research on the chemical and physical changes that take place during processing, and evaluation at a pilot-plant scale, as required.

**2 New product development**

To develop and characterize useful new ingredients or products for presentation to private industry for evaluation and application, and to develop the technology required to produce them, including evaluation at a pilot-plant scale, as required.

## DISTRIBUTING—RESEARCH

To increase efficiency in the distribution sector.

**1 Stored products**

To improve the technology and effectiveness of off-farm storage of fresh fruits and vegetables, and to reduce losses in stored grains and oilseeds by controlling insects.

## FOOD QUALITY AND NUTRITION RESEARCH

To ensure safety, quality, and nutritive value of edible agricultural products.

**1 Food safety**

To increase consumer protection by conducting research to reduce antinutritional factors and microbiological and chemical contaminants in agricultural products and food.

**2 Nutrition**

To assist in improving the general level of nutrition of Canadian consumers.

## EXECUTIVE AND GENERAL MANAGEMENT

To provide managerial, financial, personnel, and administrative services required for the efficient management of the Department.

## TECHNICAL INFORMATION DISSEMINATION

To provide information on the agricultural and food system and ensure public awareness of Departmental programs.

# STRUCTURE DU PROGRAMME DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

## Objectif du Ministère

L'objectif fondamental d'Agriculture Canada, dans le cadre de l'ensemble des objectifs gouvernementaux et en collaboration avec les gouvernements provinciaux, est de développer le réseau agro-alimentaire canadien et de l'aider à répondre aux besoins des marchés national et étrangers, et à remplir ses engagements en matière d'aide international de manière à assurer: (*a*) aux consommateurs, un approvisionnement sûr d'aliments sains et nutritifs à prix raisonnable et (*b*) aux producteurs et aux transformateurs, une rémunération équitable.

## Objectifs et sous-objectifs

### TERRES

Contribuer à assurer le maintien, la disponibilité et l'utilisation optimale des terres agricoles de manière à répondre aux besoins actuels et futurs de la production agro-alimentaire.

**1 Utilisation et conservation des sols**

Parvenir à comprendre les propriétés qui limitent la productivité de certains sols.

**2 Inventaire et évaluation des terres**

Constituer un inventaire complet des sols canadiens et améliorer les méthodes permettant de les caractériser, de les classifier et de les évaluer.

### EAU

Contribuer à l'utilisation plus efficace des ressources hydriques en production agricole.

**1 Irrigation, drainage et dessalage**

Améliorer les techniques d'utilisation de l'eau, d'irrigation et de drainage des sols canadiens afin d'en augmenter la productivité.

**2 Agrométéorologie**

Accroître l'utilisation de l'information disponible sur les ressources climatiques.

### ÉNERGIE

Aider à la conservation, à la production et à l'utilisation de l'énergie dans tout le réseau de production alimentaire.

**1 Énergie**

Améliorer la production, l'utilisation et la conservation de l'énergie à la ferme.

### QUALITÉ DE L'ENVIRONNEMENT

Réduire au minimum les torts causés à l'environnement par les operations agricoles.

**1 Qualité de l'environnement**

Élaborer des modes de gestion agricole compatibles avec les exigences de la production et celles de la protection de l'environnement.

### DÉVELOPPEMENT DES PRODUCTIONS ANIMALES

Accroître l'efficacité de la production et améliorer la qualité des animaux de manière à favoriser l'expansion des marchés.

**1 Bovins de boucherie**

Accroître l'efficacité de la production bovine et améliorer la qualité des produits.

**2 Bovins laitiers**

Accroître l'efficacité de la production laitière.

**3 Porcs**

Accroître l'efficacité de la production porcine et améliorer la qualité de la viande et des produits dérivés.

**4 Volaille**

Accroître l'efficacité de la production d'oeufs et de volailles, et améliorer la qualité des produits avicoles.

**5 Moutons**

Accroître l'efficacité de l'élevage ovin et améliorer la qualité des produits du mouton et de l'agneau.

**6 Abeilles et autres animaux**

Accroître l'efficacité de la production des abeilles et autres animaux, et améliorer la qualité de leurs produits.

## DÉVELOPPEMENT DES PRODUCTIONS VÉGÉTALES

Accroître l'efficacité de la production et améliorer la qualité des cultures de manière à favoriser l'expansion des marchés.

**1 Blé**

Poursuivre des recherches pluridisciplinaires afin d'améliorer la production, la protection et l'utilisation du blé.

**2 Autres cultures céréalières**

Poursuivre des recherches pluridisciplinaires afin d'améliorer la production, la protection et l'utilisation des autres cultures céréalières.

**3 Oléagineux**

Mener des recherches pluridisciplinaires afin d'améliorer l'efficacité de la production, l'adaptabilité et la qualité des oléagineux et de leurs produits.

**4 Cultures fourragères**

Poursuivre des recherches pluridisciplinaires afin d'augmenter l'efficacité des systèmes de production des cultures fourragères ainsi que la qualité de ces dernières.

**5 Cultures horticoles**

Améliorer, par le biais de la recherche pluridisciplinaire, l'efficacité de la production et la qualité des cultures horticoles.

**6 Grandes cultures**

Améliorer l'efficacité de la production et la qualité des grandes cultures comme le tabac, le pois, le haricot, le sarrasin et les nouvelles cultures.

## APPUI À LA PRODUCTION

Assurer la mise au point et la disponibilité des services auxiliaires nécessaires à la production agro-alimentaire.

**1 Recherche et développement**

Fournir des données scientifiques sur les cultures, les animaux et les sols.

**2 Protection**

Fournir de nouvelles données scientifiques sur la protection des cultures contre les maladies, les insectes et les mauvaises herbes.

**3 Biosystématique**

Clarifier la taxonomie et assurer des services d'identification des plantes vasculaires, des insectes, des arachnides, des nématodes et des champignons du Canada.

## FACTEURS DE PRODUCTION AGRICOLE

Contribuer à assurer la disponibilité et la qualité des moyens de production fondamentaux au secteur agro-alimentaire.

**1 Machines et bâtiments agricoles**

Mettre au point les données et les techniques nécessaires à l'amélioration et à une meilleure utilisation des bâtiments et des machines agricoles.

## DÉVELOPPEMENT INTERNATIONAL

Aider les pays en voie de développement, directement ou par le truchement d'organismes internationaux, à devenir plus autosuffisants en matière d'alimentation et à leur venir en aide en cas de crises alimentaires.

## DÉVELOPPEMENT RÉGIONAL

Favoriser le développement du secteur agro-alimentaire dans chaque région—selon les capacités de leurs marchés—en collaboration avec les ministères des gouvernements provinciaux, les ministères fédéraux et les organismes non-gouvernementaux.

## TRANSFORMATION

Favoriser l'innovation technologique et l'efficacité dans le secteur de la transformation.

**1 Technologie de la transformation**

Élaborer de nouvelles techniques de transformation alimentaire et améliorer l'efficacité des systèmes existants, y compris la recherche de base sur les modifications chimiques et physiques que subissent les aliments au cours de la transformation, ainsi que leur évaluation en usine pilote, le cas échéant.

**2 Mise au point de nouveaux produits**

Mettre au point et caractériser de nouveaux ingrédients ou produits utiles en vue de les faire évaluer et fabriquer par le secteur privé et mettre au point également la technologie nécessaire à leur production, y compris l'évaluation en usine pilote, le cas échéant.

## DISTRIBUTION

Accroître l'efficacité du secteur de la distribution.

**1 Produits entreposés**

Améliorer les techniques et l'efficacité de l'entreposage des fruits et des légumes frais à l'extérieur de la ferme et réduire les pertes de céréales et d'oléagineux dans les entrepôts par une lutte soutenue contre les insectes.

## QUALITÉ ET VALEUR NUTRITIVE DES ALIMENTS

Voir à la salubrité, à la qualité et à la valeur nutritive des produits agricoles comestibles.

**1 Salubrité des aliments**

Augmenter la protection du consommateur par des recherches visant à réduire les facteurs antinutritionnels et les contaminants microbiologiques et chimiques dans les produits agricoles et les aliments.

**2 Nutrition**

Contribuer à améliorer en général le régime alimentaire du consommateur canadien.

## DIRECTION ET GESTION GÉNÉRALE

Fournir les services nécessaires dans les domaines de la gestion, des finances, du personnel et de l'administration afin d'assurer une gestion efficace du Ministère.

## DIFFUSION DE L'INFORMATION TECHNIQUE

Diffuser de l'information à l'intention du circuit agro-alimentaire et s'assurer que le public est au courant des programmes du Ministère.

DATE DUE
DATE DE RETOUR

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| MAR 2 | 1985 | | |
| MAY 2 4 | 1985 | | |
| APR AVR 25 | 1986 | | |
| MAR 1 9 | 2010 | | |

LOWE-MARTIN No. 1137