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1980

RAPPORT DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

AGRICULTURE CANADA

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Research
Branch Report

1980

Rapport de la
Direction générale
de la recherche

RESEARCH BRANCH
DIRECTION GÉNÉRALE DE LA RECHERCHE

AGRICULTURE CANADA

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Agriculture Canada
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CONTENTS

Executive of the Research Branch, v *L'exécutif de la Direction générale de la recherche*, v
Finance and Administration Division, vi *Division des affaires financières et administratives*, vi
Map of research establishments, vii *Carte des établissements de recherche*, vii
Organization of the Research Branch, viii *Organisation de la Direction générale de la recherche*, ix
Foreword, x *Avant-propos*, xi

INSTITUTES AND PROGRAM COORDINATION DIRECTORATE *DIRECTION DES INSTITUTS ET DE LA COORDINATION DU PROGRAMME*

Executive, 3 *L'exécutif*, 3

Preface, 4 *Préface*, 5

- Biosystematics Research Institute, 7
- Chemistry and Biology Research Institute, 25
- Engineering and Statistical Research Institute, 41
- Food Research Institute, 49
- Land Resource Research Institute, 61
- Research Program Service, 77

ATLANTIC REGION *RÉGION DE L'ATLANTIQUE*

Executive, 85 *L'exécutif*, 85

Preface, 86 *Préface*, 87

- St. John's West, Nfld., 89
- Charlottetown, P.E.I., 95
- Kentville, N.S., 105
- Fredericton, N.B., 121

QUEBEC REGION *RÉGION DU QUÉBEC*

Executive, 135 *L'exécutif*, 135

Preface, 137 *Préface*, 136

- Lennoxville, Québec, 139
- Sainte-Foy, Québec, 149
- Saint-Jean, Québec, 163

ONTARIO REGION *RÉGION DE L'ONTARIO*

Executive, 173 *L'exécutif*, 173

Preface, 174 *Préface*, 175

- Animal Research Centre 177
- London Research Centre 203
- Delhi, Ont., 215
- Harrow, Ont., 223
- Ottawa, Ont., 239
- Vineland Station, Ont., 257

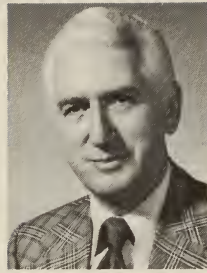
WESTERN REGION *RÉGION DE L'OUEST*

Executive, 269 *L'exécutif*, 269

Preface, 270 *Préface*, 271

- Brandon, Man., 273
- Morden, Man., 281
- Winnipeg, Man., 289
- Melfort, Sask., 303
- Regina, Sask., 309
- Saskatoon, Sask., 317
- Swift Current, Sask., 331
- Beaverlodge, Alta., 343
- Lacombe, Alta., 351
- Lethbridge, Alta., 361
- Agassiz, B.C., 385
- Kamloops, B.C., 391
- Saanichton Research and Plant Quarantine Station, B.C., 397
- Summerland, B.C., 403
- Vancouver, B.C., 413

Program Structure, 423 *Structure du programme*, 429



Dr. E. J. LeRoux



Dr. J. W. Morrison



Dr. E. E. Lister



Mr. J.-J. Jasmin



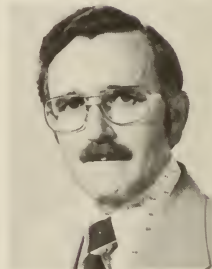
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Dr. A. A. Guitard



Dr. T. H. Anstey



Mr. J. E. Ryan

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Sous-ministre adjoint, recherche
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Directeur général, Direction des instituts et de la coordination du programme
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Director General, Atlantic Region
Directeur général, région de l'Atlantique
E. E. LISTER, B.Sc., M.Sc., Ph.D.

Director General, Quebec Region
Directeur général, région du Québec
J.-J. JASMIN, B.Sc. (Agr.), M.Sc.

Director General, Ontario Region
Directeur général, région de l'Ontario
J. J. CARTIER, B.A., B.Sc., Ph.D.

Director General, Western Region
Directeur général, région de l'Ouest
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Senior Adviser, International Research and Development
Conseiller principal, programmes internationaux de recherche et de développement
T. H. ANSTEY, B.S.A., M.S.A., Ph.D.

Director, Finance and Administration Division
Directeur, Division des affaires financières et administratives
J. E. RYAN, R.I.A.

FINANCE AND ADMINISTRATION DIVISION
DIVISION DES AFFAIRES FINANCIÈRES ET ADMINISTRATIVES

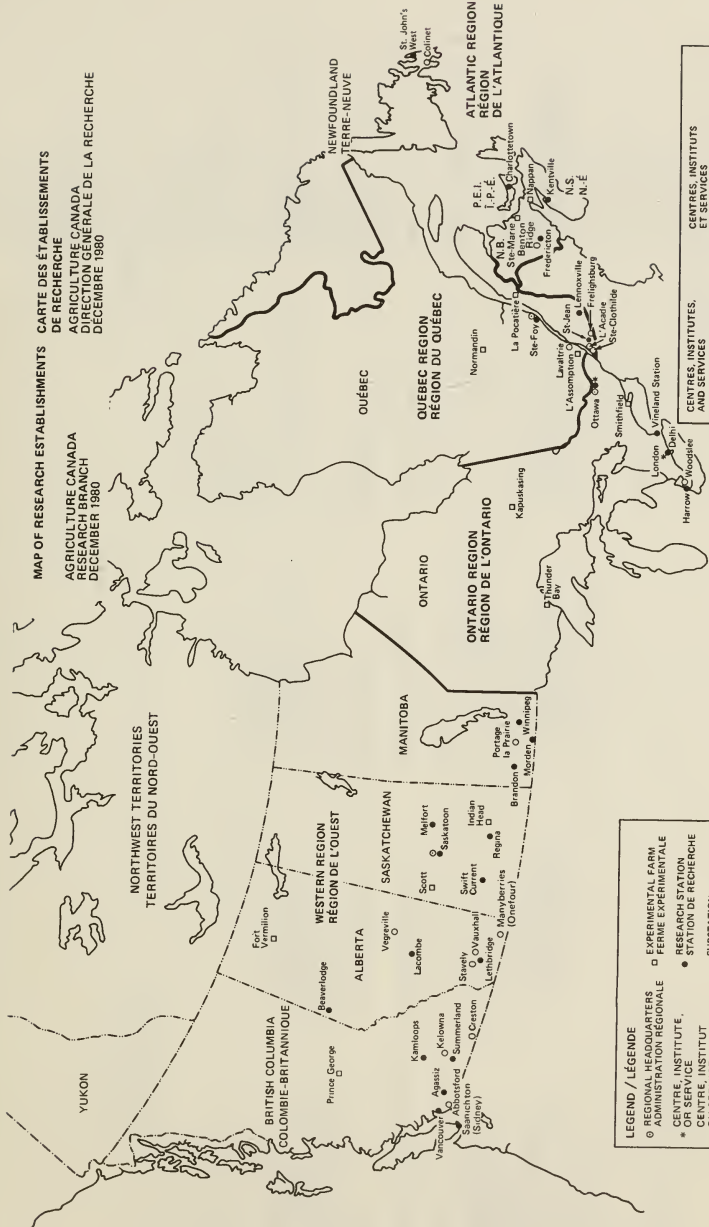
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Chief, Finance Section
Chef, Section des finances J. E. RENAUD, C.D.

Chief, Administration Section
Chef, Section de l'administration H. D. BRANNEN

MAP OF RESEARCH ESTABLISHMENTS
DE RECHERCHE
AGRICULTURE CANADA
RESEARCH BRANCH
DECEMBER 1980

CARTE DES ÉTABLISSEMENTS
DE RECHERCHE
AGRICULTURE CANADA
BRANCHE DE RECHERCHE
DÉCEMBRE 1980



LEGEND / LÉGENDE

- REGIONAL HEADQUARTERS / ADMINISTRATION RÉGIONALE
- EXPERIMENTAL FARM / FERME EXPÉRIMENTALE
- * CENTRE / INSTITUT
- RESEARCH STATION / STATION DE RECHERCHE
- SUBSTATION / SOUS-STATION

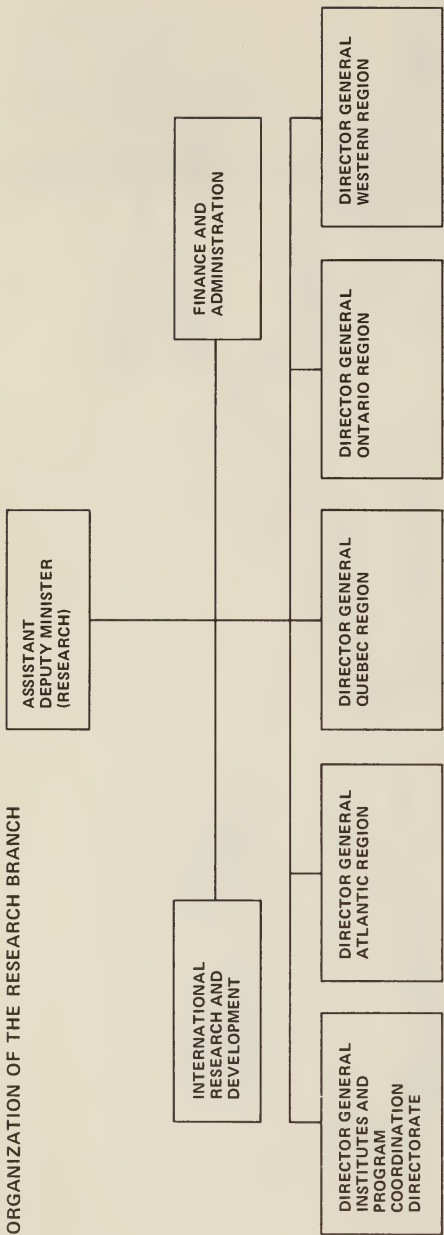
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CENTRES, INSTITUTS ET SERVICES

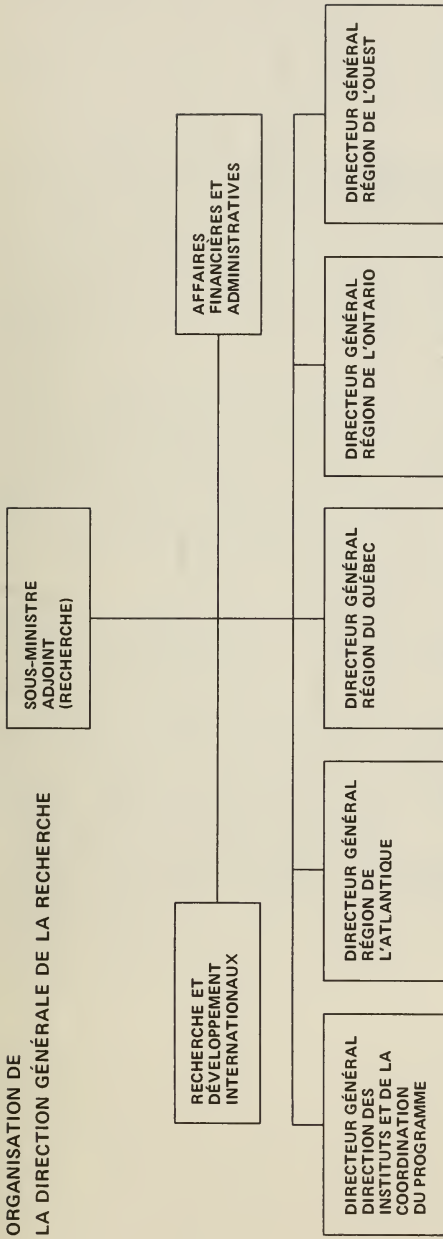
- Centre de recherche zootechnique
- Centre de recherche de London
- Animal Research Centre
- Biological Institute
- Chemistry and Biology Research Institute
- Food Science and Statistical Research Institute
- Land Resource Research Institute
- Research Program Service

ORGANIZATION OF THE RESEARCH BRANCH



- | | | | | |
|---|---|---|------------------------------------|---|
| Research Coordinators | Research Stations | Research Stations | Research Stations | Research Stations |
| Analysts | St. John's, West Nfld., Colinet, Nfld., Charlottetown, P.E.I., Kentville, N.S., Nappan, N.S., Fredericton, N.B., Benton Ridge, N.B., Sainte-Marie, N.B. | Lennoxville, Qué., Sainte-Foy, Qué., La Pocatière, Qué., Normandin, Qué., Saint-Jean, Qué., Frélichsburg, Qué., L'Acadie, Qué., L'Assomption, Qué., Lavaltrie, Qué., Sainte-Clothilde, Qué. | Animal, Ottawa, Ont., London, Ont. | Brandon, Man., Melton, Man., Portage la Prairie, Man., Winnipeg, Man., Melfort, Sask., Regina, Sask., Indian Head, Sask., Saskatoon, Sask., Yorkton, Sask., Swift Current, Sask., Beaverlodge, Alta., Fort Vermilion, Alta., Lacombe, Alta., Vegreville, Alta., Lethbridge, Alta., Onefour (Manyberries), Alta., Slavelty, Alta., Exshaw, 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., Okanogan, B.C., Kelowna, B.C., Vancouver, B.C. |
| Advisers | | | | |
| Research Institutes | | | | |
| Biosystematics
Chemistry and Biology
Engineering and Statistical
Food
Land Resource
Research Program Service | | | | |
| | | Research Centres | Research Stations | |
| | | Delhi, Ont., Harrow, Ont., Woodbrier, Ont., Okanogan, B.C., Kapuskasing, Ont., Thunder Bay, Ont., Vineland Station, Ont., Smithfield, Ont. | | |

**ORGANISATION DE
LA DIRECTION GÉNÉRALE DE LA RECHERCHE**



Coordonnateurs de la recherche

Analystes

Conseillers

Instituts de recherche

- 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 (I.-P.-É.)
- Kentville (N.-É.)
- Nappan (N.-É.)
- Fredericton (N.-B.)
- Benton Ridge (N.-B.)
- Sainte-Marie (N.-B.)

Stations de recherche

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

Centres de recherche

- London (Ont.)
- Zootecnie (Ottawa) (Ont.)

Stations de recherche

- Delhi (Ont.)
- Harrow (Ont.)
- Woodlee (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.)
- Stavelly (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.)

FOREWORD

The Research Branch of Agriculture Canada conducts about one-half of the agricultural research and development in Canada. It also cooperates with universities and industry by supporting research that augments the Branch's goals and objectives. The budget for 1980 was \$140 million, of which \$5 million was spent on contracted research. In 1980 the Branch staffed 3659 person-years, of which 918 were professional positions.

Branch Headquarters are located at the Central Experimental Farm, Ottawa. A reorganization of the Research Branch became effective on 25 August 1980. A new directorate and three new regions were established on that date, by reorganizing the administration of the former Central and Eastern regions and by renaming two institutes. The mandate of the Western Region remains unchanged from that given it in 1978.

Dr. J. W. Morrison was named Director General of the new Institutes and Program Coordination Directorate. He now assumes responsibility for the institutes in Ottawa and for Research Program Service, all formerly administered by the Central Region, while retaining his control over the Branch's research coordinators.

The Animal Research and London Research institutes have been renamed centres and are now under the direction of Dr. J. J. Cartier, Director General for the new Ontario Region. As well as the two research centres, Dr. Cartier also assumes responsibility for all the stations and experimental farms formerly located in the Central Region.

Two new regions, the Atlantic Region and the Quebec Region, were created from the former Eastern Region. Dr. E. E. Lister heads the Atlantic Region, with headquarters in Halifax. Dr. J.-J. Jasmin is the Director General for the Quebec Region, with Headquarters in Quebec City.

This Report is divided into five sections, with each director general describing his organizational structure and highlighting achievements for the year. The research establishments then give details

of their work in separate chapters, for which reprints are available.

The Branch conducts basic and applied research on soils, plants, animals, pests including diseases and weeds, engineering and energy, and food. There is close cooperation with other branches in the Department, with other federal agencies, and with universities, provincial departments of agriculture, the agricultural industry, and farm organizations.

In Canada there is a unique system for coordinating agricultural research and services, called the Canadian Agricultural Services Coordinating Committee (CASCC). This organization reviews governmental and institutional services affecting the general welfare of Canadian agriculture. Its members include provincial deputy ministers of agriculture, deans of agricultural colleges and colleges of veterinary medicine, and representatives from the private sector. The Chairman is the Deputy Minister of Agriculture Canada. The research arm of CASCC is the Canadian Agricultural Research Council, which advises the parent committee on the state and needs of agricultural research and development. Despite resource constraints, the Research Branch has maintained a high quality of output and has contributed significantly to the departmental aims and the government's policies in support of the Canadian agricultural industry.

The Branch also strongly supports and cooperates in research at the international level. This support is partly provided through the Canadian International Development Agency and the International Development Research Centre. The Branch also has direct relations with the Organization for Economic Cooperation and Development (OECD) and the Food and Agriculture Organization (FAO). Through annual tripartite meetings with leaders of agricultural research in the USA and the UK, effective exchanges are occurring and cooperation is being maintained. In 1980 the meeting was attended by a delegation from France.

E. J. LeRoux

AVANT-PROPOS

La Direction générale de la recherche d'Agriculture Canada réalise environ la moitié des travaux de recherche et de développement agricoles effectués au Canada. Elle coopère également avec les universités et l'industrie en appuyant financièrement les recherches qui viennent compléter ses buts et ses objectifs. En 1980, son budget s'élevait à \$140 millions dont \$5 millions pour la recherche contractuelle et son effectif était de 3659 années-personnes dont 918 employés professionnels.

La Direction générale loge son administration centrale à la Ferme expérimentale centrale d'Ottawa. Depuis le 25 août 1980, elle compte une nouvelle Direction et trois nouvelles régions, issues d'une restructuration de l'administration de la région du Centre et de la région de l'Est. En outre, deux instituts ont changé de nom. Le mandat de la région de l'Ouest n'a pas changé par rapport à celui de 1978.

M. J.W. Morrison a été nommé Directeur général de la nouvelle Direction des instituts et de la coordination du programme. Il cumule donc maintenant la direction des instituts et du Service des programmes de recherche, qui relevaient auparavant de la région du Centre, et celle des coordinateurs de la recherche de la Direction générale.

L'Institut de recherche zootechnique et l'Institut de recherche de London portent maintenant le nom de Centres et relèvent de M. J.J. Cartier, Directeur général de la nouvelle région de l'Ontario. En outre, M. Cartier assure la direction de toutes les stations et fermes expérimentales qui faisaient auparavant partie de la région du Centre.

L'ancienne région de l'Est a été subdivisée en deux nouvelles régions: l'Atlantique et le Québec. M. E.E. Lister assure la direction de la première, dont l'administration centrale est située à Halifax; M. J.-J. Jasmin dirige la région du Québec dont l'administration centrale est située à Québec.

Le présent rapport se divise en cinq sections, chaque directeur général décrivant l'organisation dont il est responsable et ses principales réalisations durant l'année écoulée. Chaque établissement de recherche présente ensuite ses travaux dans des chapitres dont on peut obtenir des tirés à part.

La Direction générale fait de la recherche fondamentale et appliquée sur les sols, les plantes, les animaux, les ravageurs, les pathogènes, les mauvaises herbes, le génie rural et l'exploitation de l'énergie, ainsi que l'alimentation. Elle travaille en étroite collaboration avec d'autres Directions générales du Ministère, d'autres organismes fédéraux ainsi que les universités, les ministères provinciaux de l'agriculture, l'industrie agricole et les groupements d'agriculteurs.

Le Canada s'est doté d'un mécanisme particulier de coordination de la recherche et des services agricoles. Il s'agit du Comité canadien de coordination des services agricoles (C.C.C.S.A.) dont le rôle est de superviser les services gouvernementaux et institutionnels touchant l'état général de l'agriculture canadienne. Il est composé des sous-ministres provinciaux de l'agriculture, des doyens des facultés d'agriculture et de médecine vétérinaire ainsi que des représentants du secteur privé. Son président est le sous-ministre fédéral de l'agriculture. La fonction «recherche» est confiée au Conseil de la recherche agricole du Canada qui conseille le C.C.C.S.A. sur l'état et les besoins de la recherche et du développement agricoles. Malgré le resserrement de ses ressources, la Direction générale a réussi à conserver un rendement de haut calibre et à épauler le Ministère et le gouvernement dans la réalisation des politiques axées sur la prospérité de l'industrie agricole canadienne.

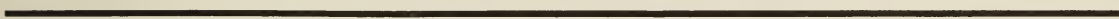
En outre, la Direction générale encourage la recherche au niveau international et y coopère énergiquement, entre autres par l'entremise de l'Agence canadienne de développement international et le Centre de recherche pour le développement international. Elle est également en contact direct avec l'Organisation de coopération et de développement économiques (O.C.D.É.) et l'Organisation des Nations-Unies pour l'alimentation et l'agriculture (F.A.O.). Les réunions annuelles tripartites tenues avec les chefs de file de la recherche agricole aux États-Unis et au Royaume-Uni sont l'occasion d'établir des échanges fructueux et de renouer des liens de coopération. En 1980, une délégation française a assisté à cette réunion.

E.J. LeRoux

INSTITUTES AND PROGRAM
COORDINATION DIRECTORATE



DIRECTION DES INSTITUTS
ET DE LA COORDINATION
DU PROGRAMME



EXECUTIVE OF THE INSTITUTES AND PROGRAM COORDINATION
DIRECTORATE

*L'EXÉCUTIF DE LA DIRECTION DES INSTITUTS ET DE LA
COORDINATION DU PROGRAMME*

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

Research Coordinators/Coordonnateurs de la recherche

Animals/ <i>Animaux</i>	F. K. KRISTJANSSON, B.S.A., M.S., Ph.D.
Crops/ <i>Cultures</i>	W. J. SAIDAK, B.S.A., M.S., Ph.D.
Food/ <i>Aliments</i>	R. R. RIEL, B.S.A., M.Sc., Ph.D.
Production/ <i>Production</i>	C. J. BISHOP, B.Sc., A.M., Ph.D. F.R.S.C., F.A.S.H.S., F.A.I.C.,
Protection/ <i>Protection</i>	R. M. PRENTICE, B.Sc., M.Sc.
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Analysts/Analystes

Contracts/ <i>Contrats</i>	J. R. AITKEN, B.S.A., M.Sc., Ph.D.
Program/ <i>Programmes</i>	A. P. CHAN, B.Sc., M.Sc., Ph.D.

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Crops/ <i>Cultures</i>	J. C. ST-PIERRE, B.Sc. (Agr.), B.Sc., M.S., Ph.D.
Crops/ <i>Cultures</i>	L. DESSUREAUX, B.A., B.Sc., M.S., Ph.D.

Directors of the institutes/Directeurs des instituts

Biosystematics/ <i>Biosystématique</i>	G. A. MULLIGAN, B.Sc.
Chemistry and Biology <i>Chimie et biologie</i>	A. I. DE LA ROCHE, B.Sc., M.Sc., Ph.D.
Engineering and Statistical <i>Technique et statistique</i>	P. W. VOISEY, F.I., Mech.E
Food/ <i>Aliments</i>	J. HOLME, B.A., M.A., Ph.D.
Land Resource/ <i>Terres</i>	J. S. CLARK, B.S.A., M.Sc., Ph.D.
Research Program Service <i>Service des programmes de recherche</i>	R. TROTTIER, B.Sc., M.Sc., Ph.D.

PREFACE

With reorganization of the Branch in August 1980 a new directorate, Institutes and Program Coordination, was formed, with Dr. J. W. Morrison as Director General. The Institute group comprises the Biosystematics Research Institute, the Chemistry and Biology Research Institute, the Engineering and Statistical Research Institute, the Food Research Institute, the Land Resource Research Institute, and Research Program Service. The institutes' programs were conducted by a staff of 590, with a budget of \$18.5 million.

The institutes have the responsibility of carrying out national programs of research in response to problems that may have been identified in the regions. Biosystematics research includes taxonomic studies on insects, arachnids, nematodes, vascular plants, and fungi. The Institute also maintains national collections of these biota and provides an identification service. The Chemistry and Biology Research Institute carries out research in specialized areas such as winterhardiness, nitrogen fixation, and plant diseases. It also provides analytical chemistry and electron microscopy services to other Branch establishments. The Engineering and Statistical Research Institute is involved in research on mechanization and farm structures. During the year two new sections, Energy and Food Engineering, were formed within the Institute to respond to research needs in these high-priority areas. Statistical research in support of Branch programs is another important activity. The research program of the Food Research Institute is oriented toward food quality, food processing, new food ingredients, food safety, and nutrition. The Land Resource Research Institute carries out soil surveys in all provinces and performs research in land classification and utilization and in agrometeorology. Research Program Service provides research support to the Branch in the form of

a wide range of scientific information, technical, and publication services.

Program Coordination, formerly known as Planning and Evaluation, is located at Headquarters and is now made up of six coordinators, two program analysts, and three special advisers. The staff serves as advisers to the Assistant Deputy Minister, Research, and to the Research Branch Management Committee. Program Coordination serves also as a training ground for potential managers. Dr. Yvon Martel, who is now Director of the Lennoxville Research Station, served as Special Adviser, Soils, and as Executive Assistant to the Assistant Deputy Minister. Dr. Réjean Bouchard, Program Specialist for the Quebec Region, spent a year as Special Adviser, Animal research. Dr. D. G. Dorrell, recently appointed Director of the Winnipeg Research Station, was Special Adviser, Crops. Dr. Ian de la Roche, formerly Coordinator, Crops, is now Director of the Chemistry and Biology Research Institute. Dr. W. J. Saidak has just been appointed Crops Coordinator. Dr. W. Baier is at present acting as Special Adviser, Resources, and Dr. J. C. St-Pierre, as Special Adviser, Crops.

Dr. E. E. Lister, Program Specialist, left the Directorate to assume the responsibilities of Director General, Atlantic Region. Dr. Robert Trotter was appointed Director of Research Program Service.

Further information about our programs may be obtained by writing to the research establishments concerned or by addressing inquiries to Institutes and Program Coordination Directorate, Research Branch, K. W. Neatby Building, Agriculture Canada, Central Experimental Farm, Ottawa, Ont. K1A 0C6.

J. W. Morrison

PRÉFACE

La restructuration de la Direction générale, en août 1980, a donné lieu à la création de la nouvelle Direction des instituts et de la coordination du programme, dont le Directeur général est M. J.W. Morrison. Cette direction englobe l'Institut de recherche biosystématique, l'Institut de recherche chimique et biologique, l'Institut de recherche technique et statistique, l'Institut de recherche sur les aliments, l'Institut de recherche sur les terres et le Service des programmes de recherche. La réalisation des programmes des Instituts est assurée par un personnel de 590 personnes qui dispose d'un budget total de \$18,5 millions.

Les Instituts ont pour mandat de procéder à la réalisation de programmes nationaux de recherches visant à régler les problèmes qui surgissent dans chacune des régions. La recherche biosystématique englobe des études taxonomiques sur les insectes, les arachnides, les nématodes, les plantes vasculaires et les champignons. L'Institut qui en est responsable garde aussi des collections de spécimens et dispense un service d'identification. L'Institut de recherche chimique et biologique travaille dans les domaines spécialisés comme la résistance à l'hiver, la fixation de l'azote et les maladies des plantes. Il fournit aussi les services de chimie analytique et de microscopie électronique aux autres établissements de la Direction générale. L'Institut de recherche technique et statistique fait des études sur la mécanisation et sur les constructions agricoles. Au cours de l'année, deux nouvelles sections y ont vu le jour; celle de l'énergie et celle du génie industriel alimentaire. Ce changement vise à répondre aux besoins nouveaux de recherches dans deux domaines hautement prioritaires. La recherche statistique menée dans le cadre des programmes de la Direction générale constitue également une activité importante. Le programme de l'Institut de recherche sur les aliments englobe les domaines de la qualité et de la transformation des aliments, des nouveaux ingrédients alimentaires, de l'innocuité des aliments et de la nutrition. L'Institut de recherche sur les terres effectue des prospections pédologiques dans toutes les provinces et s'occupe

de la classification et de l'utilisation des terres et d'agrométéorologie. Enfin, le Service des programmes de recherche assure le soutien des diverses directions en leur fournissant une large gamme de services d'informations scientifiques et techniques ainsi que de publications.

La coordination du programme, autrefois connue sous le nom de planification et évaluation, fait partie de l'Administration centrale et compte six coordinateurs, deux analystes de programmes et trois conseillers spéciaux. Elle assure un service de conseil auprès du sous-ministre adjoint à la recherche et du Comité de gestion de la Direction générale de la recherche. Elle constitue finalement un champ de formation pour les futurs gestionnaires. M. Yvon Martel, l'actuel Directeur de la station de recherche de Lennoxville, était conseiller spécial sur les sols et adjoint administratif du sous-ministre adjoint. M. Réjean Bouchard, spécialiste en programmes de la région du Québec, a été pendant un an conseiller spécial en recherche zootechnique. M. D.G. Dorrell, récemment nommé Directeur de la station de recherche de Winnipeg, était conseiller spécial sur les cultures. M. Ian de la Roche, auparavant coordinateur pour les cultures, est aujourd'hui Directeur de l'Institut de recherche chimique et biologique. M. W.J. Saidak vient tout juste d'être nommé coordinateur pour les cultures. M. W. Baier est actuellement conseiller spécial sur les ressources et M. J.C. St-Pierre est conseiller spécial sur les cultures.

M. E.E. Lister, spécialiste en programmes, a quitté la Direction pour devenir Directeur général de la région de l'Atlantique. M. Robert Trottier a été nommé Directeur du Service des programmes de recherche.

Pour de plus amples renseignements sur nos programmes, prière d'écrire aux établissements de recherche concernés ou de s'adresser à la Direction des instituts et de la coordination du programme, Direction générale de la recherche, Édifice K.W. Neatby, Agriculture Canada, Ferme expérimentale, Ottawa (Ontario) K1A 0C6.

J.W. Morrison

Biosystematics Research Institute

Ottawa, Ontario

PROFESSIONAL STAFF

Administration

G. A. MULLIGAN, B.Sc.	Director
A. GIROUX	Administrative Officer
E. GAVORA, ¹ I.N.G., B.L.S.	Librarian, Botany
V. DESROCHES, ¹ B.Ph.A., B.L.S.	Librarian, Entomology
J. E. H. MARTIN	Head, National Identification Service, Zoology; Unit Curator, Miscellaneous insect orders
P. M. LECLAIR	Head, National Identification Service, Botany

Coleoptera, Lepidoptera, and Trichoptera

J. M. CAMPBELL, B.S., M.S., Ph.D	Head of Section; Staphylinidae (rove beetles)
S. A. ALLYSON, B.Sc., M.Sc.	Lepidopterous larvae
D. E. BRIGHT, B.S., M.S., Ph.D.	Scolytidae (bark beetles), Curculionidae (weevils)
J. R. BYERS, B.S.A., M.Sc., Ph.D.	Reproductive biology and behavior of cutworm moths
P. T. DANG, ² B.S., M.S., Ph.D.	Microlepidoptera of forest importance (spruce budworm)
J. D. LAFONTAINE, B.A., Ph.D.	Noctuidae (cutworm moths); Unit Curator, Lepidoptera-Trichoptera
L. LESAGE, B.S., M.S., Ph.D.	Chrysomelidae (leaf beetles) and larval Coleoptera
A. MUTUURA, B.Sc., Ph.D.	Tortricidae (leafroller moths)
F. SCHMID, Lic. ès Sc. Nat., D. ès Sc. Nat.	Trichoptera (caddisflies)
A. SMETANA, M.U.D.R., Cand. Sc. Biol.	Aquatic beetles, Staphylinidae (rove beetles); Unit Curator, Coleoptera

Diptera and Hemiptera

D. M. WOOD, B.A., M.A., Ph.D.	Head of Section; Tachinidae (parasitic tachinid flies), Culicidae (mosquitoes)
K. G. A. HAMILTON, B.S.A., M.Sc., Ph.D.	Cicadellidae (leafhoppers), Cercopidae (spittlebugs); Unit Curator, Hemiptera
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)
D. R. OLIVER, B.A., M.A., Ph.D.	Chironomidae (nonbiting midges)
R. V. PETERSON, B.Sc., M.S., Ph.D.	Simuliidae (black flies), Nycteribiidae and Streblidae (bat flies)
W. R. RICHARDS, B.Sc., M.Sc., Ph.D.	Aphidoidea (aphids, plant lice), Psyllidae (psyllids), Coccoidea (scale insects), Thysanoptera (thrips), Psocoptera (psocids, book lice), Collembola (springtails)
H. J. TESKEY, B.Sc., M.S.A., Ph.D.	Tabanidae (horse flies, deer flies), dipterous larvae; Unit Curator, Diptera
J. R. VOCKEROTH, B.A., M.A., D.Phil.	Syrphidae (flower flies), Scatophagidae (dung flies)

Experimental Taxonomy and Nematology

R. V. ANDERSON, B.A., M.S., Ph.D.	Head of Section; Hoplolaimidae (spiral nematodes), Tylenchorhynchidae (stylet nematodes), Aphelenchoidea (foliar nematodes); Unit Curator, Nematodes
J. W. ARNOLD, B.A., M.Sc., Ph.D.	Insect hemocytology
B. A. EBSARY, B.Sc., M.Sc., Ph.D.	Criconematidae (ring nematodes), Paratylenchidae (pin nematodes), Hemicycliophoridae (sheath nematodes)
E. S. EVELEIGH, B.Sc., M.Sc., Ph.D.	Dorylaimida (dagger nematodes), Acarine systems (mites)
B. N. A. HUDSON, B.Sc., Ph.D.	Chemical taxonomy of insects: polymorphic enzymes
R. MATSUDA, B.A., Ph.D., D.Sc.	Comparative morphology, Tingidae (lace bugs), Aradidae (flat bugs)

Hymenoptera and Arachnida

I. M. SMITH, B.Sc., Ph.D.	Head of Section; Acari (mites)
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J. R. BARRON, B.Sc., M.Sc., Ph.D.

C. D. DONDALE, B.Sc., M.Sc., Ph.D.

H. GOULET, B.A., B.Sc., M.Sc., Ph.D.

E. E. LINDQUIST, B.S., M.S., Ph.D.

L. MASNER, B.Sc., M.Sc., Ph.D.

W. R. M. MASON, B.Sc., Ph.D.

C. M. YOSHIMOTO,² B.A., M.Sc., Ph.D.

Ichneumonidae (ichneumon wasps)

Araneae (spiders), Opiliones
(harvestmen); Unit Curator
Arachnida

Symphyta (sawflies)

Acari (mites, ticks)

Proctotrupeoidea (proctotrupid
wasps), Bethyloidea (bethylid
wasps), Sphecoidea (digger wasps),
Evanioidea (ensign wasps); Unit
Curator, Hymenoptera

Braconidae (braconid wasps)

Chalcidoidea (chalcid wasps),
Cynipoidea (gall wasps)

Mycology: Plant Disease and Biodegrading Fungi

R. A. SHOEMAKER, B.S.A., M.S.A., Ph.D.

D. J. S. BARR, B.Sc., M.Sc., Ph.D.

J. D. BISSETT, B.Sc., Ph.D.

M. P. CORLETT, B.A., M.A., Ph.D.

J. H. GINNS, B.S., M.S., Ph.D.

S. J. HUGHES, B.Sc., M.Sc., D.Sc., F.L.S., F.R.S.C.

G. A. NEISH, B.Sc., Ph.D.

J. A. PARMELEE, B.Sc., M.A., Ph.D.

S. A. REDHEAD, B.Sc., M.Sc., Ph.D.

Head of Section; Ascocarpic
parasites of cereals

Zoosporic parasites of vegetable
crops

Conidial parasites of forage crops

Ascocarpic parasites of fruit crops

Curator, National Collection of
Fungus Cultures; Basidiocarpic
tree wood rots

Conidial molds of wood and insects

Mycotoxin fungi

Curator, National Mycological
Herbarium; Obligate parasites of
plants (rusts, smuts, mildews)

Mushrooms

Vascular Plants

E. SMALL, B.A., B.Sc., M.Sc., Ph.D.

S. G. AIKEN, B.Sc., M.Sc., M.S., Ph.D.

I. J. BASSETT, B.A.

B. R. BAUM, M.Sc., Ph.D.

P. M. CATLING, B.Sc., Ph.D.

W. J. CODY, B.A.

J. MCNEILL, B.Sc., Ph.D.

G. A. MULLIGAN, B.Sc.

S. I. WARWICK, B.Sc., Ph.D.

Head of Section; Cultivated crops,
Medicago

Grass flora of Canada

Hay-fever plants, palynology, weeds

Cultivated crops, *Hordeum*

Sedges, aquatic plants

Curator, Herbarium; Canadian
flora, ferns

Weeds, Polygonaceae,
Caryophyllaceae

Weeds, Cruciferae

Weeds, genecology

Honorary Research Associates

E. C. BECKER, B.S., M.S., Ph.D.	Elateridae (click beetles, wireworms)
J. A. DOWNES, B.Sc.	Ceratopogonidae (biting midges)
D. F. HARDWICK, B.A., M.Sc., Ph.D.	Noctuidae (cutworm moths)
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)
O. PECK, B.Sc., M.Sc., Ph.D.	Chalcidoidea (chalcid wasps)
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

Departures

E. C. BECKER, B.S., M.S., Ph.D.	Elateridae (click beetles, wireworms)
E. H. SALKELD, B.S.A., M.S.A., Ph.D.	Comparative micromorphology of insect eggs

Transfers

F. W. COLLINS, B.Sc., Ph.D.	Chemotaxonomy, <i>Brassica</i>
C. C. LOAN, B.A., M.S., Ph.D.	Ichneumonidae (ichneumon wasps), Braconidae (braconid wasps)

¹Seconded from Libraries Division, Finance and Administration Branch.

²Seconded from Environment Canada.

INTRODUCTION

The Biosystematics Research Institute provides a national identification service for insects, mites, spiders, nematodes, vascular plants, and fungi of importance to Canadians. The Institute conducts research on various aspects of biosystematics and maintains custody of the Canadian National Collection of Insects, Arachnids, and Nematodes; the Agriculture Canada Vascular Plant Herbarium; the National Mycological Herbarium; and the National Mycological Culture Collection. Eight new curators were appointed for the zoology national collections during 1980.

The Institute emphasizes taxonomic studies on organisms of special interest to Canadians and the production of identification guides and inventories of organisms having economic or environmental impact.

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

IDENTIFICATIONS, COLLECTIONS, AND SURVEYS

National Identification Service

A total of 85 900 specimens of insects, arachnids, and nematodes were identified during 1980, an increase of 14% over the previous year. Agriculture Canada (25%) and Canadian and American universities (22% and 13%, respectively) were the greatest users. Some 5150 were received from the general public for identification, general information, or advice on control measures.

A total of 12 552 collections of vascular plants were identified during 1980. Universities were again the major users of this service (50.4%). An increased number of inquiries were received directly from the general public and through Public Services Section, Information Services, Agriculture Canada. Assistance was provided to the Poison Control Centre for 15 cases of suspected poisonings from vascular plants.

A total of 3015 collections and cultures of fungi were identified during 1980. Principal users of the service were the general public (28.1%), followed by other federal departments (17.0%) and Canadian universities (14.4%). Assistance was provided to the Poison Control Centre for 54 cases of suspected poisonings from mushrooms. The accompanying table shows the number of specimens identified and their sources.

Collection development

The holdings of the Canadian National Collection of Insects, Arachnids, and Nematodes increased by some 675 000 specimens. Major contributions were made by 28 officers of the Institute collecting across Canada, the Yukon Territory, and eastern and central United States. The use of devices newly designed or modified by Institute scientists for collection of micro-hymenoptera and other minute arthropods resulted in a spectacular increase of holdings of many species in the collection. Donations of specimens to the collection totaled some 38 400 specimens and purchases amounted to 7715 specimens. Some 222 loans totaling 73 438 specimens of Canadian National Collection material were made to scientists around the world for research study. Material incorporated into the collection totaled some 195 500 specimens.

The holdings of the Vascular Plant Herbarium now stand at 690 596 collections, an increase of 13 555 during 1980. Approximately 7000 collections were made during field trips by staff members in Ontario, the western provinces, the Yukon Territory, southwestern and central United States, and Mexico. Some 3804 collections were donated to the Herbarium, 2991 as exchange and 813 as gifts from other herbariums.

The holdings of the National Mycological Herbarium stand at 231 426 specimens, an increase of 8054 accessions during 1980. A total of 4498 specimens were donated, 4348 as

Zoological and botanical identifications for 1980

	Arthropods and nematodes, number of specimens	Vascular plant collections ¹	Fungus collections ¹	Fungus cultures ²	Total
Canada					
Agriculture Canada	21 811	259	48	133	22 251
Environment Canada	5 623	1 434	37	9	7 103
Other federal departments	915	898	423	92	2 328
Provincial departments	8 941	169	15	33	9 158
Industry	111	—	5	4	120
Universities	19 051	3 344	291	143	22 829
General public	5 038	606	848	—	6 492
USA					
Government departments	6 571	2 637	233	29	9 470
Universities	10 844	2 989	338	12	14 183
General public	1 181	—	—	—	1 181
Other countries	5 828	216	276	46	6 366
Total	85 914	12 552	2 514	501	101 481

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.

exchange from other herbariums and 150 as gifts. Approximately 4700 collections were made by staff members during the year. The National Collection of Fungus Cultures has increased its holdings from 6093 to 6558, an increase of 465 cultures. These cultures were received for deposit from other institutions, through the Identification Service, or from isolations made by staff members. At the present time 2066 cultures have been successfully lyophilized for long-term preservation.

During the summer of 1980, the Institute carried out a 4-mo survey of the insects, mites, vascular plants, and fungi of Waterton Lakes National Park, Alberta. The purpose of this survey was to collect specimens pertinent to research interests of Institute scientists and to enhance the collections. This park was selected because it serves as an excellent site for studying the flora and fauna of the Rocky Mountains as well as those of western prairie elements and aspen parkland. Ten Institute scientists and technicians participated in the survey. The material collected is being sorted and prepared, and will be incorporated into the collections. Institute personnel worked closely with park naturalists to provide them with useful biological information. Four Institute scientists, including two entomologists, one mycologist, and one vascular plant taxonomist, collected extensively in the Yukon during 1980. Particular emphasis was placed on collecting organisms in areas where there were glacial refugia.

Identification aids

Insects and Arachnids of Canada. This faunal series was initiated several years ago and is now established as an Institute activity. This activity is designed to treat the insect and arachnid fauna of Canada in a series of books that will permit the nontaxonomic biologist to identify various arthropod entities. Since the last annual report two contributions were published: Part 7, *Genera des Trichoptères du Canada et des États adjacents*; and Part 8, *The Plant Bugs of the Prairie Provinces of Canada, Heteroptera: Miridae*.

Vascular Plants of Continental Northwest Territories. This work is a guide or manual to the species and major geographical races of the 1113 flowering plants and ferns of the continental Northwest Territories and includes keys, descriptions, distribution maps, and line drawings. The area covered is roughly 1.6 million square kilometres.

Poison-ivy, Western Poison Oak, and Poison Sumac/L'herbe à la puce, le sumac à vernis et le rhus diversiloba. This bulletin, with line drawings and color plates, includes information on the biology and identification of the plants, symptoms of poisoning and treatment, how poisoning occurs, and how to eradicate the plants.

Common and Botanical Names of Weeds in Canada/Noms populaires et scientifiques des plantes nuisibles du Canada. This bulletin presents the botanical names and English and French common names of all the plants growing as weeds in Canada.

Grasses of Ontario. This manual treats the species and major geographical races of all the grasses growing in Ontario. It includes keys, descriptions, distribution maps, line drawings, and photographs for 78 genera, 238 species, and 123 subspecies and varieties.

Fungi Canadenses. During 1980, 30 contributions were published, bringing the total in this series to 190. An additional 20 contributions are being processed. Taxa illustrated and described include several new records of Canadian fungi, two new species, and three new combinations. Species of parasitic and biodegrading fungi from the following genera are described: *Aecidium*, *Arachnophora*, *Endophragmiella*, *Gerronema*, *Helminthosporium*, *Hemimycena*, *Hygrocybe*, *Marasmiellus*, *Melanotus*, *Microascus*, *Mycena*, *Olpidium*, *Peziza*, *Phaeomarasmium*, *Psilachnum*, *Puccinia*, *Spiropes*, *Stigmina*, *Taeniola*, *Tyromyces*, and *Venturia*.

SECTIONAL RESEARCH

Coleoptera, Lepidoptera, and Trichoptera

Coleoptera. Carabidae—A major systematic and phylogenetic analysis of the genus *Elaphrus* was redrafted and submitted for internal review. The revision of the 34 species and four subgenera of *Elaphrus* includes a review of both adult and larval characters. An analysis of structural variation in two subspecies of the *Elaphrus americanus* complex was submitted for publication. A similar study of the *E. finitimus* complex is in progress.

Staphylinidae—A large revision of the subfamily Xantholininae for America north of Mexico was completed. The subfamily includes 28 genera and 105 species. Revisions of the genera *Lordithon* and *Carphacis* were

completed; the latter has been published. Two new species, including one in a new genus, of the subfamily Phloeocharinae were described and illustrated.

Scolytidae—A monograph on the large genus *Pityophthorus* in North America was completed. Over 200 species are described and illustrated, and keys are provided to aid in identification.

Buprestidae—A handbook on the Buprestidae of Canada for *The Insects and Arachnids of Canada* series is nearing completion. Over 200 Canadian species are treated.

Miscellaneous—Considerable progress was made on the inventory of pest species of Coleoptera of agricultural importance. It is expected to be completed in 1981.

Lepidoptera. Tortricidae—A paper describing a new species of *Clepis* from the Yukon Territory was published. Manuscripts for two papers on the pine cone borer genera *Eucosma* and *Laspeyresia* were prepared. Genitalia drawings, and keys to genera and species, of Archipini were completed for a handbook in the series *The Insects and Arachnids of Canada*. Forty populations of spruce budworm from across Canada were established for use in a projected taxonomic revision of the *Choristoneura fumiferana* complex.

Pyralidae—A paper describing a new species of *Dioryctria* from Eastern Canada was completed. Two papers on the larvae of the subfamily Pyraustinae were submitted for publication.

Noctuidae—A manuscript on the biogeography of the 180 North American species of *Euxoa* was submitted for publication. A taxonomic study of the *Euxoa comosa* group, using both classical and experimental approaches, was completed. On the basis of larval growth rates, hybridization, mating discrimination, and pheromone specificity studies, it was concluded that nine normal species were best regarded as five subspecies comprising a single polytypic species. A catalog of the 450 species and 45 genera of cutworms of the subfamily Noctuinae in the Neotropical region was completed.

Geometridae—The fourth memoir in the series *Guide to the Geometridae of Canada* on the subfamily Ennominae was submitted for publication.

Trichoptera. A world revision of the family Xiphocentronidae was completed. The family includes 88 species, of which 68 are new.

Diptera and Hemiptera

Diptera. Volume I of the *Manual of the Nearctic Diptera*, covering 43 families of Nematocera and lower Brachycera, was published. The text of the second volume covering all 65 families of the higher Diptera (Muscomorpha or Cyclorrhapha) occurring north of Mexico was completed; work on illustrations for the second volume is now in progress. Fifty-two world specialists collaborated in this two-volume work, which provides new keys and abundant illustrations to 2150 genera of flies known to occur in Canada, Greenland, and continental United States. Well-illustrated family keys to adults and larvae of soil-dwelling Diptera were prepared for inclusion in a book entitled *Soil Biology Guide*. Adults and immature stages of one of the major blackfly vectors of onchocerciasis in Venezuela, *Simulium sanguineum* Knab, were redescribed as part of a study of these vectors under the auspices of the World Health Organization. Nine new genera and six new species of Mycetophilidae (fungus gnats) were described. As part of a cooperative project involving both North American and European specialists on midges (Chironomidae), keys, diagnoses, and illustrations of the larvae of 21 genera of the subfamily Orthocladiinae and nine genera of Diamesinae were completed. Six New World genera of Empididae related to *Megagrapha* were revised, incorporating the description of one new genus and 27 new species. Illustrated keys to the larvae of horse flies and deer flies of Illinois were completed as part of a manual to the Tabanidae of that state. Fifty-three Canadian species in 10 genera of Syrphidae (flower flies) were redescribed as part of a handbook to the Syrphidae of Canada, Alaska, and Greenland. The 14 world genera of Pallopteridae were redefined and keyed for the first time. One new extant pallopterid species was described whose sister-species is known only as a fossil species in Baltic amber of Oligocene age (± 40 million years). The identities of the 12 described species of *Neosilba* (Lonchaeidae), whose larvae live in fruit and vegetables, were established and three new species described. In cooperation with the Food Production and Inspection Branch of Agriculture Canada, a detection survey for the anthomyiid wheat-bulb fly, *Delia coarctata* (Fallén), turned up numbers of adults on quack grass from Quebec to Nova

Scotia. No damage to winter wheat was detected.

Siphonaptera. A monographic treatment of the fleas of Canada and Alaska, including keys to all genera and species, and illustrations and distribution maps for each species, is nearing completion.

Hemiptera. Studies of plant bugs of the family Miridae resulted in publication of descriptions of nine new species. Five European species were reported from North America for the first time. Technical bulletins dealing with the plant bugs infesting apple trees in Quebec and fruit crops in Canada were completed. The second part of a handbook to the genera of Aphidoidea of Canada is nearing completion and will be published, along with the first part, as a single major treatment. Morphological characteristics and a diagnosis for a new species of flat bugs (*Aradus*) in Canada were published.

Experimental taxonomy and nematology

Biosystematics of cutworms. Two species of cutworm moths of the genus *Xestia* from North America and one from Europe were compared morphologically and electrophoretically. Where morphological distinctions were unclear, the species were readily differentiated by the allozymes of six enzymes. Relationships between the species were clarified by measures of genetic distance, attractiveness to pheromones, and hybridization experiments. The morphological characters, allozyme frequency distinctions, and behavior of the species are described in two published papers and in one manuscript nearing completion.

A manuscript comparing hemocyte complexes in 85 species of cutworms has been completed. Data show that, with some exceptions, a natural system of classification of the family based on hemocyte complexes is more relative to one based on larval, rather than adult, morphology. It is thought that these hemocyte characteristics may be associated with the biology of larval development. Some anomalies in cell complexes, however, lend support to projected taxonomic revisions based on adults.

Insect morphology. In two memoirs submitted for publication the eggs of 124 species of cutworm moths (Noctuidae) and 112 species representing 40 other families are described and cataloged. The characters of taxonomic and phyletic importance depicted

in 235 plates of scanning micrographs include position and form of the chorionic microsculpture and surface texture, features of the micropylar area, and position, shape, and size of the aeropyles. Descriptions include date, site, and pattern of oviposition, and color and dimensions of eggs. In a continuing study of evolutionary processes in animals a new theory of inheritance of environmentally acquired characters was extended to talitrid amphipods and salamanders, and the results were submitted for publication. Based on newly postulated concepts concerning morphogenetic plasticity and environmental effects of the epigenetic system involving hormonal action, a new theory on the origin of insect wings was developed and submitted for publication.

Nematology. Published were descriptions of a new species of root-knot nematode, a new genus and species of cyst-forming nematodes, a bulb-and-stem nematode that induces leaf galls, and a new species and subgenus of *Aphelenchus*.

Revisionary studies of the plant-parasitic ring nematodes (Criconematidae) were completed and the data were presented in a series of papers that are in press, submitted, or completed. Nominal species of the 22 genera considered were realigned into more tenable groupings, for which six new genera were proposed. Taxonomic keys are provided to facilitate identification of 180 species of ring nematodes, including new species described from Canada.

A manuscript was completed that concludes morphological and taxonomic studies of plant-parasitic species of the genus *Merlinius* in Canada. The text contains descriptions and illustrations of three new species and a key to the Canadian species. Also completed were descriptions of a new species of spiral nematode (*Helicotylenchus*), with a revised key to the Canadian species, and of a new species of *Triversus*. New records of nematodes for Canada have been documented for a species each of *Merlinius* and *Helicotylenchus*, and for the genus *Triversus*. Host plants of nematodes recorded for the first time are spike rush, *Eleocharis acicularis* (L.) R & S, and dryas, *Dryas integrifolia* M. Vahl.

Hymenoptera and Arachnida

Hymenoptera. Progress continued on the introductory volume on Hymenoptera for the faunal series, *The Insects and Arachnids of*

Canada. Important research, leading to reclassification of some major groups of Hymenoptera, was continued, with one preliminary paper completed and three others initiated. These will contribute to a general classification basis for the faunal handbook.

Symphyla (sawflies)—A paper on distinguishing more readily among three species of *Gilpinia* in North America was submitted for publication; included are two species actually or potentially introduced from Europe, one of which could become a pest of spruce. A manuscript on distinguishing five species of *Phymatocera* in North America, with a discussion of the natural relationships of these liliaceous plant feeders, was submitted for review.

Braconidae—A major revision of the subfamily Microgastrinae, with a reclassification and phylogenetic analysis of its genera, is in press. This study centers on the large, complex genus *Apanteles*, and shows that this group of parasites of lepidopterans is not a natural assemblage.

Ichneumonidae—A taxonomic revision of the genus *Ctenopelma* for North America, treating 24 species (18 new) that are parasites of pamphiliid sawflies, was submitted for publication. A revision of the genus *Pyracmon*, based on larvae and adults, was largely completed.

Chalcidoidea—A synopsis of eight North American species of the genus *Chrysonotomyia*, endoparasites of small insect eggs and larvae, was published. A paper on natural relationships of endemic Chalcidoidea of Hawaii was presented at the 16th International Congress of Entomology in Kyoto, Japan, in 1980. A paper was nearly completed that describes a new species of *Thripoctenoides*, a genus of entedontine Eulophidae, and parasites of thrip eggs not previously known from North America. A revision of North American species of *Pediobius*, endoparasites of various immature insects and spiders, was nearly completed.

Proctotrupoidea—A large paper providing keys to 67 genera of the family Scelionidae for the Northern Hemisphere was published. A similar work on 46 world genera of inostemmatine Platygastriidae was nearly completed. A paper treating six species of the platygastriid genus *Acerotella* for North America was published, and another on 18 species of the related genus *Metaclisis* was completed; wasps of both genera are parasites of gall flies. Two papers on the scelionid genus

Calotelea, including a revision of 10 species (all new) for North America, and another paper revising two species of the diapriid genus *Leaiopria*, associated with termites in Australia, were published.

Arachnida. Araneae (spiders)—A paper, providing the first description of the female of *Xysticus winnipegensis* Redner & Dondale, was published. A paper was published on the spider fauna of Canada, given at the 8th International Congress of Arachnology in Vienna, Austria, in 1980. A chapter providing illustrated keys to the spiders of litter, representing 95 genera in 16 families, was submitted for publication in a book entitled *Soil Biology Guide*. Two papers on the wolf spider genus *Pirata* were submitted for publication: *Pirata* is redefined, along with the description of a new genus, *Trebacosa*, in one; and a new species of *Pirata* is described from Canada in the other. The second contribution on spiders to the faunal series *Insects and Arachnids of Canada* is in press. Entitled *The Sac Spiders of Canada and Alaska (Araneae: Clubionidae and Anyphaenidae)*, this handbook includes taxonomic keys, illustrations, descriptions, and notes on living habits concerning the 11 genera and 72 species of sac spiders found, or anticipated to occur, in Canada and Alaska.

Acari (mites)—An important paper on evolutionary and ecological strategies of mites and other arthropods inhabiting annually temporary pools was published. A major revision of North American species of the eriophyoid genus *Trisetacus*, sporadic pests of coniferous trees, was nearly completed. A large monograph on morphology, systematics, and natural relationships of the world genera of Tarsonemidae, and on classification of this family with others in the Heterostigmata, was completed as a preliminary draft for internal review.

Mycology: plant disease and biodegrading fungi

Ultrastructural examinations of fungal zoospores have revealed numerous new characteristics that substantially aided biosystematic theory. Included prominently among these new characteristics is the microtubule rootlet complex that anchors the flagellar apparatus and provides cytoskeletal support for the cell. As a direct result of these findings, a new order, Spizellomycetales, in the class Chytridiomycetes, was described.

The order includes many newly reported soil-inhabiting fungi, as well as ones previously known such as the virus-transmitting *Oplidium brassicae* and *O. radiale*. The genus *Synchytrium*, which includes *S. endobioticum*, the cause of black wart disease of potato, is retained in the revised order Chytridiales.

An ecological study on the effect of fire on the soil microflora of coniferous forests was published. Accelerated microbial activities were observed as a long-term effect of fire on soil microbial populations and metabolism. These could be attributed to specific environmental changes caused by burning. A revision of the species of Septorioid fungi occurring on Gramineae in Canada is nearing completion. Descriptions of these important disease-causing fungi will be published in a format that should assist pathologists and others with their identification.

A taxonomic revision of some species of *Didymella* parasites of raspberry, cucurbits, and legumes has been completed. A taxonomic study of the hyphomycetous genus *Stemphylium* is nearly completed. Canadian species of *Mycosphaerella* parasitizing selected groups of economically important plants are being investigated.

A taxonomic monograph of the genus *Coniophora* was completed. Detailed descriptions and illustrations will allow rapid identification of specimens of these dry rot fungi. They cause economically significant losses in wood of buildings and other wooden structures as well as decay in forest trees.

A supplement to the 20-yr-old reference, *An Annotated Index of Plant Diseases in Canada*, is progressing and, when completed, will be a useful reference work for plant pathologists, ecologists, and other biologists.

Studies on the taxonomy and distribution of *Fusarium* species in Canada, emphasizing the fusaria associated with cereal grains, are being continued. Collaborative work with Animal Research Centre and Plant Products scientists is focusing on toxin production by these fungi with emphasis on zearalenone production by *F. graminearum* and on the trichothecenes produced by this and other *Fusarium* species. A new variety of *Fusarium moniliforme* was described.

A study of 17 species of *Puccinia* completing their life cycles on Cichorieae (Compositae) in North America was completed. It revealed one new species on the genus *Agoseris* and recognized that certain rusts

attacking *Taraxacum*, *Hieracium*, and related plants are distinct from the wide-ranging *Puccinia hieracii*, under which they had been treated synonymously. Seven rusts parasitizing the family Primulaceae in Canada were described.

A revision of section *Herbicolae* of the mushroom genus *Coprinus* on a global basis was necessary to determine that a winter pathogen of winter wheat and legume forage crops in Western Canada represented an undescribed species. A second species in the section, which was associated with a turf disease, was discovered in Canada. Fieldwork continued to reveal mushrooms new to Canada, including species new to science, and many new provincial records. This documentation will assist decision making by Plant Quarantine officers, should any of the species be found on imported materials.

Revision of the genus *Leptosphaeria* and its segregates progressed through type studies and additional fieldwork in northern Ontario. A review was prepared on "Changes in taxonomy and nomenclature of important genera of plant pathogens".

Vascular plants

Alfalfa. Four publications on alfalfa were prepared. Examination of pubescence distribution on alfalfa leaves led to the discovery that trichome density is greater on the lower halves of the two outer leaflets than on other parts of the leaf. Numerical taxonomic analyses of 55 species of *Medicago* resulted in recognition of 12 major groupings in three assemblages. Study of floral structures in species of *Medicago* and their relatives enabled separation of *Medicago*, *Factorovskya*, and a segment of the genus *Trigonella* (fenugreek) from *Melilotus* (sweet clover) and the remainder of *Trigonella*. In the first group, features were found which promote the 'tripping' phenomenon of alfalfa. A study of pollen grains revealed that pollen could be used taxonomically to separate *Medicago* from several closely related genera.

Hops. A study of the relationships between the structure and geographical origin of hops (the fruit of *Humulus lupulus* L., widely used in brewing) was completed. Fruit structure could be used to identify hops from North America, Britain, continental Europe, and Japan.

Wheat group. Based on ultrastructure of epicuticular waxes, the relationships among

genera of this difficult group was investigated by means of electron microscopy, chemistry, and numerical taxonomy. Two papers have been accepted for publication.

Barleys. Preparation of a worldwide barley cultivar registry, to include pedigrees, coefficients of common parentage and inbreeding, and synonyms, is progressing. A new method of identifying species and cultivars was undertaken, using a combination of starch granules from the grain and an image analyzer, and computer data analysis. This approach yielded excellent results that were summarized in a comprehensive paper. About 300 accessions of wild species of *Hordeum* were collected this summer in the southwestern United States and Mexico by a joint Canadian-Danish-Swedish exploration team.

Inventory of cultivated crop plants of Canada. Literature collection continued toward compilation of a treatment of all plants known to be cultivated outdoors for crop purposes in Canada. Treatments of 50 of the most important genera of Canada were drafted.

Inventory of Canadian weeds. Work continued toward publication of an inventory of all weeds and other noxious or potentially noxious plants found in Canada. For each of about 1500 species to be included there will be information on the correct scientific name, widely used synonyms, English and French names, geographical distribution, and habitat.

Biology of Canadian Weeds series. Accounts were completed of the common horse-tail (*Equisetum arvense* L., a pernicious weed of pastures and a variety of other habitats), narrow-leaved plantain (*Plantago lanceolata* L., a weed of pastures, lawns, and waste places, known to shed large amounts of pollen leading to many cases of hay fever), and night-flowering catchfly (*Silene noctiflora* L., an important weed, particularly of grain and leguminous crops in Western Canada).

Aquatic weeds. The genus *Myriophyllum* includes the watermilfoils, which are extremely damaging to waterways in Canada. Several studies were published documenting the relationships of substrate on the growth and form of *M. spicatum* L., *M. exalbescens* Fern., and *M. alterniflorum* DC., and clarifying the difficulty many individuals have had in identifying these species due to the differential development of the plants in various

habitats. An identification key to the 13 species found in North America and discussions of their taxonomic difficulties were published.

White cockle. A revised treatment of variation within this weed species was completed. Four subspecies are recognized and the correct scientific name for the species is shown to be *Silene pratensis* (Rafn.) Godron & Gren.

Knotweeds. Morphology and cytology of introduced knotweeds (*Polygonum* spp.) in Eastern Canada established the existence of two groups of plants recognizable as species. The most common knotweeds in open habitats are tetraploid plants that are distinguishable from others that are hexaploid by size of their leaves, and form of their perianth segments and fruit. These plants are referable to *P. arenastrum* Boreau. The more erect introduced hexaploid plants that can more readily compete as field weeds belong to a species with the name *P. aviculare* L., which may be rejected as ambiguous and replaced by the name *P. monspeliense* Pers.

Silky-bent. Discovery of two species of silky-bent (*Apera*) in southern Ontario enabled preparation of an account that distinguishes this genus from other grasses with which it might be confused, and indicates the diagnostic features and potential hazard of loose silky-bent, *A. spicaventi* (L.) Beauv., a weed of winter wheat.

Lamb's-quarters. An extensive account was prepared for all 31 species of lamb's-quarters (*Chenopodium*) in Canada and presents descriptions, distribution maps, chromosome numbers, a key, and discussions of morphology and nomenclature.

Herbicide-resistant weeds. Three papers were published on comparisons of triazine-resistant and susceptible weed strains. Resistant strains of groundsel, *Senecio vulgaris* L., were less competitive in the absence of herbicides and much more homogeneous than nonresistant strains of North American and European populations. Resistant and susceptible strains of lamb's-quarters, *Chenopodium album*, and late-flowering goosefoot, *C. strictum* Roth, differ in competitive fitness both between species and between strains of the same species. The literature on three resistant pigweed species was clarified, and documented both the occurrence of green pigweed, *Amaranthus powellii*, and the first known

occurrence of resistant redroot pigweed, *Amaranthus retroflexus*, in southern Ontario; a key for identification of all three species of pigweed was provided. Three studies were completed assessing differences between triazine-resistant and susceptible populations of lamb's-quarters. Differential growth and response to atrazine and isoenzyme variation provided evidence for climatically adapted populations of both susceptible and resistant strains; electrophoretic studies of isoenzyme variation indicated remarkable homogeneity within resistant populations, but provided evidence for two independent mutations of triazine-resistant lamb's-quarters within well-established populations in Ontario. The genetic basis of ecoclimatic adaptation in lamb's-quarters was clarified, based on photoperiodic and reciprocal transplant studies

into contrasting climatic regimes. A differential nitrogen response to atrazine in susceptible and resistant populations showed that a degree of inhibition of photosynthesis by atrazine was necessary to elicit the increase observed in nitrogen compounds for susceptible plants.

Floristic studies. A paper on distribution of the orchid twayblades (*Listera*) was published. One on distribution of plants of restricted geographical range in Ontario was completed. Numerous distribution maps were prepared toward publication of a handbook of plants of Riding Mountain National Park. A paper on water-meal (*Wolffia columbiana* Karst.), previously unreported in the Park, was published. Considerable progress was made toward preparation of an identification guide to the more than 180 species and 60 genera of grasses of western cattle rangelands.

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INTRODUCTION

The activities of the Chemistry and Biology Research Institute are integrated into multidisciplinary, mission-oriented programs that have regional responsibility for research in basic and applied sciences related to agriculture. The activities are conducted under eight main programs.

Research is concerned with interrelationships between microorganisms, viruses, soils, and plants. The research programs place particular emphasis on the mineralogy, biology, and chemistry of soils; frost hardiness; nitrogen fixation in legume crops; plant viruses and mycoplasma; environmental chemistry including organic toxins, trace elements, and pesticides; and fusarium-spot blotch disease. New or improved analytical methods for the determination of various constituents in agricultural materials are developed.

Services include mineralogical analyses by means of X-ray diffraction, electron microscope facilities, and analytical chemistry services. The facilities of the Electron Microscope Centre were used by various establishments within the Research Branch, universities, and outside agencies. The Analytical Chemistry Services provided a wide range of chemical analyses and structural information on extracts from agricultural and food products by means of advanced analytical instrumentation such as gas chromatography - mass spectrometry.

There were some organizational changes in the Institute. The Acting Director, W. Baier, returned to the Land Resource Research Institute in May 1980 and assumed his duties as Head, Agrometeorology Section. Dr. A. I. de la Roche of the Planning and Evaluation Directorate was appointed Director of the Institute in May 1980.

This report summarizes only the highlights of our achievements in 1980. Reprints of the 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

PLANT PATHOLOGY

Enzymes and inhibitors related to lipid and membrane biochemistry in *Fusarium* spp.

A number of inhibitors to the enzymes hydroxymethylglutaryl-CoA reductase and sterol ester hydrolase from *F. culmorum*, a wheat pathogen, have been examined. After 10 h incubation at pH 7, the optimum pH for activity, linoleoyllysine and linoleoylaspartate at 0.5 mM concentration inhibited the hydrolase system and respiration by 50%. However, after 25 h incubation linoleoylaspartate showed significantly more effective inhibition of respiration than linoleoyllysine. Similarly, linoleoylaspartate reduced phenylalanine transport into the mycelium and spores and the net-sterol content more effectively than linoleoyllysine. Other studies demonstrated the laboratory degradation of these compounds by the pathogen.

Mycelia of *F. oxysporum* f. sp. *lycopersici* transported methionine by an energy-dependent process. The energy required for uptake

may be derived from either respiration or glycolysis at the optimum pH 4 and the optimum temperature 35°C. Apparent K_m and the V_{max} for methionine was 3 μ m and 0.27 nmol/min per milligram dry weight, respectively. *S*-Adenosylhomocysteine was found to be the major metabolic product of the accumulated methionine.

Methionine uptake was not inhibited by the acidic and basic amino acids and amino acids having less than a four-carbon chain. The rate of methionine transport was greatest in log-phase cells and decreased substantially as the cells entered the stationary phase.

Macroconidia of *F. sulphureum* actively transported L-glutamate via a specific acidic amino acid permease. The apparent K_m for uptake (pH 5) was $0.8 \times 1.7 \times 10^{-5}$ M and the V_{max} varied from 0.8 to 1.2 nmol/min per milligram dry weight. The pH and temperature optimums for transport were 3.5-4.5 and 30°C, respectively. The transport of glutamate was shown to occur against a concentration gradient of at least 1:140 and was

suppressed by uncouplers or inhibitors of respiration.

Cell wall structure and composition in *Fusarium* spp.

Conidiogenesis in *F. sulphureum*, *F. culmorum*, and *F. decemcellare* exhibited a primitive phialitic mode of ontogeny. The macroconidia were produced terminally and externally on conidiophores. Mature macroconidial cell walls were found to have a highly crystalline chitin structure, whereas those of younger conidia were amorphous as determined by X-ray diffraction and infrared analyses. Similar analyses of cells treated with thiols indicated that these compounds produced depolymerization of the chitin network in the cell walls.

Biology of seed infestation by *Cochliobolus sativus*

Field trials were undertaken in 1980 to follow natural seed infestation by *C. sativus* throughout the course of grain development. Prolonged periods of leaf-surface wetness, high relative humidity, and elevated temperatures (15 July–4 August) resulted in the rapid spread of the disease with the concomitant increase in aerial spore populations. The percentage of internally infected seed paralleled the incidence of airborne spores and the progression of spot blotch. At harvest *C. sativus* was recovered from 90% of surface-sterilized seed.

Light transmission and scanning electron microscope studies of naturally infected seeds and seed parts established the following: fungal mycelium was present within the parenchyma and sclerenchyma cells of the lemma and palea and between these outer husks and the closely appressed pericarp of the caryopsis. Mycelium was also observed in the pericarp and between the pericarp layers and the seed testa. No fungi (or spores) were observed in other parts of the grain.

Disease-producing toxins from *Cochliobolus* spp.

Derivatives of a toxin produced by *Cochliobolus* were prepared by complexing this toxin with a variety of inorganic ions. These derivatives were bioassayed and were found to be biologically stable. They can be used for further chemical characterization.

Disease control studies

Mixtures of European and Maneb fungicides as a wheat seed treatment did not synergistically enhance the disease control capacity of either fungicide. Thiols, which enhanced the in vitro fungicidal capacity of benomyl against *F. sulphureum*, were ineffective under field conditions for controlling the pathogen. Clofibrate, an inhibitor of sterol biosynthesis which inhibits spore germination and growth of the pathogen, was examined as a seed treatment. DMSO, ethyl ether, and ethanol (5%) tested as carriers of the inhibitor for seed treatments for 6 min, 1 h, and 6 h, respectively, did not affect seed germination. Clofibrate at 0.02 mg per seed (5% ethanol carrier) afforded 50% fungus infestation reduction in 6 days in cultures of wheat seedlings containing 10^5 spores per millilitre of sand. Results from preliminary field trials were inconclusive.

VIRUS AND MYCOPLASMA

Peach-X disease

Twenty-five species of plants in 13 families were tested for disease susceptibility by exposing them to infective vector leafhoppers *Paraphlepsius irroratus*. Eight plant species developed the disease symptoms and infected plants were shown to contain typical mycoplasma cells. Based on high susceptibility to infection, insect palatability, and mycoplasma concentration, celery was found to be the most promising plant species for pathogen purification.

Forage legume diseases

Four viruses were identified in alfalfa from 26 isolates obtained in 1979. To determine the incidence of these viruses, extracts of each of 700 plants that were collected from seven alfalfa fields in Ontario were tested against antisera of the four viruses. Virus distribution was: alfalfa mosaic, 3–92%; tobacco streak and pea streak, 0–10%; and clover yellow mosaic, 0–12%. Incidence of five viruses, suspected to be present in red clover, was similarly determined by testing 350 samples collected from six fields. Incidence of viruses was: red clover vein mosaic and pea streak, 1–6%; clover yellow mosaic, 1–7%; bean yellow mosaic, 2–10%; and white clover mosaic, 4–11%. Two- to three-year-old alfalfa

or clover stands had the highest infection levels.

Examination of field-collected white clovers through electron microscopy revealed the presence of rickettsia-like organisms in some plants. The disease was transmitted to healthy plants by means of dodder. Infected plants showed severe stunting, leaf chlorosis, twisting, and reduction in size of leaflets. Both experimentally infected plants and the dodder contained rickettsia. This is the first record of a disease in Canada involving such an organism.

Aster yellows

The mycoplasma found associated with the disease was first detected serologically in extracts of aster plants 3 wk after infection. The mycoplasma concentration reached a peak by the 7th wk, remained at the same level for another 2 wk, and then declined to a lower level by the 13th wk. Leafhopper transmission pattern of the disease, after the vector leafhoppers *Macrostelus fascifrons* acquired the pathogen from plants of different infection ages, was similar to the mycoplasma growth curve.

Barley yellow dwarf virus

Tests on 140 samples of perennial grasses from five locations in Ontario revealed generally low virus infection levels (0–5%) with the exception of samples collected from Ottawa area which showed 40% infection. Three virus strains were identified in grasses and four in winter and spring wheat grain. An RP-specific strain was predominant in the grasses, whereas wheat contained only a nonspecific one. Virus incidence ranged from 1 to 8% in winter wheat; from 5 to 10% in spring grains at locations of very low grass infection; and from 2 to 3% in the Ottawa area. These epidemiological studies suggest a limited role of grasses as a source of virus for the cereal crops.

ENVIRONMENTAL CHEMISTRY

Inorganic chemistry

Biological availability of trace minerals from silages. A number of tissues from sheep fed with normal alfalfa and corn silages or with similar silages treated with trace minerals were analyzed using wet digestion – flame spectrometry. Different levels of Mg, Ca, Zn,

Cu, Mn, Fe, Cr, and P were present in samples of rumen, duodenal, and ilial digesta and components. A computer program for analytical calculations was used to assess the bioavailability of these elements from silage.

Detection of hazardous silo gases. A simple, inexpensive device for detecting the presence of hazardous gases in silos was identified for use by farm workers after a comprehensive survey of the literature and manufacturers of gas detection devices. Several certified, length-of-stain chemical detectors for nitrogen dioxide, the dominant toxic silo gas with a threshold-limiting value of 5 ppm, and other silage-produced gases were chosen for field testing. Modifications were suggested and testing protocols were established.

Organic chemistry

Ergot alkaloids. The variability in total and individual ergot alkaloid contents in wheat sclerotia collected from about 60 different locations throughout Canada was determined. The total alkaloid content was highly variable between sclerotia and ranged from 0.013 to 0.307% (av. 0.163%). Ergocristine and its isomer ergocristinine were the major constituents (~46%). Other alkaloid pairs observed were ergotamine (~17%), ergocryptine (~12%), ergocornine (~11%), ergometrine (~7%), and ergosine (~5%), together with some unidentified alkaloids (~2%).

Short- and long-term feeding of ergotamine to poultry showed that 5% reductions in weight gain resulted with diets containing 40–60 ppm of the alkaloid. Alkaloid residues in tissues, when detected, were very low (<10 ppb).

Pesticides

Pesticides in soils, plants, and food crops. Field microplots were treated with fensulfothion containing active ingredient (ai) at equivalent to field treatment rates of 8.48 and 16.96 kg/ha and with fensulfothion at 2.23 and 4.47 kg ai/ha for banded application. The half-lives in a sandy loam soil were 30–39 and 14–23 days, respectively. Fensulfothion sulfone and fensulfothion sulfide were the main derivatives found in fensulfothion-treated soil. The residue levels in crops at harvest decreased in the order carrot peel > pulp > rutabaga root > peel > pulp. The sulfoxide to sulfone ratio in rutabagas ranged from 0.4

to 1.5 and in carrots from 1.7 to 7.6. This phenomenon is thought to be due to active oxidative enzyme systems present in rutabagas. Dimethyl phosphorothioic acid, but not dimethyl phosphoric acid, was detected (max 1.33 ppm) in some rutabaga samples but not in carrots.

Effect of copper (0, 100, 200, 500, and 1000 ppm) on the degradation of fensulfothion in an organic soil was examined in a greenhouse study. Copper was rapidly adsorbed by the soil. The half-life of fensulfothion was 30–40 days with sulfone as the main derivative formed. During the first 30 days, soil with low copper levels degraded fensulfothion slightly faster. However, by day 52, there was no significant difference in the levels of fensulfothion in all the treatments.

Soil-bound ^{14}C residues were absorbed by the oat plants grown in an organic soil treated with ^{14}C -ring-labeled prometryn. The roots contained more extractable ^{14}C residues (75.0%) than did shoots (51.1%). The majority of extractable ^{14}C residues in the plant tissue was present in the form of conjugates. Plant-bound ^{14}C -unextractable residues were lower in roots (19.9%) but greater in shoots (40.2%). Mono- and di-*N*-dealkylated metabolites of prometryn were present in the plant-bound ^{14}C residues. A major bound- ^{14}C residue in plant tissues was associated with lignin.

Other studies demonstrated that time and method of atrazine application (pre-plant incorporated, preemergence, postemergence), and the presence of oil-surfactant additives in the herbicide formulation had no long-term effect on persistence. However, postemergence application, along with the presence of additives, resulted in slightly greater initial degradation rate of atrazine. In all treatments, application of atrazine at less than phytotoxic amounts and hydroxyatrazine persisted into the next growing season. Residues from the field-treated soil were taken up, metabolized, and conjugated by oats seeded in the following spring.

Pesticides in farm animals. Incubation of deethylatrazine and deisopropylatrazine with the soluble fraction ($105\,000 \times g$) from goose liver homogenates resulted in formation of the corresponding hydroxy analogues. No dealkylation of hydroxyatrazine occurred when incubation was carried out with the enzyme preparation. These data suggest that in the metabolism of atrazine by the soluble

fraction from liver homogenates, the formation of 2-hydroxy partially *N*-dealkylated metabolites occurs by the hydrolysis of the respective 2-chloro analogues rather than by partial *N*-dealkylation of hydroxyatrazine.

Analytical methodology and chemistry of pesticides. The performance of a range of element-selective detectors was studied using chlorpyrifos as a standard. Similar linear ranges were observed when standards containing one specific heteroatom were compared on different element-selective detectors. Because of the latter fact and its sensitivity to these detectors, chlorpyrifos was recommended as a common standard for the evaluation of gas chromatography detectors.

The hydrolysis of fenitrothion was studied in buffered distilled water, natural lake water, and buffered lake water. Above pH 8, the formation of 3-methyl-4-nitrophenol was demonstrated, whereas below pH 7 demethyl-fenitrothion was also detected. The half-lives for disappearance of fenitrothion at 23°C and pH 7.5 in natural lake water kept in the dark and in field plots were 49.5 and 1.5–2 days, respectively. This difference suggests that photolysis and microbial processes are the main degradative routes of fenitrothion in natural aquatic systems.

Identification of cultivars by pyrolysis gas chromatography. Pyrograms of four Canadian oat cultivars were obtained using a Curie-point pyrolyzer and capillary column gas chromatography. Fifty-seven peaks in each chromatogram were normalized and used as variables. The occurrence of a number of missing values in one or another replicate, and singularities in the covariance matrix, resulted in the use of only 10 variables for discriminant analyses. Four variables were sufficient for the correct identification, given the classification functions obtained. This approach to automated cultivar identification in oats shows promise but will require further investigation.

SOIL CHEMISTRY AND BIOLOGY

Soil chemistry and mineralogy

Exchangeable aluminum in soils. The ability of five extractants (NaCl , KCl , NH_4NO_3 , NH_4Cl , and CaCl_2) to measure exchangeable aluminum in soils was investigated. Ammonium salt solutions consistently extracted greater amounts of Al than did the

other solutions. The extra Al could have come from sources other than exchangeable Al. Orthic Ferro-Humic Podzol soils yielded more Al from nonexchangeable sites than did Orthic Luvic Gleysol soils. Corrections for contributions of Al from nonexchangeable sites need to be made if meaningful assessments of exchangeable Al in acid soils are required.

The aqueous and exchange chemistry of Al in selected soils was investigated by equilibrating the soils with 10^{-2} M solutions of CaCl_2 and CaSO_4 . Total Al was higher in the SO_4 system, whereas Al(III) was higher in the Cl system. The ion activity product $\text{Al}(\text{OH})_3$ was found to be higher in the CaSO_4 than in the CaCl_2 solution. Differences in ion activity products indicate changes in solid phases which control the products.

Mineralogy of Arctic soils. The mineralogical characteristics of 12 horizons, taken from five soil profiles on Ellef Ringnes Island, N.W.T., were determined. Little soil differentiation was found between parent materials and surface horizons. One of the Arctic soils contained a 7Å iron-rich trioctahedral layer silicate, whose occurrence in soils is unusual. A detailed analysis showed that this mineral was berthierine with an intermediate ferrous-ferric composition. Apparently the severely restricting weathering environment in the Arctic region contributed to the preservation of berthierine in this soil.

Cemented soil horizons. Chemical dissolution methods were found to be useful for the characterization of cemented soil horizons. Cementing agents ranged from inorganic amorphous substances containing Si, Al, and Fe to Al-Fe-organic matter and clay-organic matter complexes. In some soils imogolite was found to act as a cementing agent.

Separating amorphous from crystalline soil components. The separation of amorphous from crystalline components improves the sensitivity of X-ray diffraction methods for the quantification of soil minerals. Four dissolution methods, making use of solutions of Tiron, NaOH, Na_2CO_3 and citrate-dithionite, were tested. Dissolution with Tiron was found to be the most efficient procedure for this purpose.

Microbial formation of jarosites. The microbial formation in the laboratory of Rb- and Cs-jarosites was investigated. Crystalline Rb-jarosite was formed rapidly, only slightly

more slowly than jarosite but much faster than were NH_4 - and natro-jarosites. Cs-jarosite did not form under these conditions, probably because of the comparatively large ionic size of Cs.

Mineralogical analysis service

Some 1100 X-ray diffractograms were recorded on a wide variety of soils and minerals. In addition, 250 diffraction film patterns from Guinier, Gandolfi and Debye-Scherrer cameras were developed along with their densitometer patterns. A total of 65 thermal analyses were done. Some 325 infrared curves were recorded on soil minerals and mineral-organic complexes, and 50 Mössbauer spectra were recorded and analyzed for calibration and mineral identification purposes. Four least-square computer programs were purchased and used for assigning crystallographic indexes and for calculating X-ray diffraction patterns.

Soil organic matter and organic soils

'Unknown' soil nitrogen. Of 10 fractions separated from two soils by sedimentation, the silt-1 fraction (2–5 μm) was found to contain an unusually high 80% 'unknown' N, compared with only 52 and 30% 'unknown' N in the two adjacent fractions. The C:N ratio of the silt-1 fraction was 3. Mössbauer and electron spin resonance spectra showed that the organic matter in this fraction occurred as a Fe-organic matter complex with which the 'unknown' N appeared to be associated. Biodegradation experiments with soil microbes showed that the N in the silt-1 fraction was less available than the N in the two adjacent fractions.

The behavior toward mild chemical oxidation with peracetic acid of the N in one fulvic and three humic acids was similar. There were decreases in amino acid N and 'unknown' N but increases in NH_3 -N, NO_3 -N, and N gases. Between 16.6 and 59.1% of the 'unknown' N was converted to NH_3 and N gases, indicating that the 'unknown' N was not inert. Proportions of 'unknown' N in soils and humic materials were found to be affected by the method of hydrolysis. The most suitable method for obtaining reliable estimates of the 'unknown' N was continuous hydrolysis for 24 h with hot 6N HCl.

Chemistry of humic and fulvic acids. Significant new information was obtained on the fluorescence and viscosity behavior of

fulvic acid and its copper and iron complexes under widely differing experimental conditions. Fluorophore groups in the fulvic acid were found to participate in formation of metal complexes. The molecular flexibility of fulvic acid decreased with increasing formation of metal complexes. Some of the complexed metals formed bridges between fulvic acid molecules, thus bringing the macromolecular segments closer to each other. Fulvic acid was found to be more reactive at pH 6 than at pH 4 because of a reduction in intramolecular hydrogen bonding at the higher pH, which allowed the fulvic acid to interact more freely with metal ions.

Interactions of 11 metal ions, namely Hg(II), Fe(III), Al, Cr(III), Pb, Cu, Ni, Cd, Zn, Co, and Mn, with humic and fulvic acids under a variety of experimental conditions were investigated. Orders of sorption and of formation of water-insoluble precipitates were established. The data provided useful information on the fixation, release, transport, and immobilization of metals in terrestrial and aquatic environments.

Organic soils

To assess effects of incubation on the carbohydrate composition of organic soils, four peat samples were incubated for 1 yr at room temperature in the greenhouse. Bitumen and lignin-humic fractions increased during incubation but hemicelluloses and celluloses decreased. Xylose degraded most rapidly, whereas relative proportions of glucose increased.

Experiments on four sets of microplots on organic soils at Ste. Clothilde, Que., and Holland March, Ont., showed that yields of radishes, onions, and celery were not affected by the application of four times the recommended rate of copper. A net gain of up to 3 cm in soil height was noted in microplots started in 1978. The addition of copper appeared to adversely affect degradative soil enzymes in the microplots on which the crops were grown.

SYMBIOTIC NITROGEN FIXATION

Competition between *Rhizobium meliloti* strains

The ability of inoculum strains of *Rhizobia* to survive in soil and compete with less active nitrogen-fixing strains is a critical property which determines the effectiveness of inocula

to colonize the roots of legume forage crops. Methods have been developed for determination of the competitive ability of the many naturally occurring strains of *R. meliloti* to establish symbiotic nitrogen-fixing nodules on the roots of alfalfa.

Heterologous serological reactions of four *R. meliloti* strains, selected on the basis of differences in their nitrogenase activities, showed that they can be identified through gel diffusion tests. Plant passage of these strains did not change their immunodiffusion patterns.

Tests to determine the susceptibility of *R. meliloti* strains to a wide range of antibiotics indicate that the strains may be grouped on the basis of their antibiotic resistance or sensitivity. Although many of the strains possessed similar sensitivity patterns, the unique response of others to one or more specific antibiotics provides an additional aid for positive identification during studies to evaluate competitive ability for nodulation in alfalfa.

A third method of characterization which utilizes the specificity of infection of various strains by bacteriophages has been developed. Preliminary experiments showed that when indigenous strains of *R. meliloti* were each used as an inoculum and applied to freshly germinated alfalfa seedlings at 100 times the concentration normally found in soil, all of the test plants were fully nodulated at 9 wk of growth. However, bacteria isolated from individual nodules of these plants were found to be genetically different from those used as inoculum when characterized by rhizophage infection. The inoculum cells apparently were not effective as competitors against the other indigenous strains in the soil. This approach will allow selection of highly competitive strains for inoculation in the future.

Plant breeding

In collaboration with scientists at the Ottawa Research Station, a program was initiated for selection and propagation of individual alfalfa clones having outstanding nitrogen fixation activity in symbiotic growth with selected *R. meliloti* strains. Selection criteria will be based on screening tests previously developed as well as on conventional criteria such as root morphology and dry weight yield. Possible new criteria for

selection based on measurement of photosynthetic rates, efficiency of utilization of photosynthate for nitrogen fixation, and diurnal variations in nitrogenase activity of alfalfa seedlings are under investigation.

Rhizobium genetics

Nodulation and nitrogen-fixation-defective mutants of *R. meliloti* obtained by the insertion of $M\mu$ bacteriophage were characterized. Although these mutants contained $M\mu$ bacteriophage as evidenced by DNA-DNA hybridization and by the transfer of $M\mu$ from these mutants to *E. coli*, they were incapable of production of the phage particles. Their ability to stably maintain and to transfer $M\mu$ to other organisms was progressively lost with time. Electron-microscopic examination showed that the defects in abnormal nodules infected with these mutants are quite different compared with the abnormalities in nodules obtained following alfalfa infection with *Rhizobium* mutants obtained by ethylmethane sulfonate treatment.

Work aimed at mobilization of genes for an uptake hydrogenase system in *Alcaligenes eutropus* progressed slowly. Procedures were modified and a new class of auxotrophic mutants was obtained. These mutants were incapable of growth on CO_2 and H_2 conditions and were deficient in hydrogen uptake. Analyses of DNA content and type must be made to determine the basis of this defect and to understand the intracellular localization of hydrogen uptake genes. This project will possibly lead to construction of new strains of *R. meliloti* having the capability of recycling hydrogen gas which is formed as a byproduct of nodular nitrogenase activity. A new staff member has joined the program to provide the expertise in recombinant DNA and genetic engineering techniques that are important in developing such genetic approaches to inoculant improvement. To achieve success with these approaches, new information is needed concerning the location and organization of the genes for nitrogen fixation and symbiotic traits on very large plasmids.

Nutritional requirements for optimal growth and nitrogen fixation

Immature alfalfa seedlings do not utilize symbiotically fixed nitrogen effectively in support of early growth as compared with added nitrogen fertilizers. There appears to be a switch over to NH_4^+ utilization at about 23

days of growth. Alteration of this pattern to encourage early growth on symbiotic nitrogen may require both genetic alteration (plant breeding) and induction by nutritional management. Nutritional factors other than fixed nitrogen which influence the development of high nitrogenase activity in root nodules have been identified. The balance of cation concentrations have proven to be important factors in this regard. Concentrations of Mg^{2+} and Ca^{2+} , which produce maximal nitrogen fixation and growth, have been identified. Studies of the bacteroid membrane physical properties suggested that divalent cations are essential for maintenance of the membrane in a state which supports optimal energy supply to the nitrogenase enzyme system.

WINTERHARDINESS

Field and controlled environment studies

Winter survival of 10 winter cereal cultivars was assessed from plantings established at seven different sites to determine suitable cultivars for production in Eastern Ontario. Survival was high in all regions due to an unusually open winter in 1979-1980, and significant cultivar differences were not observed at most sites. Low survival was recorded only from samples taken from commercial winter wheat plantings under natural ice cover and in extremely exposed locations. Snow mold damage was minimal in test plots and commercial fields due to low snow accumulation. Seventy-five lines of wheat and triticale from Guelph, Harrow, and Ottawa were ice encased in the field in January. Seventeen of the lines tested were found to be significantly more tolerant to ice encasement than the commercially grown check variety Fredrick. Investigations of the promotive effect of prior flooding on subsequent survival of winter cereals after ice encasement implicated increased levels of alcohol dehydrogenase produced during prior flooding in this promotive effect. Forage grasses were found to be more susceptible to freezing injury but more resistant to ice-encasement injury than winter wheats. Studies on changes in tolerance to winter stresses of cereal plants due to virus infection showed that infected plants of two wheat cultivars dehardened less than noninfected plants under warm temperature regimes used for virus infection and disease development. Also, uninfected plants rehardened more readily than those infected with

virus on further exposure to hardening temperatures. Inhibition to rehardening increased as the virus incubation period in the plants was increased. Infected plants were 2–3°C less hardy than the healthy plants.

Cellular and membrane studies

Electron spin resonance spectroscopy was employed to examine changes in the properties of cellular membranes during cold acclimation and freezing of winter cereals. During freezing, membranes of protoplasts obtained from hardened and nonhardened rye seedlings respond in a manner similar to that of egg yolk lecithin liposomes subjected to either freezing or dehydrative stress. Membrane packing caused by extracellular freezing was most pronounced near the polar head groups of the phospholipid bilayer, and the rigid limit of the membrane was reached at -12°C in both hardened and nonhardened protoplast membranes. Measurements of the fluidity of membrane lipids from wheat seedlings of contrasting freezing tolerance demonstrated a lack of correlation between changes in membrane fluidity and cultivar hardiness. These observations suggest that changes in the physical properties of membrane lipids may not be a prerequisite to the development of freezing tolerance in winter cereals.

Methods were developed for the successful isolation of single mesophyll cells from hardy and nonhardy rye seedlings. These cells retain the freezing and dehydrative resistance properties of intact seedlings and will be used for biophysical studies of freezing phenomena. Ultrastructural studies on frozen and ice-encased winter wheat crowns fixed in the frozen state showed that lethal damage by low freezing temperatures is accompanied by severe cell disorganization, whereas little structural damage occurs during lethal injury by ice encasement just below the freezing point.

Desiccation studies

Considerable progress has been made in attempts to develop a method for rapid screening of large numbers of cereal lines for cold hardiness, based on the close relationship between cold and drought tolerance. The 24-h induction of freezing tolerance by desiccation stress, and the concomitant protoplasmic augmentation, has been confirmed. In several cultivars, tolerance to freezing developed under normal low temperature acclimation

was closely correlated with that developed in 24 h by desiccation. If this correlation is found to apply to a wide range of cereal cultivars of contrasting hardiness, this method could eliminate the need for cold conditioning equipment and protracted periods of conditioning normally required for assessing hardiness potential of cereal lines.

ANALYTICAL CHEMISTRY SERVICES

The Analytical Chemistry Services continued to provide Branch establishments with a comprehensive service in analyzing materials as part of research programs. A method for rapid estimation of sulfide in rumen and blood with a sulfide-specific electrode was developed. The method is now being used routinely for the determination of free sulfide in rumen fluid and acid-labile sulfide in blood.

The four subunits of the Analytical Chemistry Services completed more than 88 000 analyses. The Amino Acid Laboratory carried out 2494 protein hydrolysates and 633 physiological fluid samples analyses. The Instrumentation Centre used capillary column GC-MS as a routine analytical technique for separation of some components in complex biological samples. The Centre produced 1664 spectra consisting of 236 nuclear magnetic resonance, 208 infrared, and 2057 mass spectra. The Micro Analytical Laboratory carried out 6739 organic elemental microanalyses. The Technical Service Unit performed 60 642 analyses for a wide variety of constituents. The Unit consistently employed the two computer Datacom 400 terminals which improved the calculations, compilation, and sorting of analytical data. The Glassblowing Service Unit processed more than 100 orders for various Branch establishments.

ELECTRON MICROSCOPE CENTRE

Sixty professional and technical staff of six institutes, five research stations, three universities, and four outside agencies made use of the personnel and facilities of the Centre. The Postal Service responded to requests by research workers at the Harrow and St. John's West research stations and at L'Assomption and Smithfield experimental farms.

The Centre contributed to research papers in a number of diverse disciplines including biosystematics; microbiology; plant pathology;

and plant, animal, soil, and food sciences. Particulars of these publications appear under the listings of the institutes and stations in this report.

In-house research projects included the development of techniques for high-resolution

studies on the structure and arrangement of plant and bacterial DNA; the development of replica techniques for viewing the macromolecular configuration of soil organic matter polymers; and the assessment of imposed insults on the nature of eggshell fractures.

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Departures

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INTRODUCTION

In 1980 the Institute was reorganized to reflect the changes in programs to meet departmental priorities. Staff in various sections working on energy research and development (R & D) were assembled to form an energy section to better coordinate the work in this increasingly important area. The remainder of the staff working on agricultural engineering R & D in the Mechanization and Systems and the Structures and Environment sections were assembled to form a single section, called Structures and Mechanization. This reflects the focus of the agricultural engineering program on structures and mechanization and the reduced emphasis on systems and environmental engineering. A new Food Engineering Section was formed to expand this program in response to the departmental priority on the processing, distributing, and retailing sectors of the agribusiness system.

The diverse activities of the Institute in engineering and statistics involved 216 projects, of which 56 were completed during the year. The internal work was supplemented by 66 research contracts on energy, buildings, and mechanization, of which 19 were completed. The contracted work now represents 20% of the total program. The outcome resulted in the release of 93 publications; those that are published are listed at the end of this report. Further information is available upon request from the Engineering and Statistical Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Peter W. Voisey
Director

ENERGY

All the R & D work was contracted out in 1980 and plans were completed for a considerable expansion of this activity under the national energy program. In-house R & D was also initiated.

The program included work on energy conservation in mechanization, farm buildings, greenhouses, and food processing. Application of solar technology to greenhouses, crop drying, and farm buildings was also studied. Studies on renewable energy from biomass focused on methane from manure, direct combustion of residues, and fuel alcohol from residues, culls, and crops. A review of the fuel alcohol potential from the agribusiness system was completed.

To date the results from the program are contained primarily in unpublished contractors' reports, which are available on a loan basis (or as microfiche copies) from the Institute. Summaries of these reports were published to indicate the information available.

FOOD ENGINEERING

The program concentrates on process and equipment development and on the study of the fundamental properties of foodstuffs. A

new process for separating γ -globulins from swine blood was developed using differential salting out of proteins, centrifugation, and electro dialysis. Continuous microwave processing of oilseed to inactivate myrosinase was found promising. A computer simulation of heat transfer in retortable food pouches and instrumentation to monitor pilot scale experiments were developed.

A number of techniques and the necessary instruments were developed for measuring food quality. Factors measured included graininess of tomato juice, wheat hardness, and dough development. The past work in this area is coming to fruition, with a number of Canadian food companies adopting the techniques.

RESEARCH SERVICE

Work on the development of instruments and equipment to support research operations across the Branch continued and produced a range of equipment for use in both research and regulatory work of the department.

Plot equipment included a rainfall simulator, a portable herbicide sprayer, a string-spaced seeder for cereals, a tobacco leaf lamina punch, a cereal sample bag aeration punch, an oat dehuller, an oat classifier, an

oat thresher and polisher, a scutcher vacuum dust collector, and a soybean seed cleaner.

Laboratory equipment included an automatic cigarette diameter control, a spore counter, an electronic heat sink for microscopes, and an automatic weighing system for a micro flour mill.

Scientific instruments included an open path CO₂ analyzer. Flight tests showed its capability for measuring variations in CO₂ flux over crops, forests, water, and terrain. A ground coverage and leaf wetness measuring system was also developed. Work was carried out on the development of remote sensing techniques using field spectroscopy to detect yield, disease, stress, variety, and crop. Field tests continue to demonstrate the potential for the techniques as a research and crop estimation tool.

STRUCTURES AND MECHANIZATION

Structures

The Canada Plan Service continued to work according to national committee priorities. Emphasis was on beef cattle, swine, and dairy cattle; completed were 49 trusses, 7 plans, and 18 revisions, with 63% of the plans now in metric measurements.

An up-to-date index of plans and leaflets was published. Listed are 13 plan sets and 32 leaflets on beef cattle facilities; 24 plan sets and 31 leaflets on dairy cattle; 27 plan sets and 32 leaflets on swine; 16 plan sets and 33 leaflets on sheep; 9 plan sets and 8 leaflets on poultry; 10 plan sets and 12 leaflets on fruit and vegetable storage; 15 plan sets and 16 leaflets on grain, forage, and feed storage; 21 plan sets and 25 leaflets on special structures; and 4 plan sets and 15 leaflets on building engineering. Generally the plans and leaflets are available in English or French and in Imperial or metric measures, except that Imperial measure is progressively being phased out. Also, 13 departmental bulletins on farm buildings have been published. Copies of the index are available from: Information Services, Agriculture Canada, Sir John Carling Building, Ottawa, Ont. K1A 0C7.

A new, improved sandwich-design wall panel was developed. Multiple-shear, nailed joints were analyzed. Expanded data collection on snow loads commenced. Friction

angles for corn were measured, and new silo-erection equipment was designed. Tests showed failure loads lower than expected for long-span wood trusses.

Two major projects on manure handling and land application were completed. Effect on crop growth and groundwater quality were defined. With handling costs at 25% of the nutrient value, and winter land application unacceptable, good management is necessary. Materials for floating covers were tested, and the covers were found to suppress odors from liquid manure tanks.

Silo foundation settlement data were recorded for another empty-fill cycle, and a study showed that silo foundation costs can be reduced considerably.

Mechanization

Work on narrow-row seeding and bed-seeded vegetables produced two new seeders, a modified harvester, and three tested toppers. Two other improved seeders are in use by clients.

In harvesting horticultural crops, a new juice-apple sweeper prototype was built and was found to work well in Ontario and Quebec orchards. Height control was improved on a tomato harvester, and a sensing shoe was built for possible field use. A spinach harvester was developed and is in production, and a leek harvester was improved. Work has started on a multiple picking cucumber harvester and a cauliflower tier.

Silage distributors were evaluated and improvements suggested, fans to purge silo gas were evaluated, and gas detectors and gas production are being studied. Development of a round bale processor has progressed to preproduction prototypes.

Work on grain storage and drying included evaluating a belt dryer; adjustments were determined that increased capacity 20% and efficiency 15% while drying corn acceptably.

In Burley and cigar tobacco mechanization, racks were made lighter and less expensive in a new rack wagon.

New design tracks were installed to improve performance of the peatland tractor.

Modifications to a manure injector were made to overcome problems in operation in sod, and the unit is in operation at Kapuskasing.

Under the project research applicable in industry (PRAI) program and the industry research assistance program (IRAP), an

elementary combine feed rate control was developed, and testing and market development continued on sickle knives.

The agricultural engineering computerized data base of technical and scientific information continued to expand.

STATISTICS

Statistical support was provided to many research areas through collaborative work, particularly in poultry research and the study of toxins, trace element metabolism, disease resistance in sheep, and swine and cattle research. Bioassay studies of mixtures of slow- and fast-acting agents, and mixtures to obtain synergistic effects, were designed and interpreted. A coordinated approach to support tobacco research involves studies of field conditions, genetic and chemical parameters, manufacturing processes, health aspects, yield, and sampling methods at the research stations at Delhi (cigarette tobacco) and

L'Assomption (cigar tobacco). Crop-loss estimation procedures are being investigated for corn and soybeans. A general study is being made of genotype \times environment interaction. Support is being provided for the barley breeding program and for the potato program at the Research Station at Fredericton.

Statistical software was implemented on the new departmental computer network (AgNet) that will handle 60–80% of the analyses needed by researchers. In addition, software has been implemented to simplify data input and preparation of analyses.

TECHNICAL SERVICES

Technical services continued to provide a service for the fabrication and maintenance of scientific equipment. A preventive maintenance program for scientific equipment (e.g. growth chambers and centrifuges) was initiated. During the year, 1900 work orders were completed.

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Food Research Institute

Ottawa, Ontario

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E. LARMOND, B.Sc.	Assistant Director
J. SCHAFER	Acting Administrative Officer

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D. F. WOOD, B.Sc. (Agr.), M.Sc., Ph.D.	Meat processing

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M. KALAB, M.Sc., Ph.D.	Electron microscopy
C. Y. MA, B.Sc., M.Sc., Ph.D.	Protein functionality
R. C. MCKELLAR, B.Sc., M.Sc., Ph.D.	Microbiology
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C. G. ZARKADAS, B.S.A., M.Sc., Ph.D.	Meat proteins

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W. J. MULLIN, L.R.I.C., Ph.D.	Analytical methodology
A. C. NUNES, B.Sc.	Nutrient analysis
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H. W. MODLER, B.S.A., M.S., Ph.D.	Dairy products
G. PAQUETTE, B.Sc., (Agr.)	Dairy products
M. SAHASRABUDHE, B.Sc., M.Sc., Ph.D.	Lipids
J. WEISZ, B.Sc.	Carbohydrates

Departures

D. DOBSON Promoted to new position 1 August 1980	Administrative Officer
JOHN R. QUINN, B.S.A., M.S., Ph.D. Deceased July 1980	Meat processing

INTRODUCTION

The Food Research Institute (FRI) was pleased in making substantial progress in its staffing activities during 1980. Several additions to professional staff were realized, which permitted the Institute to attain most of its goals in research in the year. The Institute welcomes all these new members. Dr. C. Y. Ma has initiated projects on the physical-chemical and functional properties of food proteins. Dr. B. Oomah has joined the cereal processing program and is engaged in research on oat fractionation and functional assessment of fractions therefrom. Dr. W. Collins came to FRI from Biosystematics and has renewed research on the phenolic constituents of cereals and oilseeds. D. Froehlich joined the food quality team, where she will be further developing the sensory evaluation area of our program. F. Russell has begun her research on the nutrient data base for Canadian fruits and vegetables. G. Paquette has joined the dairy research group and he has taken on duties for administering our large contract research program in that area. J. Weisz was promoted to the professional staff and will be operating the Institute's new carbohydrate analytical laboratory and continuing his research on carbohydrates.

The Department and the Institute were deeply saddened by the untimely death of Dr. John Quinn, who had maintained a valuable research program in meat and plant proteins over several years with FRI.

During the year Dr. John Mullin began a transfer of work at the Food Research Institute in Norwich, England, where he will be studying new methodologies in glucosinolate analysis and nutrient composition determination.

The Institute's programs in utilization of agricultural resources progressed well in 1980 with continued growth of contract research, addition of new in-house projects, and expanded collaboration with industry in most areas of its program. Institute staff continued to serve on important national and international committees endeavoring to coordinate research and development (R & D) activities and to detail future R & D needs.

Highlights of the year's results are described in this report. Inquiries for more information should be directed to the Food Research Institute, Research Branch, Agriculture Canada, Ottawa Ont., K1A 0C6.

John Holme
Director

FOOD PROCESSING

Extrusion cooking

Outside interest in FRI research directed toward the measurement of the degree of cook of extruded cereal products has resulted in the formation of a Technical Committee of the American Association of Cereal Chemists to evaluate this and other related methodology.

Mechanisms of cake baking

Extensive layer cake baking experiments have been conducted using a novel oven design which monitors the net internal forces during the development of a baking cake. Such measurements are responsive to formulation-ingredient changes. It has been shown that sugar and oil act in opposition to the protein and starch components; sugar and oil lower the net internal forces, whereas protein

and starch increase them. A fully baked layer cake shows a moderate net positive force development. The wheat flour used in cake baking is normally chlorinated to give cake improvement; it has been shown that a chlorinated flour when used in a cake formulation gives rise to a consistently higher net internal force value than does an unchlorinated wheat flour. These findings further corroborate the well-known roles which have been previously established for the cake system.

Meat products

The changes in heat stability of beef protein during processing of meat into sausage batters has been studied using differential scanning calorimetry (DSC). Neither the mechanical work done nor the presence of fat affected the protein structural stability, but the presence

of NaCl drastically lowered the temperature of denaturation. This effect was partly reversible upon dialysis. Rabbit and pork muscle behaved in a similar fashion. The role of salt in decreasing the temperature of denaturation may be critical to the manufacture of batter-type meat products. Through contracts, methodology has been developed for microscopic examination of meat batters and for determining least-cost formulations of poultry meat-sausage blends.

FOOD QUALITY

Dairy products

Yogurt. Yogurts were manufactured in which the hydrocolloids were replaced with a variety of dairy-based proteins and then subjected to physical and sensory evaluation tests. The objective was to prepare an all-dairy yogurt that would utilize more milk solids or protein or both. Three whey protein concentrates (WPC), one milk protein concentrate (MPC), casein, and skim milk powder (SMP) were tested at the 0.5, 1.0, and 1.5% levels of addition. All products had levels of syneresis which exceeded the gelatin control, with casein at 1.5% having the least syneresis. Products with firmness similar to gelatin control were unacceptable in terms of syneresis; however, all products were equal to or better than the control with respect to flavor. The ultrafiltered-WPC (1.5%) and MPC (1.5%) had thicker consistencies than the control, whereas the remaining samples were the same as or thinner than the control. Three products, ion exchange - WPC at the 1.0% level and electrolyzed-WPC at the 1.0 and 1.5% levels, had a texture comparable to gelatin. The remaining 15 formulations scored higher in terms of smoothness, with casein being the superior product. An overall ranking of ingredients revealed that 9 of 18 treatments were acceptable in all respects, except for syneresis. Six of the nine products contained casein.

Generally it can be concluded that products containing casein (MPC, SMP, and caseinates) at levels of 1.0 to 1.5% are acceptable substitutes for gelatin and can be faulted only on the basis of syneresis. The whey protein concentrates used at 1.0% and casein containing products at 0.5% produce one or more serious defects in yogurt.

Milk quality. The survival of heat-stable extracellular protease of microbial origin in processed milk presents a serious shelf-life problem. Studies were initiated to determine the correlation between proteolysis and the development of off-flavors in milk, with a view to developing a rapid test for proteases.

The addition of crude proteases to ultra high temperature (UHT) and pasteurized milk resulted in the breakdown of milk proteins as measured by the increase in trichloroacetic acid soluble free amino groups using trinitrobenzene sulfonic acid and by the development of off-flavors. Proteolysis could be detected in milk samples that had received insufficient protease to cause off-flavor. Significant off-flavor was detected at various levels of proteolysis for each of the three enzymes tested. Long-term studies are in progress to determine if trinitrobenzene sulfonic acid can be used to monitor stored UHT milk.

Protein functionality

The effect of chemical modification on the physicochemical and functional properties of food proteins was studied. Succinylated wheat gluten, rapeseed protein concentrate, and oat protein were found to have improved solubility, emulsification capacity, and water hydration capacity. Succinylated egg albumin has distinct physicochemical properties and is more resistant to heat coagulation. Data suggest that ionic interaction is essential for thermocoagulation of egg white proteins, with disulfide and hydrophobic interactions playing a role in the initial stages.

Microstructure

A technique was developed for high-resolution electron microscopy of dried milk products. It is based on coating the dried product with platinum while the specimen is rotated, backing the coating with carbon, and separating the double layer in the form of a replica which is subsequently cleaned and examined under a transmission electron microscope. Submicellar ultrastructure of casein micelles was visualized in this way.

Differences in the microstructures of traditional and newly formulated cream cheeses were found by electron microscopy. Fat globules remained almost intact in the traditional products but were coalesced in the newly formulated products. Manufacturing

processes were found responsible for the different microstructures.

In collaboration with Utah State University, we detected crystals of emulsifying salts in process cheeses by electron microscopy. The results suggested that the use of salt solutions might be more efficient than the current practice of adding salt in the crystalline form. Because only the salts solubilized in the cheese curd contribute to the emulsification of fat, the portion of crystalline salt that remains undissolved is not being utilized.

Carbohydrates

A systematic fractionation of lower molecular weight tobacco carbohydrates by various chromatographic techniques has led to the recognition and characterization of a number of monosaccharides and oligosaccharides: D-glucose, D-fructose, sucrose, myoinositol, D-xylose, D-ribose, D-psicose, D-sorbitol, maltose, gentiobiose, glucopyranosyl-myoinositol, di-D-glucopyranosyl-myoinositol, gentianose, and erose. Some of these were not previously known to occur in tobacco.

Tobacco contains a number of alkaloids, of which nicotine predominates. The recognition, quantitation, and characterization of 1-(1'-2'-S-nornicotino)-1-deoxy- β -D-fructose from Canadian tobacco (Delhi 76) is a first attempt to discover bound nornicotine in a good-quality Canadian tobacco. The Cherry Red strain of Bright Yellow tobacco, an inferior variety that contains nornicotine as a principal alkaloid, contains the nornicotine-fructose derivative at around 1% of dry weight. The Delhi 76 contains 0.3–0.4% of this compound, which is regarded as an undesirable leaf component because it imparts a disagreeable taste to smoke. Additionally, based on the presence of both secondary amines and oxides of nitrogen, it is feasible that interaction between these compounds could produce nitrosamines, which would account for the implication of tobacco smoke in tumor growth. Indeed nitroso derivatives of nornicotine have been shown to be carcinogenic in laboratory animals.

Natural back mutation of nicotine-type tobacco to Cherry Red type has been known to occur about 0.8% in a generation. It appears that Delhi 76 is undergoing such mutation. Obviously the Delhi figure of 2.75–3% total alkaloids with 95% nicotine for Delhi 76 needs to be reevaluated in view of the

presence of this bound nornicotine/fructose Amadori product.

Sensory evaluation

Sensory evaluation has been conducted in support of several projects within and outside FRI and also outside the government. Product characteristics evaluated include milk flavor, butter flavor, veal quality, chicken quality, and beef tenderness.

Electrical stimulation

The effect of electrical stimulation (ES) on the sensory quality of A1, C1, and D1 grades of Canadian beef cattle was determined. Fifteen animals from each grade were split at about 30 min postslaughter and half of each carcass was stimulated (600 V, 2.18 A) with 17 pulses of 2-s duration followed by 1-s pauses. Steaks from the loin and round were evaluated for tenderness, juiciness, flavor, and overall acceptability; Warner–Bratzler shear values were also determined. No positive improvements were found for any of the parameters studied, as a result of the ES treatment.

Milk-fed versus grain-fed veal quality

Samples were obtained from the loin and round of grain-fed and milk-fed veal. The sensory attributes tested were: raw and cooked color, tenderness, flavor, juiciness, and overall acceptability. Warner–Bratzler shear force was also determined. These attributes were determined for fresh veal and for duplicate cuts of each muscle which had been frozen at -20°C and held 4 mo before evaluation. The fresh grain-fed veal cuts were judged to be significantly more red in color and significantly less tender by Warner–Bratzler shear. However, the panelists did not detect the tenderness difference and rated both milk-fed and grain-fed cuts equal in overall acceptability. The freezing did not appear to affect the quality, as panel scores for the frozen samples were similar to those for the fresh veal.

Contracts

Fat levels in ground beef. A survey of fat levels in ground beef at the retail level revealed that in most cases fat levels are well below regulatory limits. This is a reflection of the inadequacy of current fat determination techniques for in-store use. Methodology and

regulations have been reviewed and recommendations are being developed for both government and industry.

Mechanically deboned meat. The rheology and bone strength of chicken, beef, and pork meat have been determined. The data obtained are to be used in modifying deboning equipment in order to improve end product texture.

Meat proteins

The new amino acid methodology recently developed in this laboratory for the determination of the myofibrillar and connective tissue contents of meats and composite meat products was successfully applied to a variety of composite meat samples. The determination of the N^Y -methylhistidine and 5-hydroxylysine contents of selected composite meat products was carried out by this chemical approach with an accuracy of 0–3%. The method has also been successfully used for an accurate nutritional assessment of novel protein supplements, such as fish and crab meals and potato waste products, in broiler poultry diets. Further application of the method has shown previously unreported methylation in certain important purified muscle proteins.

FOOD SAFETY AND NUTRITION

Microbiology

Mold inhibition on salami casings. Potassium sorbate and natamycin (pimaricin) were used to prevent uncontrolled surface mold growth on several types of raw-cured Italian dry salami during ripening under commercial production conditions. Salamis were dipped into, or sprayed with, natamycin or they were given a combined organic acid plus potassium sorbate treatment. Acetic and citric acids potentiated the inhibitory effects of potassium sorbate significantly, but lactic and succinic acids showed no effect. At 10% potassium sorbate on all types of salami and 2.5% sorbate on Casalingo salami, visual inhibition of mold growth was observed. Natamycin spray (2×1000 mg/L) was as effective or slightly better than 2.5% potassium sorbate, but greater concentrations of each were required to satisfactorily inhibit surface mold growth during the 25- to 50-day ripening period. The lowest most effective concentration of potassium sorbate was 5% when

applied as two separate 60-s dips at day 0 and day 5 of curing.

Sorbic acid methodology. A method for determining sorbic acid in dry salami was developed and used to follow the sorbate penetration into the salami after treatment. It was found that the residual sorbic acid in slices of these salamis was directly related to the concentration of the dipping solution used and inversely related to the diameter of the salami. Salametti salami, dipped twice into 5% potassium sorbate, contained 332 mg sorbic acid per kilogram after 25 days of ripening. Natural casings tended to retain more sorbic acid after dipping than did regenerated collagen casings.

Contracts. Four contracts were completed during the past year with the main highlights being as follows.

(a) Catalase destruction can be used to monitor the extent of cooking of sausage batters. The method will be used in the plant.

(b) Water flow rate and methods of sanitation of poultry chillers need to be standardized and controlled. A report was sent to all Agriculture Canada personnel across Canada.

(c) Many organisms isolated from cheeses showing late gas were screened and *C. tyrobutyricum* was not found.

(d) Sampling of bird feathers prior to shipment was found to be a reliable indicator of *Salmonella* status of broiler flocks.

Amino acid derivatives

The synthesis of new essential amino acid derivatives was terminated. Biological testing showed a variety of potential uses for some of these compounds. Methionine, tryptophan, and threonine derivatives were found to exhibit strong biostatic activity toward several strains of bacteria (zone inhibition studies).

Nitrosamine analysis

Two contracts are currently in place. The first is to develop an improved method for nitrosamine analysis which does not need extremely expensive detection systems, and the second is to determine the source of extremely low, but consistent, levels of dimethylnitrosamine in cured meat products.

Vitamin analysis

Folic acid. A number of improvements have been developed for the standard microbiological assay procedure. Data have been

accumulated for several broccoli and spinach varieties over two different growing seasons.

Vitamins A and C. The vitamin A and vitamin C contents of a number of cultivars of spinach, carrots, and cabbage have been determined. The loss of vitamin C on storage of spinach at 4°C has also been determined. Up to 80% of the vitamin C content of spinach may be lost during 10 days storage at 4°C. Mini carrots were found to contain about 75% of the amount of vitamin A found in regular carrots.

Glucosinolate studies

An improved method for the high pressure liquid chromatographic determination of glucosinolates has been developed and successfully applied to quality control of mustard and horseradish.

NEW FOOD INGREDIENTS

Oats

Carbohydrates. Studies have continued to establish that the dyes Congo Red and Calcofluor may be used to specifically locate cereal β -glucans histochemically (collaborator: Dr. R. G. Fulcher, Ottawa Research Station). Staining of oat, wheat, and barley aleurone and endosperm cell walls by Congo Red and Calcofluor is largely removed after treatment with a β -glucanase specific for the $\beta(1\rightarrow4)(1\rightarrow3)$ -D-glucan of cereal cell walls. Crude cell wall extracts, wheat pentosan preparations, and wheat arabinogalactan-peptide either did not interact with dye in solution or did not interact with dye following removal of contaminating β -glucan.

Loss of β -glucan interaction with dyes during incubation with β -glucanases parallels loss in viscosity, and can thus be used to follow endo- β -glucanase activity. The technique employed for routine endo- β -glucanase assay utilizes the concentration dependence of rate of radial diffusion of enzyme into a substrate-bearing gel slab. The area of diffusion, which is proportional to the logarithm of enzyme concentration, can be visualized by means of interaction of Congo Red with undergraded substrate. The technique is suitable for routinely monitoring a large number of samples for $\beta(1\rightarrow4)$ -, $(1\rightarrow3)$ -, and $\beta(1\rightarrow4)(1\rightarrow3)$ -glucanase activity by use of

CM-cellulose, CM-pachyman, and oat β -glucan, respectively, as substrate. Cereal extracts, both germinated and ungerminated, malt, and a large number of fungal enzyme sources have been examined in this fashion.

Phenolics. Fluorescence microscopy of hand-sectioned oat grains (cultivar Hinoat) using the flavone-flavonol fluorochrome, diphenylborinic acid, ethanolamine complex has revealed flavonoid-like compounds in the aleurone and subaleurone layers. The embryo and central endosperm tissues are devoid of this type of phenolic reaction. The flavonoid-like constituents are only partly extracted from the tissues using standard aqueous alcohol extraction procedures. Examination of the extractable components by preparative column chromatography and high-resolution thin-layer chromatography revealed a complex mixture of as many as 25 different flavonoids. Kaempferol and quercetin (3,5,7,4'- and 3,5,7,3',4'-OH-flavone) have been identified from this mixture, which marks the first reported occurrence of 3-OH-flavones in the cereals. The major components of the flavonoid mixture were tightly bound to anionic exchange columns, suggesting that the majority of oat flavonoids may be substituted with free acidic functions and may be ionically bound to cationic substrates in the tissues.

Fluorescence microscopy of hand-sectioned oat grains indicated that the peripheral region of the grain contained *para*-dimethylaminocinnamaldehyde-positive components. The distinctive long ultraviolet-stimulated red orange fluorescence in the grain is characteristic only of aromatic primary amines. In vitro testing of a wide number of aminophenols and aminobenzoic acids using cellulose and polyamide adsorbents to simulate the in vivo staining matrix of the grain suggests the reactive substance contains an *ortho*-aminophenol function. In thin sections, the aminophenol-like material was restricted to the aleurone layer and within these cells was confined to the protein bodies.

In view of the high redox potential and propensity to form highly colored oxidation products, the structure and properties of these oat components are of potential importance in evaluating color quality of processed oat ingredients.

Lipids. A simple microquantitative method for the estimation of lipase activity in cereal grains has been developed. The method is

based on the colorimetric estimation of free fatty acids hydrolyzed from the endogenous neutral lipid.

Oilseeds

Progress has been achieved in evaluation of the FRI 1975 process to produce rapeseed oil and meal of improved quality, but further improvements in technology are required before commercialization.

A contract study at the University of Toronto on an improved process for rapeseed protein isolate preparation has shown an insoluble by-product to contain 26–33% protein, 23–34% fiber, and no detectable glucosinolate, and to possess good nutritional value. Waste-disposal problems associated with the whey-protein by-product was effectively reduced by bentonite treatment, which allowed recovery of a soluble protein fraction.

A contract study at Laval University on proteolytic products from plant and animal proteins as nutritional indicators showed that casein and animal proteins (controls) gave the highest nutritional values. Of rapeseed, soya, and wheat concentrates, rapeseed protein concentrate (RPC) had the highest nutritional value and was equal to that of casein. Autoclaving improved the nutritional value of the 2 S plus 11 S fraction of soya but the fractionated proteins had significantly lower value than the unfractionated. Admixtures of different plant proteins generally increased the nutritional value above that of the individual components, but addition of wheat albumin – globulin and glutenin to RPC significantly decreased the nutritional value of RPC.

Contracted investigations to study the effect of heat processing on canola proteins showed that the pre-cooking and steam-desolvation steps decreased the protein solubility of the meals.

A contract to evaluate, with rapeseed, a US patent for preparing an oil-protein complex (from soybean) was unsuccessful in obtaining an oil-protein complex from the rapeseed.

Whey protein

To gain understanding of the differences in functionality of whey protein concentrates (WPC) prepared by heating before (heat-UF) or after (UF-heat) ultrafiltration, proteins of

WPC were further evaluated by the determination of intrinsic viscosity $[\eta]$ and fluorescence emission spectra. The $[\eta]$ of denatured proteins, soluble at pH 2.5, generally increased with pH of heat treatment in both the methods of preparation. This is indicative of greater unfolding at the higher pH's of heating. The viscosity data correlated with the increased water binding capacity of WPC prepared by heating at higher pH. The fluorescence intensity decreased with the increased extent of denaturation, indicating changing hydrophobic conditions for the residues causing fluorescence.

In model systems, β -lactoglobulin (β -lg) denaturation was examined by susceptibility to proteolysis and by fluorescence spectroscopy. β -Lactoglobulin, thermally denatured at pH 2.5, showed increased rate of hydrolysis by pepsin. Changes in fluorescence emission spectra in 1, 2, 4, and 8 M urea were examined. The emission maximum (λ_{max}) increased from 334 nm to 349 nm in the presence of 8 M urea. A similar red shift was not observed with lower concentration of urea (excitation was at 285 nm). However, intensity of fluorescence, as indicated by peak height, decreased with increasing urea concentration, although width at half height showed change only with 8 M urea. Heat denaturation of β -lg also causes a decrease in peak height and increase in λ_{max} from 333 nm to 337 nm but no change in width at half height. The differences in fluorescence behavior between different concentrations of urea and between urea and heat denaturation of β -lg arise from a different degree of unfolding and are consistent with the previously reported viscosity and optical rotation data.

White bean

Four varieties of white bean were analyzed for proximate and amino acid composition and air-classified into high-protein and low-protein fractions. The lipids, oligosaccharides, and minerals were concentrated in the high-protein fraction. More than 80% of protein was soluble at pH 7.5. Functional properties of the protein were comparable to those of other vegetable proteins. The starch from the low-protein fraction contained 30% amylose and gave torque-temperature curves typical of legume starches.

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Departures

W. B. BAIER, Diplomlandwirt, Dr. agr., M.Sc. Seconded to Branch Coordination and Evaluation Directorate, 18 August 1980	Head of Agrometeorology Section
C. E. OUELLET, B.A., B.Sc.A., M.Sc. Retired 29 December 1980	Ecoclimatology
R. B. STEWART, B.A., M.Sc., Ph.D. Transferred to Regional Development and International Affairs, Crop Production Division, 28 November 1980	Applications

VISITING SCIENTIST

O. IIZUKA, Ph.D. Transfer of work from College of Agriculture, Nikon University, Tokyo, Japan	Soil classification
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INTRODUCTION

The Land Resource Research Institute (LRRI) was established in 1978 to bring together the main professional disciplines involved in agricultural land resource studies in Agriculture Canada. In 1980, the second year of operation for the Institute, activities continued to focus on (1) the assembly and integration of information on land forms, soils, and climate and their interactions relative to the evaluation of land resources for potential agricultural and related uses; (2) the collection and synthesis of information on the seasonal dynamics of weather and its effects on land use and food production; and (3) the undertaking of research as required to meet the needs of the first two functions. Regional programs have been maintained through regional soil survey units working in cooperation with provincial survey agencies.

This report briefly outlines the activities and achievements during 1980. Requests for details should be addressed to: Land Resource Research Institute, 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 governments, educational institutions, and agribusiness. 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. Soils, climate, agronomic, and economic data 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 for monitoring the areal distribution of growing conditions and crop production prospects from meteorological, environmental, remotely sensed agroclimatic, and crop statistical data. Agroclimatic resources are assessed as a means of providing 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 DURING 1980

Soil resource inventory and mapping

The soil resource inventory and mapping program involves personnel of the soil survey units throughout Canada and a group at headquarters of the Land Resource Research Institute in Ottawa concerned with soil correlation and cartography. The survey projects are conducted in cooperation with personnel of provincial agencies according to priorities that are established in the provinces through consultation and mutual agreements. Many of the federal soil survey units share offices and other facilities with their provincial counterparts. The report that follows includes only the resource inventory and mapping carried out by the federal soil survey staff.

Newfoundland. The introductory sections of the Gander Lake report, and the soil and capability maps, as well as the manuscript report and maps for the Terra Nova development area, were completed. The field work in Red Indian Lake - Burgeo was completed. The Bonavista report was edited and revised. The Codroy report was published.

Prince Edward Island. Manuscript maps were compiled and the 1:10 000 maps were generalized to 1:75 000 for the remainder of Prince County, and the preparation of the accompanying soil report is in progress. Observation wells at five sites were installed and monitored.

Nova Scotia. A high-intensity pilot soil survey project in Kings County was organized; 2400 ha were mapped for land planning. Mapping in Pictou County was completed. In addition, the Cape Breton Development Corporation site near Sydney was mapped and a draft report compiled. Preliminary photo interpretation was completed for Hants County. Erosion plots and wells were monitored.

New Brunswick. The soil report for the Richibucto-Rogersville area was revised. The draft report and preliminary map for the Sussex project (phase 1) was completed and part of the phase 2 area was mapped. Field checking and map compilation was completed in the Chipman-Harcourt area. Soils were mapped and sampled in the St. John River valley area as part of a contribution to the study of soil erosion in the province. The soil report for Madawaska County was published.

Quebec. Saint-Hyacinthe County was mapped (1:20 000 scale), and manuscript maps were compiled for the north half. Reconnaissance-intensity mapping was conducted in parts of Richelieu County in order to establish the mapping legend for the detailed survey to be initiated in 1981. In addition, 30 observation wells were installed and monitored.

Ontario. The report for the Ottawa urban fringe was published, as was a field manual for describing soils. Mapping was completed in Ottawa-Carleton. Checking and correlation was completed in Norfolk-Haldimand, and 90% of the mapping was completed in Ottawa-Carleton regional municipalities. All interim maps and legends were completed, and manuscript reports are being prepared for both areas. Specifications for Niagara and Durham projects were completed and preparations for fieldwork were initiated, such as transects of representative landscapes. In addition, half of the Timmins-Rouyn-Noranda report was completed, as well as parts of the Brant report, of the Sudbury legend, and of the Sault Ste. Marie - Blind River extended legend. Draft reports for Dryden-Kenora, Fort Frances - Rainy River, Ville Maire - North Bay, and Gogoma sheets were completed. Guidelines were established for soil suitability interpretations for tobacco and woodlands, and others are under development for horticultural crops. Methodology was developed for interpretation of erosion potential of soils, and Brant County soils were rated accordingly. A cooperative program with the Ministry of Natural Resources to develop mapping and classification systems suitable for forestry purposes was further developed; staff was trained, and 250 plots were characterized and sampled.

Manitoba. Approximately 107 000 ha in 13 selected areas of southern Manitoba were resurveyed. This included mostly urbanizing

areas, land around small rural townsites, and provincial parks. Reports and maps were published for 14 areas including Ste. Rose du Lac, Minnewasta, Killarney, Rockwood, Glenboro, Sandy Lake, north shore Lac du Bonnet – Bird River, Paint Lake, Cranberry Portage, Beauséjour, Matlock–Gimli–River-ton, Dauphin, West Interlake, and organic study areas near Hadashville. Soil landscape and physiographic region maps at a scale of 1:1 000 000 were compiled.

Saskatchewan. The manuscript of the Swift Current report was completed. The Hudson Bay – Swan Lake report has progressed to the editing stage. Mapping was conducted on 376 000 ha in the Melville – Riding Mountain area, and five preliminary rural municipality maps were printed and distributed in those municipalities. In addition, eight maps were compiled. In the Battleford area work was conducted to establish a mapping legend and to compile a pilot map and report of the distribution in the region of acid soils for use by extension specialists. Monitoring of saline soil and groundwater sites has shown that reclamation of salt-affected soils will be a slow if not impossible task with normal agronomic management practices. Deep-plowing experiments have shown that yield increases are possible.

Alberta. The report for Newell County was completed and submitted for publication. The survey of Warner County is 80% completed; preliminary soil maps were released to the Irrigation Division of the Alberta Department of Agriculture. For the Banff–Jasper national parks project the maps and legends were completed and submitted for processing. The Yoho National Park biophysical map was submitted for printing; a report is nearly completed. A small-scale map of Solonchic soils was completed. Another small-scale map of physiographic areas of the province was compiled and amended.

British Columbia. The Taseko Lakes maps were completed. Quesnel area soil maps and report are in the process of publication. The Lac La Hache – Clinton report was published. The Horsefly and Barkerville reports were compiled. Soil–vegetation relationships were reported for the Cariboo Wetlands and Power River project areas. The Mill–Wood-fibre creeks report was completed and submitted for editing. Gulf Islands phase 1 maps and interim report were completed. Mapping was

conducted in priority areas of Saltspring Island (part of Gulf Islands phase 2). New plots were installed to measure erosion losses in the Peace River area. Soil and wheat suitability maps were submitted to cartography and a draft report was completed for Basuto and Balangida–Lelu sheets in Tanzania.

Ottawa. Soil correlation studies were conducted in cooperation with regional correlators in many areas: Valemount, McBride, and south Vancouver Island and Gulf Islands (B.C.); selected areas in the Yukon; Melville area (Sask.); Warner area (Alta.); Portage la Prairie and Morden (Man.); and 16 other areas in Eastern Canada. Soil reports were edited for Port au Port, Cormack, Prince Edward Island, Bonavista, Iosegun, Hudson Bay, Newell. Recommended soil correlation procedures were tested; modification of the procedures was undertaken. The soil temperature installation at Inuvik was serviced and a report on soil temperatures was completed. A paper on soil temperatures in northcentral Keewaten was published. Mapping was completed in the Firth and Horton rivers area; the map and report compilation is under way. An outline was completed for a proposed “Manual of soil survey procedures.”

Cartography. Maps completed were: soils 62, special projects 136, miscellaneous LRR1 65, other agencies 87. A total of 93 maps were added to the CanSIS system, 82 maps were completed, and 142 derived maps were generated. In addition, 46 maps were completed for the Canada Land Inventory (CLI) and Land Use Information. An index to soil surveys and a soil map color specification book were published. A change in priorities by Lands Directorate saw nine maps of a coastal zone resource folio completed in lieu of CLI maps. The French edition of *Canada's Resource Lands Atlas* was completed.

Soil classification

Research of the soil classification section is related to soil inventory and soil interpretations. It contributes to increased understanding of soil genesis and behavior and to improved classification and interpretations of soils for various uses. Progress is outlined for each of the three projects: organic soils, mineral soils, and soil water-structure.

Organic soils. A monograph was published on the basic properties of some organic soils

from Quebec and Ontario. The most useful properties were identified for differentiation and classification of these soils. Greenhouse studies were completed on the effects of lime and copper added to organic soil material on plant growth and composition, and on peat decomposition. Grasses grew well on peat lined only to pH 3.6 and subsidence of this peat could be reduced by addition of copper. Plants grown on the copper-enriched soil were not excessively enriched in copper. Work at the University of Montreal supported by an Energy, Mines, and Resources grant showed that the botanical origin of peat materials can be determined by study of partly decomposed fragments. Five research and two miscellaneous articles were published on characterization, subsidence, chemistry, and botany of organic soils.

Mineral soils. Results from this project contribute to the basic knowledge of Canadian soils, and to improved mapping, interpretation, and classification. The transect method for assessing the variability of soils was tested further and it is being used by several soil survey units to improve the quality of soil surveys. The pedotechnical system of interpreting soil survey information for engineering applications was revised and it is being tested by three soil survey units. The sensitivity to acid rain of soils in Eastern Canada was evaluated, and a map and report were prepared. Micromorphological analysis of Cryosolic soils (shallow permafrost) showed new microfabric features related to cryoturbation (frost churning). Podzolic soils developed in situ from granite in New Brunswick were found to contain gibbsite in the horizons least affected by pedogenesis. Energy-dispersive X-ray analysis was used in determining the composition of unknown features seen in thin sections of soils from British Columbia; pyrite and sponge spicules were identified in a marine soil. Imogolite, a fibrous, tubular, microcrystalline, hydrous aluminum silicate, was identified in the clay fraction of cemented horizons of some British Columbia soils. Eluvial horizons (Ae) of some Gleysolic soils were found to be as markedly depleted of Mn, Co, Ni, and Cu as those of Podzolic soils. A total of eight research and five miscellaneous papers were published on specific topics in the field of soil characterization, interpretation, taxonomy, and genesis.

The Service laboratory analyzed some 3300 samples (total of some 20 000 determinations) mainly for the Atlantic Provinces soil survey unit and for projects at LRRRI, Ottawa. Other clients were the Ottawa Research Station and other federal agencies without facilities for soil analysis. Improvements of methods and organization of the laboratory resulted in increased efficiency.

Soil water-structure. Time domain reflectometry (TDR) was developed further as a convenient, versatile technique for measuring soil water both in the field and in laboratory experiments. Results showed that the TDR method measures the total quantity of liquid water regardless of soil type, density, salt content, or temperature. A variety of probe configurations designed to suit experimental requirements were tested and used successfully in determining soil water in the field and laboratory. The technique is beginning to be used by several research agencies in both Canada and the United States.

The spatial variability of soil water properties, such as hydraulic conductivity and desorption properties, was found to be very large within similar map units in the Ottawa area. For the soils studied, structure appeared to be the dominant feature determining the magnitude of hydraulic conductivity. Relationships between soil structure and soil water properties are being studied at four sites; three of these were instrumented for measurement of precipitation, water table, water content, and temperature. Comparisons were made of measurements of saturated hydraulic conductivity by three methods, and descriptions were made of macroporosity, microporosity, and structure with a view to relating porosity to hydraulic conductivity. Data of laboratory studies of water flow and retention in columns of structured soils are being analyzed and related to the data on porosity and hydraulic conductivity.

Land use and evaluation

The land use and evaluation program is directed to the development of new and improved systems for integrating and interpreting soil climate, landform, agronomic and economic data, for evaluating the production potential of land for various alternate agricultural uses. Activities and progress within each of the four projects that make up the program are as follows.

Canada Soil Information System (CanSIS). Improvements were made in the computer system for storage and retrieval of soil map data, experimental yield data, and soil site data. Testing has been completed on some data base management software packages: RAPID, EASYTRIEVE, SAS, and DREAM. These have been adopted for use and several computer files can now be interrogated simultaneously. This constitutes a major development toward a fully operational, computerized soil information system. Work is ongoing to convert all existing files to this system.

Computerized procedures have been completed for logging soil maps through the system, a routine was developed to plot unedited map data, and analyses were completed to accommodate the input for very large soil maps. Two papers were prepared dealing with procedures for producing derived maps and the development of computerized extended legends. A report was published describing a standard computerized format for polygon data exchange between large geographic information systems.

A standardized output has been developed for the performance/management file, and a software package that plots the geographic location of data stored in various files was instituted. The Soil Names and Atlantic Daily files were revised. The soil, wildlife, and vegetation data files maintained for Parks Canada were improved.

Procedures have been developed to initiate standard requests (output) through remote terminals. A general user's manual describing all required commands is being drafted, and training procedures are being developed for new nonspecialist users. These procedures will make CanSIS available to all users throughout Canada.

Crop production potentials. A special paper on spring wheat production potentials was prepared for the Prairie Production Symposium. Experimental and actual crop yield data contained in CanSIS were used to calculate crop yield potentials for Ontario. Equations for predicting soil physical properties were assessed for regional application. Agroclimatic maps for the Great Plains were completed (1:1 000 000) and these are currently being evaluated. A bulletin on lime requirements for soils was prepared. Work is in progress to produce a manual describing

soil and climate requirements for economically important crops in Canada.

Resource protection. Bulletins were prepared on land degradation in Canada, land management practices for pollution abatement in the Great Lakes basin, and on the effects of pipeline construction on farmland productivity. A series of scientific papers were compiled on agriculture and water quality; nitrogen, phosphorus, and liquid manure runoff to the Great Lakes; and the deterioration of Canadian soil resources. Also, two reports on acid rain in Eastern Canada were prepared. New studies were initiated on unlined manure-storage, phosphorus and nitrate leaching through tile drains, and soil erodibility.

Land use and socioeconomic evaluation. A report describing Canadian crop production potentials for spring wheat, corn, potato, soybean, and phaseolus bean has been published, using results compiled from a computerized national land potential data base. Work is ongoing to prepare a user's manual for the data base so as to make these data available through remote terminals in all regions in Canada. Agricultural land use systems maps have been published for the Ottawa-Carleton area; similar maps for the Melville region, Saskatchewan, are being prepared. The Niagara agricultural land use survey has been completed, and maps are being prepared. A report entitled "Impacts of energy supplies on land needs for agriculture in Ontario" has been prepared by the University of Guelph land evaluation research team. This is the first of a series of reports that will be prepared by the team.

AGROMETEOROLOGY

Agrometeorology is concerned with the interaction of hydrometeorological factors and soils as they affect agriculture and food supply. Discovery and definition of these relationships and application of this information toward more effective land use and crop production are of primary concern. Progress reported for 1980 is as follows.

Applications. The Soil Moisture Evaluation Project (SMEP) was used for the preparation of a number of special reports relative to the 1980 drought in Western Canada. Documentation of the Versatile Soil Moisture Budget was completed and a scientific paper published. A climatic analysis was made of data

from nine stations in northern Ontario. Two technical reports were prepared relative to fieldwork days in Canada and the weather risk in harvesting hay. Data processing support was provided to a number of projects to include soil moisture, grasshopper prediction, soil temperature, yield prediction, and crop-weather modeling. Progress was made in developing an interactive computer-ased agrometeorological information service for on-line usage in Agriculture Canada's AGNET system.

Crop information. Yield estimates for wheat, barley, and oats for the crop districts in Western Canada were provided in 1980 on a weekly basis from May to 31 July 1980 to the Commodity Markets Analyses Division, Marketing and Economics Branch (formerly Production and Marketing Branch). Production estimates in July based on derived yields and estimated hectarage agreed well with the final harvest estimates provided by Statistics Canada in November. Landsat imagery of major wheat growing areas was obtained to estimate cereal production. Microwave imagery was acquired at the Central Experimental Farm and Guelph radar test sites under the Interdepartmental Sursat Program to evaluate its suitability for analytical all-weather crop assessment.

The soil moisture estimation component of a wheat yield model was improved by testing statistical procedures to simulate soil water uptake by plant roots, taking into account root density. A site was set up at the Central Experimental Farm to obtain measurements related to latent heat and frost depth to provide data for modeling soil temperatures for snow-covered and snow-free areas.

Agroclimatic resources. Computer mapping of various agroclimatic variables for the Canadian Great Plains was carried out. The climatic data was mapped at a scale 1:1 000 000 for the Great Plains Region (18 sheets). A model for assessing general winter survival conditions for alfalfa across Canada

was completed. This study utilized survival conditions at 43 locations for over 10 years. Twenty-two new maps for inclusion in the Agroclimatic Atlas were completed. They involved mean soil temperatures at various depths for all of Canada and mean dates when soil temperatures at 20 cm rise or fall below 0°C in Eastern Canada. The climatic normals from 1941 to 1970 for the prairies are now available for: a) mapping the weather deficit (irrigation requirements) at the 50% probability for each of four soil texture classes; b) mapping the Aridity Indices for annual spring wheat production for four soil texture classes.

Crop-weather analyses. The exchange of CO₂ and water vapor with the adjacent atmosphere over a corn crop were measured using the eddy-correlation technique for developing a system to evaluate absorption of CO₂ and transpiration of water from a crop. Measurements were made on site for small areas and on board an aircraft for larger areas. Supplementary measurements were made to compare CO₂ and water exchange with growth rates and growing conditions (leaf area index, yield, temperature, soil moisture, and biomass).

Spectral measurements using a data processing system were made on several crops and crop densities in order to obtain a rapid measurement of leaf area index. A laboratory version of a microprocessor-based system for measuring soil moisture was completed and a report on the description of the unit was written.

Water extraction patterns were obtained under several soil textures and environmental growing conditions for application in testing an evapotranspiration model to clarify changes in leaf water potential with respect to atmospheric and soil water conditions.

Scientific and technical papers were also published on overwintering of nursery plants in containers, on litter decomposition, on nonlinear least square analysis, and on description of an open-path CO₂ analyzer that will be used to measure the rate of growth of crops directly.

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Research Program Service

Ottawa, Ontario

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Head of Graphics Section

Editing

INTRODUCTION

In support of research and development in the Branch, Research Program Service provides a wide range of scientific information, technical, and publication services. In 1980, the Scientific Information Retrieval Section continued to maintain the computerized *Inventory of Canadian Agricultural Research* (ICAR) and compiled an inventory of pesticide research (author, pesticide, hosts, and pests). The minor use of pesticides program was streamlined and a circular was released in collaboration with the Pesticides Section of Food Production and Inspection Branch. The 1980 *Pesticide Research Report* was published, as were four issues of the *Pesticide Information* newsletter.

News of happenings in the Research Branch was circulated to all staff members in ten issues of *Tableau* in 1980, including a tenth anniversary issue. Also, three numbers in Volume 60 of the *Canadian Plant Disease Survey* were issued.

Several scientific visits to and from Canada were coordinated, and the Canada-France exchange program was administered. The programs for operating grants, extramural research grants, and visiting fellowships were also administered.

A folder describing the services available from Research Program Service was issued and distributed to all research establishments in October.

We were deeply saddened in May by the sudden death of Ross Jackson, Head of the Graphics Section. Ross's never-failing good humor along with his sound administrative and technical advice have been sorely missed.

This report is a summary of activities during 1980. Detailed information may be obtained by writing to: Director, Research Program Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Robert Trottier
Director

AWARDS AND BRANCH LIAISON

Research Program Service continued to administer the extramural research grants, operating grants, visiting fellowships, and scientific exchange programs during 1980.

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 1980, a total of 73 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 consists of three representatives from Agriculture Canada and seven from faculties of agriculture and veterinary science. In 1980, the committee received 262 applications.

The visiting fellowships 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 1980, there were 179 applications for fellowships in this department.

A total of 31 delegations visited Canada during the past year: eleven from France, five from the People's Republic of China, three from Romania, two from Australia, and one each from Peru, Zimbabwe, Japan, Rwanda, Nigeria, Sri Lanka, Britain, Denmark, Chile, Zaire, and the USSR. Two delegations went from Canada; one to Ethiopia and one to Morocco, Spain, Portugal, and the Canary Islands.

Ten issues of *Tableau* were published, including a tenth anniversary issue.

GRAPHICS

A wide variety of services in research photography and production art and illustration were provided to the Branch and other agencies within the Department. There was a 15% increase in jobs processed over 1979, and as a result, 10% of the job requests were contracted out. Jobs were completed in an average of 15 working days, with fewer than 1% returned for correction.

Because a computerized production reporting system was developed in order to improve planning and control, a monthly detailed analysis of jobs completed is now possible.

SCIENTIFIC INFORMATION RETRIEVAL

Information on pesticides and agricultural research in Canada continued to be maintained in a computerized storage and retrieval system. The information is available to researchers; funding agencies; provincial, regional, and national research planning and coordinating committees; and anyone interested in agricultural research. Requests for information were answered in an average of nine working days.

The Summary Data Sheet system for candidate pesticides was realigned and pertinent information on 10 new experimental pesticides was included in the *Pesticide Information* newsletter, beginning in April 1980. The procedures for the minor use of pesticides program were streamlined, and a circular was released in collaboration with the Pesticides Section of the Food Production and Inspection Branch.

Commonwealth Institute of Biological Control contracts were coordinated and managed for Agriculture Canada and for the Canadian Forestry Service. In 1980, 14 shipments were received from six countries for a total of 35 210 specimens. Forty-four shipments were

sent to research establishments; 15 parasite species totaling 12 407 insects were sent to eight provinces for release or study, or both.

SCIENTIFIC EDITING/TEXT PROCESSING

Research Program Service continued to help meet the technology transfer requirements of the Research Branch by providing editorial and text processing services for scientific and technical publications of the Branch and Department. In 1980, 26 English and 40 French publications were processed, comprising 5800 and 2560 manuscript pages, respectively. Two bilingual publications, comprising 424 manuscript pages, were published. Of the total of 8784 pages completed, 40% were for Department publications of interest to growers and the general public, and 60% were for Branch reports and scientific monographs intended for research workers in universities, industry, and government.

Six major books were published during the year; Parts 7 and 8 in the series *The Insects and Arachnids of Canada—Genera des Trichoptères du Canada and The Plant Bugs of the Prairie Provinces*; *Common and Botanical Names of Weeds in Canada/Noms populaires et scientifiques des plantes nuisibles du Canada*; *The Grasses of Ontario*; *Trees and Shrubs of the Dominion Arboretum*; and *Fougères du district d'Ottawa*.

The editing of some manuscripts was contracted out to avoid serious backlogs of work and to reduce editorial and production times.

The computerized text processing facilities continued to provide support to Branch scientists. About 90% of the jobs processed were for Branch reports and miscellaneous publications in support of research and development. The remaining 10% of the work was for Department publications, where extensive retyping during the editing cycle was avoided, and where photocomposition was carried out for material already in the computer system.

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Research

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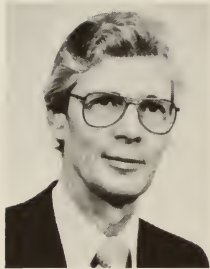
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ATLANTIC REGION
RÉGION DE L'ATLANTIQUE





Dr. E. E. Lister



Dr. W. B. Collins



Mr. J. R. Frappier

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

Director General
Directeur général

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Program Specialist
Spécialiste en programmes

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Chief, Finance and Administration
Chef, finances et administration

J. R. FRAPPIER, B.A.

PREFACE

The Atlantic Region, with headquarters in Halifax, consists of four research stations, two experimental farms, and one substation. These research establishments serve the agricultural communities in New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland. In 1980 the Region managed a budget of \$19 million and employed 88 professionals to carry out its various programs.

Construction of new facilities at the Kentville Research Station was substantially completed in 1980. The new complex, to be known as the Kentville Agricultural Centre, houses both federal and provincial personnel. Staff of the various scientific disciplines are established under one roof for the first time in the history of the Station. This arrangement will provide new incentives for strong team approaches to the major mandates of the Station.

Research in animal science was highlighted by improvements in the handling and management of corn silage, resulting in higher beef production per hectare from beef cattle and improved milk production from dairy cattle. Swine management studies produced valuable information leading to the establishment of optimum stocking densities. Further improvements in the efficiency of meat production in broiler chickens were established, with concomitant gains in net returns per bird to the producer. It was shown that there is an economic advantage to early weaning of lambs and that the feeding level of lactating ewes can be reduced without penalty in late lactation.

Key advances in cereal and forage research included the refinement and definition of production procedures to ensure consistently superior yields and quality in winter wheat and in corn for silage. Twenty-five barley selections were identified with high levels of leaf disease resistance. Red clover and

alfalfa were identified as the most suitable species for direct drilling to restore the legume component in pastures and hayfields, and a major red clover breeding program was established.

In horticultural research low-oxygen storage developments for McIntosh apples received international recognition and are already being put into commercial practice. Two significant variety releases were made in berry crops, one in strawberries and the other in red raspberries. Substantial progress was achieved in red-stele control in strawberries through a combination of resistance breeding and systemic fungicidal drench techniques. Two new potato varieties were licensed; one was a yellow-fleshed type with potential significance for the export seed market. An effective management strategy package was developed for control of potato leaf roll virus and potato virus Y in susceptible varieties.

A new high-output energy-efficient blanching system was developed in the processing research sector through the use of contract research funds. The new system has functioned so well that nearly one million kilograms of raw product were processed through the prototype, with substantial savings in energy costs.

Significant staff changes in 1980 included the appointment of Dr. E. E. Lister as Director General of the newly established Atlantic Region. Dr. W. B. Collins was named Program Specialist.

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, Suite 708, 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 une sous-station qui desservent les collectivités agricoles du Nouveau-Brunswick, de l'Île-du-Prince-Édouard, de la Nouvelle-Écosse et de Terre-Neuve. En 1980, la région disposait d'un budget de \$19 millions et son personnel comptait 88 employés professionnels.

La construction des nouvelles installations de la station de recherche de Kentville a été en grande partie achevée en 1980. Le nouveau complexe, qui portera le nom de Centre agricole de Kentville, abrite à la fois les services fédéraux et provinciaux. Ainsi, pour la première fois de l'histoire de la station, le personnel de diverses disciplines scientifiques est rassemblé sous un même toit. On espère ainsi encourager la formation d'équipes de recherche fortes, aptes à mener à bien les principaux mandats de la station.

La recherche zootechnique s'est distinguée par les améliorations apportées à la manipulation et à la gestion de l'ensilage de maïs, favorisant une plus forte production de boeuf par hectare et une amélioration de la production de lait. Les études menées sur la gestion des élevages de porc ont fourni des renseignements précieux menant à la détermination de densités optimales d'élevage. On a continué à augmenter l'efficacité de la production du poulet à griller, ce qui a contribué à augmenter les recettes des producteurs. On a démontré qu'il existe un avantage économique à procéder au sevrage précoce des agneaux et que la réduction du niveau de nutrition des brebis en fin de lactation peut se faire sans danger.

Parmi les progrès clés réalisés dans la recherche sur les céréales et les fourrages, on compte le perfectionnement et la détermination de méthodes de production visant à assurer des rendements supérieurs et une haute qualité du blé d'hiver et du maïs d'ensilage. Vingt-cinq sélections d'orge ont montré une forte résistance aux maladies des feuilles. Le trèfle rouge et la luzerne se sont avérés les espèces les plus propices au semis direct pour la

réinstallation des légumineuses dans les pâturages et les prairies de fauche et un important programme d'amélioration du trèfle rouge a été mis sur pied.

Dans le domaine de la recherche en horticulture, les progrès réalisés dans la conservation des pommes McIntosh en ambiance à faible teneur en oxygène ont suscité beaucoup d'intérêt à l'étranger et commencent déjà à être mis en exploitation commerciale. Deux nouvelles variétés importantes de petits fruits ont été mises sur le marché: une fraise, et une framboise rouge. D'importants progrès ont été réalisés dans la lutte contre la stèle rouge du fraisier grâce à la combinaison de la sélection de variétés résistantes et de la mise en application de méthodes d'épandage de fongicides systémiques par arrosage du pied. Deux nouvelles variétés de pommes de terre ont été homologuées dont l'une à chair jaune présente des possibilités d'exportation comme pomme de terre de semence. On a élaboré une stratégie efficace pour la lutte contre le virus de l'enroulement et le virus Y, chez les variétés sensibles de pommes de terre.

Un nouveau système de blanchiment à haut rendement mais peu exigeant en énergie a été mis au point par le secteur de la recherche industrielle grâce à des fonds de recherche contractuelle. Le nouveau système fonctionne si bien qu'on a pu procéder, à l'aide du prototype, au traitement de près de 1 million de kilogrammes de produit brut, tout en réalisant d'importantes économies d'énergie.

Parmi les principaux changements de personnel survenus en 1980, mentionnons la nomination de M. E.E. Lister comme Directeur général de la nouvelle région de l'Atlantique. M. W.B. Collins a pour sa part été nommé Spécialiste en programmes.

Pour de plus amples renseignements sur nos programmes, prière d'écrire aux établissements de recherche concernés ou de s'adresser à l'Administration centrale de la région de l'Atlantique, Direction générale de la recherche, Agriculture Canada, 1888, rue Brunswick, Suite 708, Halifax (N.-É.) B3J 3J8.

E.E. Lister

Research Station

St. John's West, Newfoundland

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INTRODUCTION

The responsibility center for regional agricultural research in Newfoundland and Labrador is located at St. John's West, 8 km from City Centre. The research program encompasses the reclamation and use of peat soils, potato breeding for resistance to wart disease and the golden nematode, economic insect control, plant disease control, plant nutrition, and vegetable adaptation trials. Rutabaga breeding for resistance to clubroot disease is a further responsibility, together with the design and adaptation of mechanical equipment for cultivating, fertilizing, seeding, and harvesting crops grown on peat soils.

Previous reports and reprints of publications can be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's West, Nfld. A1E 3Y3.

H. W. R. Chancey
Director

ENTOMOLOGY

Cabbage maggot

In experiments at St. John's and Wooddale to determine if cabbage root maggots were developing resistance to organophosphate insecticides, results showed that field populations of the maggot were tolerant of both Dasanit (fensulfothion) and the carbamate Furadan (carbofuran) at St. John's. However, this trend was not confirmed at Wooddale.

Split applications of Dasanit (fensulfothion) at both St. John's and Wooddale were more effective than equivalent applications applied as granules at seeding. Single applications of granules at both localities were ineffective. A split application of Dasanit (fensulfothion) at the recommended rate (5.6 kg ai/ha) gave fairly satisfactory control (73%) at Wooddale, but only 45% at St. John's. Single applications of granular Dasanit (fensulfothion) probably controlled attacks of first-generation root maggots, but were ineffective for second-generation attack. Usually cool wet weather during the growing season of 1980 may, in part, have accounted for the short residual effect of single applications of granular Dasanit (fensulfothion) at seeding.

Five pyrethroid insecticides, Ambush (permethrin), Belmark (fenvalerate), Ripcord (cypermethrin), Cymbush (cypermethrin), and Decis (decamethrin), at two levels of drench treatments, were evaluated for root maggot control on early cabbage. A light infestation of root maggots caused only 2.5% crop loss in the control plots and made

evaluation of treatments impossible. An unusually cool wet growing season may, in part, have accounted for this lack of infestation.

Lepidopterous caterpillars

Field trials with late cabbage and dwarf Essex rape to determine the effectiveness of pyrethroid insecticides, Ambush, Cymbush, Decis, Ripcord, and Belmark, together with Thiodan, were evaluated in field trials as single and double applications to control leaf-eating caterpillars: the imported cabbage-worm, *Pieris rapae* (L.); the purplebacked cabbageworm, *Evergestis pallidata* (Hufn.); and the diamondback moth larvae, *Plutella xylostella* (L.), at St. John's. The efficacy of treatments could not be evaluated because no infestation of any of these larvae occurred in any of the treated or control plots.

Leaf-tier

Ten insecticide treatments, including Ambush, Belmark, Ripcord, Decis, Cymbush, and Guthion, were tested for control of the blueberry leaf-tier, *Argyrotoza curvalana* (Kft.), at Witchazel Ridge near Gushue's Pond Park. All pyrethroid treatments significantly controlled larval populations of the blueberry leaf-tier, and all were equally as effective as Guthion. Populations in treated plots were reduced to 0-5 larvae per plot, 5 days after treatment, whereas larval populations in the control plots averaged 67. Populations within plots before treatments varied from 35 to 106 larvae.

PLANT BREEDING AND PATHOLOGY

Breeding potatoes for resistance to wart and the golden nematode

The wart-resistant selection N135-671, a sister seedling of Mirton Pearl, has been evaluated in trials and demonstration plots over a 5-yr period. These tests indicate that this selection, provisionally named Anson, is of considerable merit, having a high yield of marketable tubers. Maturity and dry matter content are similar to those of Green Mountain, and when combined with higher resistance to late blight and virus infection, it is believed that Anson could replace this variety.

As a result of preliminary yield in wart and nematode trials, N664-127 has been identified as a promising selection with resistance to both pests. Resistance to wart disease derives from Mira and to the golden nematode from Wauseon. A yellow-fleshed selection, N682-6, which has attractively shaped tubers of uniform size, is also resistant to both wart and the golden nematode. In this potato, golden nematode resistance is derived from a selection bred from C.P.C. 1685.

The recently introduced cultivars Trent, Rideau, and Longlac were severely infected in wart trials, but Yukon Gold was only slightly infected; Clairchip and Conestoga were free from infection.

Infectivity and germination in potato wart disease

Work on wart disease was pursued at field, greenhouse, and laboratory levels. In the field, further evidence was obtained to indicate that inorganic ammonium compounds influence the intensity of the disease. A survey was made of private kitchen gardens in an attempt to correlate disease intensity with physical and biological soil factors. Potato tubers, inoculated and placed in a growth room at various times during the year, showed further evidence of a seasonal factor influencing disease severity. The tubers were inoculated prior to planting, by introducing tumor pieces to a water column surrounding the rose-end sprouts.

Evidence was also obtained that showed that when potato sprouts were abraded, the incidence of potato wart disease increased. The relationship of this finding to soil conditions and fungal ingress is being investigated. The resting sporangium of the causal agent

was shown to be covered by a layer of chitin. Labeled isotope uptake and chemical analysis strongly suggested that chitin was manufactured early in the sporangial wall. Scanning electron microscopy revealed that the potato sprout is covered with many necrotic plaques. It is proposed that these necrotic areas influence the causal agent directly through sprout exudates or indirectly through the contiguous microflora. A system was devised for supplying debris-free yields of resting sporangia using sucrose-centrifugation.

Breeding clubroot-resistant rutabagas

The New Zealand cultivar Kiri remained free from clubroot infection in test plots. Roots of Kiri were longer and more tapering than were roots of RST lines. Both Kiri and RST are derived from crosses of clubroot-resistant Dutch turnips and rutabaga. Comparisons of roots of three generations of field-produced seed of RST showed that a marked improvement had been made in producing well-colored roots free from side roots.

PLANT SCIENCE

Field crops

Cabbage. In previous years, results showed that yields from transplanted Houston Evergreen cabbage planted on mineral soil were similar for an early or late planting, but in 1980 a decline in yields was observed for the later planted crops due to a cool wet growing season. Yields for the three planting dates in tonnes per hectare were as follows: 21 May—64.5; 29 May—58.2; and 11 June—53.5. Increasing the N level from 224 to 336 kg/ha by applying a side-dressing at 112 kg/ha increased the average yield from 46.4 to 58.7 t/ha. Due to similar growing conditions, very early field seeding of Houston Evergreen cabbage did not result in large yield increases as in previous years. Yields for the three planting dates in tonnes per hectare were as follows: 21 May—18.4; 29 May—22.4; and 11 June—9.9. Increasing the N level from 224 to 336 kg/ha by applying a side-dressing at 112 kg/ha increased the average yield from 9.4 to 16.9 t/ha.

Soil conditioners. Agromax NiPhoKal-1 and Agromax 17-5-5-GR, received from Hungary, were evaluated under greenhouse conditions with oats and lettuce and were found to have no effect on yields. There was

no effect on lettuce germination, but emergence time of oats was less in one trial than in the control. In a field trial with turnips, neither of these products had any effect on yields or times of emergence.

Blueberries

Atrazine at 3 and 6 kg (ai)/ha, dichlobenil at 4 kg (ai)/ha, and simazine at 3 kg (ai)/ha significantly increased yields, but weed control was only fair. Hexazinone at 1.5 and 3.0 kg (ai)/ha and dichlobenil at 8.0 kg (ai)/ha significantly reduced yields.

Productivity of native stands of lowbush blueberries was determined at various locations on the Avalon and Bonavista peninsulas. Mean yields in kilograms per hectare were as follows: Little Catalina—1031; Newman's Cove—770; Pouch Cove—722; Adams Cove—696; St. Joseph's—633; Avondale—251.

In frequency of burning experiments, results in 1980 were similar to those obtained in previous years. Higher yields occurred in the first year after burning and declined in subsequent years. Yields in the third year after burning were similar to those obtained with zero burning.

SOIL SCIENCE

Peat soils

Fertility. After 25 yr of peatland development in Newfoundland, substantial tracts exist that have been under cultivation for more than 10 yr. Fertilizer experiments on permanent grasslands on such 'mature' peat soils have shown no response to phosphorus rates over 50 kg P_2O_5 /ha. In the past season, however, a significant response was obtained from phosphorus rates between 50 and 66.6 kg/ha on a stand of timothy established the previous year. In the presence of normal soil test values for phosphorus for these soils, the question is raised of the possible influence of the new high-analysis phosphate (46% P_2O_5) fertilizer on these results.

It has been suspected that a cause for ill thrift in lambs grazing on local peatland pastures could be a molybdenum-induced copper deficiency. Initial results from a small-plot study on the influence of these elements applied to the soil on plant tissue composition show that an application of Mo at 0.4 kg/ha on virgin peat will induce close to physiologically active levels (15 ppm) in the plant. Though the rate is about five times that provided in the usual field applications where the trouble arose, the possibility of toxic accumulations from annual applications is exceedingly probable. Studies are continuing into the effects of residual and annual maintenance applications.

Peat drainage. The extremely wet season resulted in outstanding crop responses to different drainage treatments. Carrots responded in yield and root length to both ridged culture and supplemental slit drain treatments; best results were obtained from both techniques together. Although potatoes also responded in yield to supplemental drainage and ridged culture treatments, the effects of the two together were not additive. This may be somehow related to the effects of potato culture in increasing aeration as measured by oxygen flux. This latter phenomenon has now been observed for two consecutive years.

Machinery. Results of field tests with the peat soil rotoridger-precision seeder designed at the Memorial University of Newfoundland (MUN) gave approximately 75% single-plant emergence with minor occurrence of doubles. The MUN-designed peat drainage ditcher performed well, but requires modification to improve spoil spreading and to correct rear-end imbalance.

The weed sprayer and transporter developed by MUN for peat soils was highly satisfactory in field trials for both ridge- and level-seeded vegetable crops, whereas the commercial carrot harvester adapted by MUN for use on peat soils will be operational with minor modifications.

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Research Station

Charlottetown, Prince Edward Island

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¹Seconded from Libraries Division, Finance and Administration Branch.

²Seconded from Regional Development and International Affairs Branch.

INTRODUCTION

The Research Station at Charlottetown has Atlantic Region responsibility for research on the production and utilization of livestock feed crops, tobacco, and certain vegetables grown for processing.

This report includes brief summaries of some of the research completed in 1980. More detailed information may be obtained from the publications listed 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 AND PROTEIN CROPS

Breeding and testing

Oats. The oat line QO 151-103, from the cross Tarpan/QO 51-41 made at the Research Station, Ste. Foy, Que., has superior yield and relatively low hull percentage compared with presently recommended varieties and is expected to be licensed.

Spring wheat. Application will be made for licensing the Charlottetown selection AW4 for the Maritime Provinces based on its superior yield and mildew resistance.

The use of harvest index as a selection criterion for grain yield in F_2 populations of spring wheat grown at two population densities was investigated. The F_4 lines selected in F_2 for a high harvest index yielded about 9% more per plot than F_4 lines having a low harvest index in F_2 . Generally, lines selected at the higher seeding rate yielded more than lines selected at the lower planting density. Selection based on high harvest index at low population density can be used to select higher yielding plants but was not as effective as selection at high population density, which more closely approximates commercial crop densities.

Winter wheat. The feed wheat selection T 1365-216 exceeded Lennox in yield on a 2-, 3-, and 4-yr average basis. An application for licensing for the Maritime Provinces will be made by the Ottawa Research Station in 1981.

Soybeans. The soybean line AU 3-1-3 has adequate maturity for Prince Edward Island conditions and 40% greater yield potential than Maple Presto. A recommendation has been made for licensing.

Diseases

The cereal crop in Prince Edward Island is damaged severely by the fungal pathogen *Fusarium roseum* (Lk.) emend. Snyder & Hansen f. sp. *graminearum* and through contamination by its associated mycotoxin, vomitoxin. Spring wheats such as Opal and Vernon are particularly susceptible to this head blight whereas other selections or cultivars illustrated varying degrees of resistance. Best control of the disease was obtained by application to the maturing heads of the fungicides chlorothanil, captofal, triadimefon, or CGA-64250 (Ciba-Geigy) sprays. Vomitoxin levels vary considerably depending on the husbandry used to produce the crop and are generally higher in barley than wheat.

Intensive cereal production

Winter wheat. Results of a 3-yr study with Lennox winter wheat indicate that high yields of winter wheat can be obtained through the use of multiple levels of N, growth regulators for lodging control, and fungicides for disease control. Significant grain yield and N concentration responses were obtained with multiple N applications in all years and significant grain yield response to fungicides and growth regulators two years out of three.

Barley. Studies with the barley growth regulator Terpal (BASF) indicate that it is effective in lodging control but yield depression has been common.

Tillage practices

Swathing offers no advantage in either earlier harvesting or increased yields, compared with direct-cut combining of small grains. In some cases swathing resulted in

harvesting delays due to heavy rains that soaked the swaths.

FORAGE CROPS

Management and nutrition

Winter survival. Frequent occurrence of midwinter thaws is a major cause of winter injury in the Atlantic Provinces, and two major stress factors associated with midwinter thaws are freeze-thaw cycles and anaerobic environments due to waterlogging or ice encasing. Under controlled environments, responses of alfalfa to waterlogging in combination with and without freezing were determined. The effect of growing conditions on the waterlogging resistance appeared to be greater than the effect of genotype as far as *Medicago sativa* L., *M. media* Pers., and *M. falcata* L. are concerned. A greenhouse experiment, however, showed that if alfalfa plants are grown in plastic pails, thus limiting oxygen supply of the roots in comparison with that in the field, for 1 yr or longer, these plants are able to survive flooding for up to 14 wk, as long as a part of the top tissue is above the water level. Both greenhouse and field plants were damaged severely by a combination treatment of freezing-waterlogging-freezing. It appeared that the resistance to freezing after waterlogging was the most important character of alfalfa to survive midwinter thaws. The most noticeable metabolic change that occurred in alfalfa roots during the combination treatment was an accumulation of ethanol. The difference in ethanol concentration between the plants before and after waterlogging may explain the difference in freezing resistance of plants.

Annual ryegrass. Promenade Westerwolds ryegrass, *Lolium multiflorum* Lam., was grown on fine sandy and light loam soils. Nitrogen was applied at 40, 80, or 120 kg/ha after emergence and after both the first and second harvests. The first harvest under schedules A, B, and C was on 10, 15, and 22 July followed by the second harvest in 28, 37, and 40 days, and the third harvest in 30, 50, and 37 days after the second harvest, respectively. The fourth harvest for schedule A was 46 days after the third harvest. Mean dry matter yields ranged from 6.26 to 9.03 t/ha, total N in tissue from 2.09 to 2.99%, in vitro digestibility of dry matter from 73.3 to 76.3%, and dry matter content from 12.1 to 14.1%

depending on the N rate or harvest schedule or both. Nitrate-N concentration in plant tissue was low for 40 and 80 kg N/ha per application but reached 0.45% for the 120 kg/ha per application under harvest schedule A. Yield distribution within the season was most uniform for schedule B. A three-harvest schedule with N applied at 80 kg/ha at seeding and after the first and second harvests was suitable management for Promenade Westerwolds ryegrass in the Atlantic Region.

Grass silage utilization. Monocultures of Climax timothy (*Phleum pratense* L.), Lemtal Italian ryegrass, and Aubade and Promenade Westerwolds ryegrasses were cut, wilted to about 25% dry matter, in mid-June for timothy and mid-August for the ryegrasses, and were conserved as silages. Sheep fed ad libitum silage rations consumed an equal quantity of dry matter on a percent body weight basis, from either the Lemtal Italian ryegrass or Promenade Westerwolds ryegrass silage (1.8%), but the intakes were lower for Climax timothy (1.7%) and Aubade Westerwolds ryegrass (1.5%) silages. Promenade Westerwolds ryegrass silage contained the most digestible dry matter (66.7%), followed by Lemtal Italian ryegrass (64%), Aubade Westerwolds ryegrass (62.6%), and Climax timothy (60.4%). Lemtal Italian ryegrass yielded about 10% more digestible silage dry matter per hectare compared with the other ryegrasses or with Climax timothy.

Uptake of residual-applied selenium by timothy and barley. Timothy was harvested for 4 yr from plots treated with selenium (Se) as sodium selenite at the rates of 1.1 and 2.2 kg Se/ha. Timothy forage and barley grain without added Se contained only 0.02–0.03 ppm Se and were Se deficient from the animal nutrition standpoint. At 1.1 and 2.2 kg Se/ha, timothy contained adequate Se (>0.1 ppm) for 3 and 4 yr and barley grain for 1 and 2 yr following application, respectively.

Effect of soil fumigation on the nutrient content of forages. The soil fumigant, methyl bromide, used to kill pathogenic microorganisms in soil prior to crop planting, has been shown also to decrease or increase the availability of plant nutrients in soil. Experiments conducted under greenhouse conditions showed that the use of methyl bromide increased the Zn, Mn, S, and P content of timothy and alfalfa. Molybdenum content also increased, but only in timothy.

Corn management. Increasing the plant population of Canadian and European corn varieties from 50 000 to 75 000 plants per hectare increased forage yields by 18% in a 2-yr study, but decreased whole plant dry matter from 31.7 to 30.5%. At 100 000 plants per hectare the yield increase was only 15.5% and whole plant dry matter was reduced to 28.6%. Some European hybrids had a tendency for improved grain yields at 75 000 plants per hectare, whereas the Canadian hybrids tended to decline in yield. Grain yields were lowest at 100 000 plants per hectare. Grain moisture increased with increasing population. European hybrids tended to contain less moisture early in the fall, but dried more slowly than the Canadian hybrids.

In a 3-yr planting date study, mid-May planting produced the greatest whole-plant maturity at harvest (31.4%), but a 10% lower yield than planting in early June, which gave only 24.2% dry matter. Planting later than early June reduced yields and dry matter.

Total yields and the yields of various plant parts (except the ears) declined with time after the first killing frost on 25 September. Ear yields increased up to about 24 October. Leaves and stalk tops dried most rapidly, and leaf yield declined nearly 50% by 14 November. The bottom one-third of the stalk was very wet initially (15% dry matter) and dried very slowly in comparison to the middle or the top by 14 November.

Corn nutrition. A study of soil and tissue nutrient levels in corn grown in Prince Edward Island indicated that the crop is generally well managed. The mean soil pH was 6.01 and the mean P, K, Ca, and Mg soil test levels all ranked 'high.' Less than 8% of the fields had any soil nutrient testing 'low.' The mean leaf nutrient levels for N, P, K, Ca, Mg, S, B, Zn, Mn, Fe, and Mo were all within or above normally accepted sufficient levels, with K ranking very high (2.77%). Overall, only Zn appeared to warrant further study based on a number of low testing fields.

Effect of atrazine carryover on crops grown in rotation with corn. Residue carryover in a fine sandy loam from atrazine applied preemergence to corn with active ingredient (ai) at 1.13 kg/ha had no effect on yield of winter rye seeded before the corn was harvested, and of barley, field peas, alfalfa, red clover, and timothy seeded in May of the following year. Increasing the atrazine rate to 2.25 kg ai/ha reduced yield of red clover by

28% and of barley by 18%. Timothy was killed at this and higher application rates. At the maximum rate tested of 4.5 kg ai/ha, yields of red clover, barley, alfalfa, winter rye, and field peas were reduced by 100, 52, 42, 20, and 17%, respectively. Fall rye suffered greater yield reductions from atrazine carryover in the previous 2 yr. The effect of atrazine carryover was similar for all 3 yr with the other rotation crops.

Insects and nematodes

Alfalfa blotch leafminer. Although the protein concentration of alfalfa leaves decreased due to infestation by alfalfa blotch leafminer, the concentration in the combined tissues of leaves plus stems did not decrease significantly. The concentration of water-soluble carbohydrates (WSC), however, decreased in both leaf and stem tissues. Since a high WSC content is important in producing a high-quality silage, special caution may be necessary to ensure an adequate supply of sugars for making silage from leafminer-infested alfalfa.

Beginning in 1978, parasitic insects known to destroy the alfalfa blotch leafminer in the larval stage of development were introduced into Prince Edward Island in an attempt to develop a biological control program against this alfalfa pest. Of the three species released, at least one of these, *Dacnusa dryas* (Nixon), has become established near Charlottetown.

European skipper. A nuclear polyhedrosis virus, found at Normandin, Que., in 1974, was released in some Prince Edward Island timothy fields between 1976 and 1979 as a biological control agent against the European skipper, a destructive pest of timothy. Observations in 1980 indicated that the virus was active in most fields sprayed as well as in fields and roadsides not sprayed previously. The virus disease, which does not affect mammals, fish, or other beneficial insects, should provide an effective means of preventive control of the European skipper in Prince Edward Island, but the level of protection remains to be quantified.

Root-lesion nematodes in alfalfa and timothy. Numbers of *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. in alfalfa and timothy, and to a lesser extent *P. crenatus* Loof in timothy, increased substantially as soil temperature increased from 10 to 30°C. However, *P. crenatus* in alfalfa decreased in

number as soil temperatures increased. Mobility of *P. crenatus* in vertical soil columns decreased as temperature increased from 9.5 to 28.5°C. Raising the soil pH in which alfalfa was grown from 5.0 to 6.9 increased the numbers of *P. penetrans* and greatly reduced the numbers of *P. crenatus*. The numbers of both nematode species in timothy were reduced significantly as soil pH was increased. The optimum soil pH for movement of *P. penetrans* was 6.0. *P. crenatus* moved equally well over a range of 5.0–7.0.

CATTLE

Mineral elements in timothy forage

The average mineral content of timothy grown on Prince Edward Island was found to be moderately low to deficient for most of the minerals studied. Calcium content (0.25%) averaged about one-half the mean value published for timothy, whereas P content (0.24%) approximated published values. Magnesium content (0.11%) was about one-half of the requirement for dairy and beef cattle. Average K content was 2.1%, but some samples contained 5% or more of K. If these high K values were combined with low Ca and Mg in the same forage, this would create a grass tetany prone situation. Average S, Mn, Zn, Fe, and Mo contents of timothy were all borderline low to deficient. These data indicate a definite need for careful attention to the mineral supplementation of diets for cattle on Prince Edward Island, especially Ca, Mg, and trace elements.

Forage–livestock model

A computer program that models the growth, storage, and feeding of a forage and cattle housing, the milking, and the manure handling on dairy farms was used to determine the net benefits of several management alternatives available. One of the more profitable plans for a 30-cow farm includes two cuts per year of timothy, total annual applications of N fertilizer at 160 kg/ha, and storage of the wilted silage in a horizontal silo with formic acid added and covered with polyethylene. The animals in this system are housed in a free-stall barn and milked in a double-four herringbone milking parlor with automatic milker detachers. The manure is handled as a solid. The cows are fed from the silo with a tractor and front-end loader and a feed wagon. This organization is contrasted

against one of substantially lesser profitability that involves one cut per year of timothy, an annual nitrogen application at 34 kg/ha, and storage of wilted silage in a stack silo, and a stanchion barn, pipeline milker, manure handled as a solid, and with feed distributed by cart.

HORTICULTURAL CROPS AND TOBACCO

Potato management and nutrition

Potato nutrition. A study of soil and tissue nutrient levels indicated few problems in the potato crop in Prince Edward Island. Soil test levels indicated a mean pH of 5.2 and 'high plus' P, 'high' K, and 'medium plus' Ca and Mg. Literature values on adequate tissue levels are scarce, but in general, the mean P, K, Mg, S, B, Zn, Cu, and Mn levels observed in Prince Edward Island appeared sufficient. Nitrogen, Ca, and possibly Fe appeared somewhat low depending on the sufficiency levels chosen. The possibility of Mo deficiency requires further interpretation.

Small whole seed potato production. Pre-sprouting of small whole seed tubers in light at 15–20°C for 3 wk prior to planting increased total average seed yields of three varieties (Sebago, Kennebec, and Red Pontiac) over 2 yr when topkilled in early to mid-August. Total yields were increased from 19.6 to 24.0 t/ha and for tubers under 60 mm, from 10.9 to 11.7 t/ha.

Nitrogen applications above 67 kg/ha did not improve the production of Sebago small whole seed tubers. Increasing N rates increased the difficulty, and slowed the rate, of topkilling. Delaying topkilling from 27 August to 10 September increased the total yield from 24.8 to 30.5 t/ha, but the bulk of the increase was in tubers larger than 60 mm.

Six varieties of potatoes grown for seed were topkilled on either 14 August or 27 August. The extra 13 days of growth increased the mean total yield from 15.9 to 25.8 t/ha, and the yield of tubers under 75 mm from 15.9 to 25.0 t/ha. With delayed topkilling, the Superior variety produced the highest yield (31.4 t/ha) and Katahdin the lowest (15.9 t/ha) yield of tubers under 75 mm.

Planting small whole Sebago tubers (80–120 g) did not produce a significantly greater yield of tubers under 75 mm than did planting 160–240 g tubers cut in half, or 320–480 g

tubers cut in quarters. Planting small whole tubers produced more small tubers than did planting sets cut from larger tubers.

Kennebec potatoes planted at either 15 or 30 cm in-row spacings were sampled weekly from 63 to 116 days after planting. The yield of 41–60 mm tubers increased rapidly from 60 to 74 days. At the 15-cm spacing the yield of 41–60 mm tubers increased rapidly from 60 to 74 days. At the 15-cm spacing the yield of 41–60 mm tubers remained fairly constant to harvest, whereas at 30 cm the yield of 41–60 mm tubers declined with time. Yield of tubers from 61 to 80 mm increased rapidly from 74 to 109 days, with close spacing giving a greater yield. Tubers over 80 mm appeared at 81 days, increasing in yield at about half the rate of the smaller sizes. The 30-cm spacing produced about double the yield of the 15-cm spacing in this large size. Final yields at harvest were 22.0, 12.8, and 4.8 t/ha at the 15-cm spacing, and 19.3, 7.2, and 11.4 t/ha at the 30-cm spacing for the 41–60, 61–80, and over 80 mm sizes, respectively.

Processing potatoes. No differences in the N requirement of Netted Gems grown for processing were observed over 3 yr when planted after either clover or oats. The optimum yield response occurred with 67 kg N/ha. With increasing N applications up to 202 kg N/ha, tuber specific gravities were reduced.

Delayed planting of Netted Gems after mid-May by 14 or 28 days reduced both the yield and specific gravity of tubers grown for processing over a 5-yr period. Maximum yields required up to 134 kg N/ha, with less required for later plantings.

Effect of metribuzin residue on crops grown in rotation with potatoes. Residue

carryover in fine sandy loam soils from metribuzin applied preemergence to potatoes at the recommended rate of 0.5 kg ai/ha did not reduce yield of winter rye seeded in September of the year of application, and of barley, red clover, and timothy seeded in May of the following year. At two to three times the recommended rate, metribuzin carryover had negligible effects on yield of these four rotation crops.

Potato virology

The enzyme-linked immunosorbent assay (ELISA) was a reliable and sensitive technique for diagnosing potato X (PVX), S (PVS), Y (PVY), and leafroll (PLRV) viruses in foliage of secondary-infected potato plants. This technique was also used successfully to diagnose PVX and PVS in potato tubers. Use of ELISA for the diagnosis of PLRV and PVY in tubers is being developed for application in seed potato certification.

Effect of lime and K on cabbage yields

Cabbage yields were increased by 13 and 7% by applying lime at 6726 kg/ha to soils with initial pH levels of 4.8 and 5.3, respectively. Yields were affected only slightly by added K. Neither the lime nor the K treatments affected the quality of samples held in refrigerated storage for 6 mo.

Tobacco nutrition

Sources of N. Five sources of N produced varying yields and quality of flue-cured tobacco. The treatment containing 75% NH₄-N + 25% NO₃-N gave the highest yield and dollar return per hectare. This ratio will replace the previous ratio of 50% NH₄-N + 50% NO₃-N for commercial tobacco production on Prince Edward Island.

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Research Station

Kentville, Nova Scotia

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Plant physiology

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INTRODUCTION

This report highlights the principal research results from the Kentville Research Station and the Experimental Farm at Nappan for 1980. Kentville is the center for research in horticulture, poultry, food technology, and pesticide residues in the Atlantic Provinces. The Experimental Farm at Nappan, 80 km north of Kentville, serves as an associate establishment doing applied and developmental research on the production of cereals, forages, and lowbush blueberries, and on the management of livestock. The Atlantic region is characterized by a cool, humid climate and by Podzol soils which sustain a diverse agriculture.

Completion of the new office-laboratory complex is expected in the spring of 1981. Occupancy, however, commenced in October 1980, with facilities nearing full operational status at time of reporting. The consolidation of staff in the new center with access to modern facilities for controlled manipulation of scientific experimentation should offer substantial stimulus to establishment programs.

Crop physiology research was also augmented significantly with the successful recruitment of cereal and vegetable specialists during the year.

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

Seed characteristics. Seed production based on number of seeds per berry differed in four clones of lowbush blueberry (*Vaccinium angustifolium* Ait.). Large seeds were more viable than small seeds.

Promotion by tryptophan of growth and root formation in lowbush blueberry pericarp callus cultures. Lowbush blueberry (*Vaccinium angustifolium* Ait.) pericarp callus grew slowly and formed normal tetraploid roots on Nitsch's medium containing L-tryptophan and kinetin. Both growth and rooting depended on the levels of these two substances in the medium. Rooting declined but callus growth rates changed little over successive subcultures. When tryptophan was replaced by indoleacetic acid, indolebutyric acid, 2,4-dichlorophenoxyacetic acid, or naphthaleneacetic acid, callus growth rates increased but no roots formed. Tryptophan medium did not support callus growth or induce rooting unless the tryptophan was autoclaved with the rest of the medium, thus suggesting that an active substance is produced by reaction of the tryptophan with one or more other constituents of the medium during heating.

Lowbush blueberry breeding. Plants of 16 ultraselect lowbush blueberry clones were prepared for a 1981 first planting of the advanced regional replicated field trials. The trials are to be evaluated in five areas, namely Quebec, Nova Scotia, New Brunswick, Prince Edward Island, and Maine.

A replicated yield trial of 53 entries plus 10 standards was planted at Sheffield in 1980 using an incomplete block design. Plants were prepared for a similar trial to be planted in 1981, and an additional 22 clones were elevated to replicate field trial status.

The first yields were recorded from the 27-entry replicated yield trial set in 1978 and the 10-entry seedling progeny yield trial also set in 1978. Fourth harvest yields were also recorded from the block planted in 1972. Yields of 15.3 and 14.3 kg per 12-plant plot were recorded for clones 70-36 and 70-21, respectively. For the first time at Kentville, all lowbush blueberry fruit was raked and winnowed for yield records in 1980, instead of being hand picked as has been done in the past.

A total of 30 new selections were made from the block of 3336 seedlings planted in 1978, and a new block of 4368 seedlings was set in 1980 for evaluation in 1982.

Grapes

Cultivar testing. Fruit yield and juice analysis were obtained from 31 of the 56 grape cultivars on test at Kentville. The cool weather of May and June delayed flowering and thus fruit maturity by 10–15 days. This adverse growing season permitted the identification of cultivars best suited to the local environment. Four red wine, three white wine, and two seedless dessert types were identified as adaptable and useful cultivars for this region. The first local cottage wine industry was established near Kentville in 1980. Cultivars used to establish the industry had been identified in previous tests conducted at Kentville.

Raspberries

Red raspberry breeding. The Kentville seedling selection K70-II (Southland × Boyne) has been named Nova. Nova has proved to be winter-hardy following 10 yr of plot testing in Nova Scotia plus several years in Prince Edward Island and Quebec. With the exception of the cultivar Festival, no cultivar meets the regional requirement of cane winterhardiness, high fruit yield capability, plus fruit quality; Nova appears to meet these requirements, thereby potentially providing a second good cultivar for the region.

Strawberries

Breeding. Evaluation trials of selections from the Kentville breeding program have identified four superior selections (K73-2, K75-13, K76-9, K78-4) for inclusion in the 1981 regional test plots. The high-yielding, large-fruited selection K74-10 has been named Kent and released to the public via commercial nurseries.

The breeding program designed to incorporate field tolerance for the red stele organism (*Phytophthora fragariae*) has produced selections which will be propagated by a local nursery for distribution to commercial growers. All crosses made in 1980 included a parent resistant to red stele. Seedling inoculation with a strain complex of the red stele organism was carried out at Kentville. The inoculation survivors (1478) which were planted in land infested with the red stele organism will be evaluated in 1981.

Cereals

Animo fall rye. This cultivar is well adapted to the Annapolis Valley of Nova Scotia and was found to be superior in yielding ability to Kustro, Kodiak, and Puma. Animo has a higher kernel weight than its contemporaries, has good lodging resistance, and has straw which is shorter than Kodiak or Puma.

Field crops

Yields of forage peas. The first forage pea trial was carried out in 1977 and the respective yields were: Century 3274 kg/ha, Minerva Maple 3126 kg/ha, and Trapper 2610 kg/ha. Five varieties were grown in 1978 and the leading cultivar was Krupp at 8862 kg/ha followed by Rosakrone at 7544 kg/ha, Minerva Maple at 7421 kg/ha, Century at 7212 kg/ha, and Trapper at 4978 kg/ha. Forage peas are considered a highly productive one-harvest crop.

Ornamentals

Refining slow-release fertilizer treatments for containerized plants in soilless mixes. Following two consecutive years of study, a suitable rate and form of slow-release fertilizer (isobutylidene diurea, IBDU 31-0-0) has been determined to sustain growth rates and appearance of containerized Ardorra junipers through one growing season. Plants were grown successfully in a mixture containing three parts sawdust to one part peat with an admixture of 380 g pelletized IBDU per bushel. The fine, Par-Ex form of IBDU at the same rate did not provide adequate plant nitrogen through the season. In these trials phosphorus was supplied as superphosphate and potassium as muriate of potash or fritted potassium. Minor elements were also added in a fritted form as a medium premix. No visual differences in plant quality could be found between the soluble (muriate) and slow-release (fritted) forms of potassium.

Hardiness zone effects on storage of containerized ornamentals under various coverings. Despite widespread use of storage houses covered with white polyethylene for overwintering containerized ornamentals, trials conducted during 1979–80 indicated that the method is not always satisfactory for plants which are important in the Atlantic Region. Winter storage of *Cotoneaster dammeri* in plant hardiness zone 6a under white polyethylene resulted in satisfactory spring quality,

whereas in zone 5a the same treatment caused severe leaf browning and damage. The same species overwintered under flexible 6-mm styrofoam (Microfoam) was undamaged in either zone.

Differences in the effectiveness of white polyethylene storage were related to lower root temperatures under zone 5a conditions. Microfoam maintained root temperatures significantly above the killing point in both zones. *Juniperus chinensis* cv. Pfitzeriana Aurea stored well under white polyethylene or microfoam under 5a or 6a conditions. The choice of storage method for containerized ornamentals should take into consideration species characteristics (particularly root hardness) and the winter climate of the storage site.

Effects of carbon dioxide on flowering and vegetative development in Pharbitis nil. Short-day (SD) photoperiods (8 h light – 16 h dark) caused rapid flowering in *Pharbitis* plants grown in 0.03 or 0.1% CO₂, whereas plants in long-day (LD) conditions remained vegetative. At 1 or 5% CO₂, however, flower buds were developed under both the SD and LD photoperiods. Flowering was earliest in plants exposed to SD at low CO₂ concentrations, when floral buds were formed at node 3 or 4. At high CO₂ concentrations, floral buds did not form until node 6 or 7. Both high CO₂ concentrations and LD photoperiods tended to enhance stem elongation and leaf formation. Subsequent experiments on CO₂ exchange indicated that the occurrence of flowering under normally noninductive LD photoperiods at 1 or 5% CO₂ could not be readily explained in terms of higher photosynthetic rates. It is possible that inadvertently high CO₂ concentrations in greenhouses producing floricultural crops may lead to undesirable effects on plant morphology.

Ornamental cultivar evaluations. Twenty-eight species of ornamental trees and shrubs were established in test plots during 1980. This planting represented the start of an ongoing evaluation program which will be developed during future years to include locations in Nova Scotia, Prince Edward Island, and New Brunswick. The 1980 plantings were duplicated at the L'Assomption Experimental Farm, Que. Each year more species will be added to the inventory in this testing network, and evaluations will be conducted at each location over a minimum 5-year period.

Rhododendron breeding. Several promising seedlings were selected in 1980 including yellow-flowering types. The white-flowered Kentville seedling selection K74-02 (Cunningham's White × *Rhododendron yakusimanum*) was named Minas Snow.

PROTECTION OF CROPS AGAINST PESTS

Plant pathology

Persistence of captafol applied with foliar nutrients during fruit bud development of apple. Adding the foliar nutrients urea and magnesium sulfate to captafol sprays applied to apples with active ingredient (ai) at 2.4 kg/1000 L water at the pink stage of fruit bud development did not affect the persistence and redistribution of captafol deposits. Residues were higher on foliage throughout the season and on the fruit at harvest when captafol at 6 kg ai/1000 L was applied at the pink stage of fruit bud development than when it was applied when fruit buds were in earlier stages of development.

Evaluation of fungicides on apple. Apple scab pressure was high, with infection periods frequent throughout the spray season in which light sprays were applied dilute to run-off with a handgun to the cultivars McIntosh and Cortland. The experimental fungicides Baycor 50 WP and CGA-64251 look particularly promising for scab control. Both were very effective in mixtures with captan. Baycor with the surfactant AL-411F gave excellent scab control but caused a slightly mottled chlorosis to foliage. The foliage of trees sprayed with CGA-64251 was crinkled, somewhat leathery, and darker green than normal. A test in which these fungicides were applied at 24, 48, and 72 h following two heavy apple scab infection periods suggests that both act as eradicants or after-rain fungicides up to at least 72 h following apple scab infection periods.

Control of twig and blossom blight of highbush blueberry with fungicides. Foliar sprays of Funginex and Ronilan gave significant control of twig and blossom blight and the mummyberry stage of *Monilinia vaccinii-corymbosi* (Reade) Honey. Funginex was more effective than Ronilan in controlling twig and blossom blight and its use increased yields significantly over those of control plots.

Observations on white mold in snap beans. White mold (caused by *Sclerotinia sclerotiorum* (Lib.) deBary) was a problem in snap bean fields where beans had been grown in previous years and in the dense weedy areas of the fields. In these locations infections ranged from 10 to 50% of the plants exhibiting disease symptoms. Losses were less than 5% in the 40 ha surveyed.

Observations on storage rots of McIntosh apples in low oxygen storage. The amounts of storage rots were lower in the lower levels of oxygen concentrations, particularly in the absence of carbon dioxide. Increasing the concentrations of carbon dioxide from 1 to 5% decreased the amount of rots in the higher concentrations of oxygen.

Insect pests

Control of blueberry thrips with permethrin, the effect on yield, and the residue in fruit. Permethrin at 0.4 kg ai/ha controlled blueberry thrips (*Frankliniella vaccinii* Morgan). There was no plant damage, and crop yield was significantly increased. Permethrin residues were not detected in berries.

Pesticide residues

Asulam for control of eastern bracken fern in lowbush blueberry fields. Eastern bracken fern (*Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) Underw.) in fields of lowbush blueberry (*Vaccinium* sp.) was effectively controlled by spray application of asulam (methyl sulfanylylcarbamate), a systemic herbicide. No detectable residue of asulam was found in fruit harvested from treated plots. Spray applications were at 1.12 and 2.24 kg/ha. The higher rate was more thorough than the lower rate in reducing the number of bracken fronds.

Comparative behavior of simazine and terbacil in soils. Adsorption of simazine (2-chloro-4,6-bisethylamino-1,3,5-triazine) was 2.3 to 3.7 times greater than that of terbacil (5-chloro-6-methyl-3-*t*-butyluracil) in the same soils, and adsorption of both herbicides was two to four times greater in the 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

soils⁸ indicating that leaching plays a significant role in terbacil dissipation from soils. Total residues recovered from the upper 25 cm of soils ranged from 6–18% and 16–32% of that applied for simazine and terbacil, respectively. In an oat seedling bioassay, the GR₅₀ values were generally one and one-half to three times higher for simazine than for terbacil in the same soils. Both herbicides were more phytotoxic at pH 7.1 than at pH 5.4.

Herbicide residues in lowbush blueberry. Lowbush blueberry plants were treated with asulam, dichlobenil, 2,4-D, pronamide, or simazine at the recommended rates. The area was burned before regrowth began in the following spring. No residues of herbicides were detected in the berries 2 yr after application.

Persistence of dinitramine and trifluralin in soils. Persistence of two dinitroaniline herbicides in two loamy sand soils of the Somerset and Berwick series was found to be greater than anticipated. Half-lives of spring-applied dinitramine in the Somerset and Berwick soils was 51 and 72 days, respectively, and 126 days for trifluralin in the Berwick soil. Trifluralin had not dissipated to the 50% level in the Somerset soil over the 190-day test period. An indicator plant, *Setaria viridis*, showed severe stunting when grown in soils sampled in late September from plots treated with trifluralin at 1.0 kg/ha in late May.

Residues of glyphosate and its major metabolite in crops as a result of the preemergence treatment with Roundup® herbicide. Neither glyphosate nor its metabolite were found in mature crops of corn, oats, snap beans, peas, carrots, or red beets preemergently treated with Roundup® at 4 kg ai/ha in 300 L water. Analysis was made by gas and thin-layer chromatography.

PROCESSING, DISTRIBUTING, AND RETAILING

Applications of surface waxes to sweet cherries prolongs expected shelf life and reduces disorders resulting from mechanical damage. Surface damage caused by mechanical injury, stem discoloration and shriveling, and fruit weight loss in sweet cherries (*Prunus avium* L.) are persistent problems facing Canadian sweet cherry industries.

Applications of emulsifiable coatings to cherries have significantly reduced surface disorders, fruit and stem desiccation, and stem discoloration. In addition, wax formulations applied to cherries have enhanced fruit gloss, improved overall appearance of the fruit, and increased the potential shelf life by 100%.

Characteristics of frozen strawberries. The physical and chemical characteristics of numerous strawberry varieties have been examined for attributes associated with a high-quality frozen product. Measurements are made on the fresh strawberries at the time of harvest and on the frozen products after approximately 6 mo of storage at -26°C . Good agreement has been found between measurement of color with a Hunterlab color difference meter and the judgment of color by a taste panel.

Fruit maturity and storage parameters affect fruit response to low-oxygen atmospheres. Several fruit and storage parameters have been identified which affect the response of McIntosh apples (*Malus domestica* Borkh) to low-oxygen (1.0% O_2) storage atmospheres. Fruit maturity at harvest is critical for optimum low-oxygen storage retention of fruit firmness. Immature and overmature fruit will have accelerated firmness loss in storage. Postclimacteric fruit are susceptible to internal browning in 1.0% oxygen atmospheres. Similarly, storage temperatures of 0°C when McIntosh apples are held at 1.0% may predispose the fruit to an internal breakdown disorder. Carbon dioxide (0–5.0%) in the storage atmosphere is negatively correlated with the retention of fruit firmness when storage oxygen levels are at 1.0% or lower.

Low-oxygen storage maintains apple quality in several cultivars. Recent developments indicate that present oxygen levels recommended for controlled atmosphere (CA) storage of several apple cultivars (*Malus domestica* Borkh) do not provide for optimum retention of fruit quality and maximum storage life. Reduction of CA oxygen levels to 1.0% or lower has the potential of greatly enhancing the maintenance of fruit firmness, acidity, juiciness, and overall acceptability of Golden Delicious, McIntosh, and Cortland apples in storage. McIntosh apples respond particularly well to low-oxygen atmospheres and demonstrate the potential for commercial year-round marketing of this variety.

The development of a new blanching system. Blanching as a commercial process, though vitally necessary, tends to be energy intensive and high in effluent production, and in many cases significantly reduces the nutrient content of products. Over a 7-yr period a new prototype blancher has been developed which has been demonstrated to reduce energy requirements as much as 10 times when compared with conventional procedures. Most vegetables tested show ascorbic acid retentions of 85–90% of fresh produce and improvements in retention over water blanch processes of up to 52%. Effluent volumes and overall loads tend to be significantly reduced.

Extensive testing has shown the new process system provides significant improvements in the process parameters outlined above while yielding products of high quality that are, in many cases, superior to conventionally processed products. A program is now under way to develop the system as a commercial entity. A unit capable of blanching peas at 2720 kg/h was tested during the processing seasons of 1979 and 1980.

The effect of an individual quick blanching method on ascorbic acid retention in selected vegetables. Method of blanching (including cooling) was found to have a significant effect on residual ascorbic acid level in peas ($P < 0.01$) and broccoli ($P < 0.001$), but not in cut green beans ($P > 0.05$). The separate parts of the procedure (heating and cooling) had an additive effect but acted independently of one another. In each case where a difference was observed the experimental procedure (individual quick blanch – evaporative or air cool) was found to yield a product higher in ascorbic acid than the conventionally processed product (water blanch – water cool). The practical implication is that adoption of specialized steam blanch procedures or evaporative cooling will result in improved nutrient levels in sensitive vegetables (e.g. peas and broccoli) compared with the conventional product. The experiments also indicated that any contact of heat and water with susceptible vegetable materials will cause a marked reduction in ascorbic acid levels. For the vegetables studied, the K-1 individual quick blanch system yielded a fully blanched product which retained mean ascorbic acid levels between 82 and 91% of raw values, depending on the specific vegetable.

ANIMAL SCIENCE

Cattle

Early weaning of beef cows in dry lot. Calves, from half the cows which were wintered on either an adequate or a low plane of nutrition, were weaned at about 2 mo of age and reared on ad libitum creep feed and hay to the normal weaning age of 200 days. Calves left with the cows were fed creep feed ad libitum and had access to forage in the feed bunk. Early weaning did not affect the weights of calves at 200 days of age for cows on the adequate level of nutrition, but early weaned calves from the low-plane cows averaged 7 kg less than those left with the cows. Early weaning improved conception rate of the cows on the low level of feeding but had no effect for those fed adequately. The most economical feeding program was the low plane of nutrition with early weaning.

Effect on animal gain of steam-treating grass for silage. Four crops were compared as unwilted silage for beef cattle weight gain: (a) grass harvested 14–15 June, early head stage, of 61% digestible in vitro dry matter (DM); (b) similar grass, steamed standing, harvested 14–15 June, early head stage of 63% digestible DM; (c) second harvest of grass from same area as *a* above harvested 22–24 August, early head stage of 59% digestibility; (d) grass-legume, second harvest on 22–24 August, early head – early bloom stage of 62% digestible DM. Steaming of grass in *b* was accomplished with the Dutch thermal unit. Animal gains (kilograms per head per day) when silage only was offered were: (a) 0.45; (b) 0.71; (c) 0.47; and (d) 0.71. This represents an increase of 57% in animal gain resulting from steaming a standing grass sward prior to ensiling, compared with a 30% increase obtained by supplementing the conventional silage ration with 1 kg of barley per day.

Monensin for beef cows. Monensin, a feed additive approved in Canada for use with feedlot cattle, has not been approved for breeding animals. In 3 yr of testing with the Nappan beef cow herd, it has proved effective in improving the efficiency of feed conversion and has not shown any detrimental effects on reproductive performance of the cows. In 1 yr when feeding was suboptimal, there was evidence of a beneficial effect on conception rate from feeding monensin.

Stocking rate for reed canarygrass pasture.

It was found that a reed canarygrass sward grazed rotationally and at a low stocking rate will continue to persist for at least 3 yr. Two years of continuous grazing nearly eliminated the stand in previous experiments. Animal gain was not significantly different between a low and high grazing intensity, but the low grazing intensity favored the reed canarygrass production, with a dry matter yield of 8.87 Mt/ha.

Use of prostaglandin to synchronize estrus.

The main cow herd at Nappan was injected with prostaglandin on 2 days 10 days apart and inseminated twice on the 3rd and 4th day after the second injection. Less than 50% of the herd conceived to these inseminations. Weaning the calves on the day following the second injection did not improve conception rates at the timed inseminations, but it did increase conception rates of the cows over the 2-mo breeding season, especially for cows that were on a low plane of nutrition prior to weaning.

Hogs

Comparison of growing weaner pigs on raised decks and on solid flooring. Raised weaner decks are increasing in popularity across Canada and the United States. Because of this popularity it was decided to test this equipment via two experiments, using a total of 150 weaner pigs. The pigs were placed on six treatments which compared weaner decks to floor pens at three stocking densities. Results indicate that performance of pigs in terms of growth rate, feed conversion, health, and carcass quality is not improved by the use of weaner decks. It was also found that weaner pigs reared in low stocking densities perform better than those kept in higher densities.

Effect of fish silage supplementation of feed on performance of growing-finishing swine. Fish silage in addition to a 16% crude protein ration was fed to 24 pigs from 40 kg to 60 kg liveweight. Consumption of fish silage, when fed separately from the rest of the ration, does not appear to be a viable supplement for swine rations. Other feeding methods will be tested in future trials.

Effect of sodium hypochlorite on the growth of pigs. Water containing 1000 ppm sodium hypochlorite was given to 10 barrow pigs from 4 wk of age to market weight.

Consumption of sodium hypochlorite resulted in no measurable effect on growth rate, feed conversion, or carcass quality.

The influence of number of animals per pen and presence of free choice minerals on leg weakness in boars. The feeding of a free-choice mineral mix, and the opportunity for increased exercise, were tested on boars both with and without foot and leg weakness. The results indicate that neither of the treatments tested have any effect on the feet and legs of boars.

Poultry

Cooking characteristics and eating quality of broiler chickens fed squid meal. Meat from frozen broiler chickens that had been fed diets containing 0 (control), 5, 10, or 15% squid meal was evaluated for its cooking characteristics and eating quality. Ten panelists scored samples for flavor, juiciness, tenderness, and off-flavor. Control samples lost significantly more weight ($P < 0.05$) during cooking than did the 5% squid meal samples. As the level of squid meal in the diets increased, the chicken flavor intensity decreased slightly but not significantly. Off-flavors were detected in samples from all treatments including the control. The off-flavor of control and 5% squid meal samples was not characterized by the judges, whereas the most common description of the off-flavor for the 10% and 15% squid meal samples was 'fishy.' Control samples were significantly less juicy ($P < 0.05$) than squid meal and significantly less tender ($P < 0.05$) than either the 5 or 10% squid meal samples. It is concluded that up to 10% squid meal can be fed to broiler chickens without significantly affecting cooking characteristics or eating quality of the meat produced.

Effect of vitamins on the incidence of mortality and acute death syndrome ('flip-over') in broiler chickens. Eight different vitamin mixtures were each fed to six replicate pens (150 birds per pen) of day-old Cobb chicks in a completely randomized design to evaluate the effect of biotin, pyridoxine, and thiamine singly or in combination and the effect of feeding these vitamins in addition to the standard vitamins at two and four times their required level on mortality and incidence of acute death syndrome (ADS) or 'flip-over' of broiler chickens. Further additions to the standard vitamins and addition of thiamine to the standard vitamin mixture significantly

increased 28-day liveweights ($P < 0.05$). The addition of biotin or thiamine significantly improved feed conversion ($P < 0.05$). Monetary returns were reduced for those diets involving multiple additions of vitamins owing to increased feed costs. Total mortality and mortality attributed to ADS appeared to be reduced by the inclusion of additional vitamins. The inclusion of biotin alone significantly reduced total mortality ($P < 0.05$) and mortality due to ADS ($P < 0.05$).

Influence of genotype and diet on general performance and incidence of leg abnormalities of commercial broilers reared to roaster weight. Two experiments were conducted to study the influence of genotype and diet on general performance and incidence of leg abnormalities of commercial broiler chickens reared to roaster weight. In experiment 1 a total of 1960 male day-old chicks of seven different commercial genotypes were housed separately in 14 pens (25.64 m²) with 140 birds per pen and fed one dietary regimen. In experiment 2, 3000 male day-old chicks of two commercial genotypes were randomly assigned to 20 pens (13.54 m²) with 150 birds per pen, and two replicate pens were fed one of the five different dietary regimens designed to promote rapid, intermediate, or slow growth.

Differences ($P < 0.05$) were observed among the genotypes tested (experiment 1) in the incidence of mortality, leg abnormalities, liveweight, and feed conversion but not for mean monetary returns per bird housed. In experiment 2, significant differences ($P < 0.01$) were observed among the dietary regimens tested for liveweight, feed conversion, and monetary returns per bird housed. As the protein content of starters, growers, and finishers decreased, body weight decreased but monetary returns improved. Feeding the birds beyond 63 days resulted in a substantial reduction in monetary returns. A dietary regimen which included starter, grower, developer, and finisher with 18, 24, 22, and 14% protein, respectively, resulted in significantly better feed conversion and a significantly lower incidence of leg abnormalities.

Performance of chicken broilers changed from starter to finisher diets at different ages. A total of 1600 broiler chickens were fed a starter diet (24.0% protein and metabolizable energy of 12.45 MJ/kg) and a finisher diet (15.9% protein and metabolizable energy of

13.45 MJ/kg) in this experiment. Commencing at 24 days of age, and at daily intervals thereafter to 33 days inclusive, randomly selected pens of birds were switched from starter to finisher diets. All surviving birds were slaughtered at 49 days. Although mortality was slightly higher among females, body weights were numerically heavier when birds were switched from starter to finisher at 28 days of age. However, this was not reflected in a significant difference in monetary returns ($P < 0.05$). It is concluded that broiler chickens fed diets described herein may be changed from starter to finisher diets over ages ranging from 24 to 33 days without markedly affecting general performance or monetary returns. This latter relationship may change with different ingredient costs.

The effect of diet, feed withdrawal, and carcass chilling on the live and eviscerated weights of broiler chickens. Nine hundred broiler chickens, which had been reared on six different dietary regimens, were involved in an experiment to estimate the effect of feed withdrawal for 0, 8, and 18 h prior to slaughter. Gains in eviscerated weights during immersion cooling and holding in an ice pack were estimated by weighing eviscerated carcasses prior to their entrance into the ice water of the cooling tank and after being held in an ice pack for 20 h. Body weights were not significantly affected ($P < 0.05$) by dietary treatments. Compared with the control (0 h), body weights were significantly reduced with 8 h and 18 h of feed withdrawal. These weight losses represent a reduction in monetary returns over feed costs of 2.0 and 8.4 cents per bird, respectively. The increase in eviscerated carcass weight that occurred during the cooling and holding in an ice pack for 20 h amounted to 6.9% and 6.5% for male and female carcasses, respectively.

The effects of dietary protein levels, ahemeral light and dark cycles, and intermittent photoperiods on the performance of chicken broiler parent genotypes. Experimentation was undertaken to estimate the effects of: (1) two dietary protein levels (13.6 and 15.4%) in breeder diets fed to commercial meat parent genotypes; and (2) six photoperiods involving 24-h and 27-h (ahemeral) day cycles with single-stage and intermittent lighting for birds housed in floor pens. It was concluded that the 13.6% protein breeder diet, which provided 14.8 and 20.9 g of protein per bird

per day and from 301 to 425 kcal of metabolizable energy (ME) per bird per day, was adequate to support optimum performance.

The ahemeral light treatment 14L:13D used from 168 to 448 days had a depressing effect on egg production and feed efficiency compared with the conventional 24-h day cycle with 14L:10D light treatment. The 14L:13D treatment, however, did result in increased egg size and improved shell strength. The intermittent light treatments, whether ahemeral or 24-h cycle, resulted in improved egg weight and shell strength. The ahemeral intermittent treatment (10L:12D:2L:3D) had the effect of depressing fertility and hatchability, whereas the 24-h intermittent photoperiod (10L:9D:2L:3D) resulted in fertility and hatchability being equal to or better than with other treatments. It was concluded that the 24-h intermittent light treatment (10L:9D:2L:3D) supported performance which was equal to or better than other light treatments including the 27-h ahemeral day cycles.

The effect of several different photoperiods on the performance of meat-parent genotypes. A total of 4700 birds, consisting of four commercial meat-parent genotypes, were used in two experiments to estimate the effects of several photoperiod treatments. In each experiment, the rearing photoperiod treatments consisted of (1) a constant 8-h period of light per day and (2) a constant 12.5-h period of light per day. In the first experiment birds reared on 8 h of light per day were subjected to three adult photoperiods: (A) increased from 9 h at 20 wk to 16-h constant photoperiod at 32 wk, (B) 16-h constant photoperiod from 20 wk to end of experiment, and (C) intermittent photoperiod 10.5D-2L-2D-9.5L. The group reared on the 12.5-h photoperiod were subjected to three adult photoperiods: (D) increased from 12.5 h of light per day at 20 wk to 17 h constant at 32 wk, (E) increased from a 12.5 h of light per day at 20 wk to 16 h at 22 wk, and (F) changed to 10.5D-2L-9.5L day cycle. Photoperiod treatments were the same in experiment 2 except that the adult treatments were introduced 1 wk earlier and treatments C and F were changed to 9.5D-2L-2D-10.5L. There were significant genotypic effects for practically all traits measured except mortality. Photoperiods D, E, and F resulted in a significant delay in sexual maturity compared to A, B, and C. Egg production tended to be higher for

treatments A, B, and C, with treatment C supporting the best general performance.

The effect of Nutri-Bond as a pellet binder in chicken broiler genotypes. A total of 1360 male and female chickens were fed starter and finisher diets containing 0, 1, 2, or 3% Nutri-Bond in two separate experiments. A different genotype was used in each experiment. No significant treatment effects were observed for mortality or feed conversion. Body weights in one experiment were lower when Nutri-Bond was fed. Monetary returns were lower when diets contained Nutri-Bond.

The nutritional value of rapeseed meal for layer genotypes housed in pens. A total of 600 single-comb White Leghorn (SCWL) pullets of two commercial genotypes (300 of each) were fed soybean meal (SM) or rapeseed meal (RSM) during either or both the growing and laying periods. RSM can replace a major portion (74%) of the SM of starter and grower diets without affecting mortality or feed consumption adversely. Differences ($P < 0.05$) were observed between the two genotypes for age at sexual maturity, body weight, egg weight, Haugh units, and specific gravity of eggs, but not for percentage mortality, hen-housed egg production, or feed conversion. Feeding RSM had no effect on body weight at 497 days, egg production, feed conversion, or Haugh units, but it significantly ($P < 0.05$) reduced egg size at 497 days and egg specific gravity. This study indicated that RSM is a good source of dietary protein for layer genotypes housed in pens and that it can replace a major portion of SM in such diets without adverse effects.

The nutritional value of rapeseed meal for caged layers. A total of 1536 SCWL pullets of two commercial genotypes (768 of each) were fed soybean meal (SM), Tower, or Candle rapeseed meal (RSM) during either the growing or the laying period or both. RSM can replace a major portion (74%) of the soybean meal of starter and grower diets without adversely affecting mortality or feed consumption. Differences were observed between the two genotypes for all traits measured during the laying period, except for mortality. Switching the birds from an SM grower diet to a 15% RSM layer diet resulted in a significant ($P < 0.05$) increase in mortality. In general, the feeding of Tower RSM during both the growing and laying periods resulted in heavier birds, earlier

sexual maturity, higher egg production, and improved feed efficiency than when diets containing Candle RSM were fed. It is concluded that RSM can replace a major portion of the SM in grower and layer diets without adverse effects, providing amino acid and nutrition balance is maintained by slightly increasing the amount of fishmeal added.

The nutritional value of Tower and Candle rapeseed meals for turkey broilers housed under various lighting conditions. A total of 1200 poults were housed in a split-plot arrangement to evaluate four different dietary treatments and three light treatments. Pre-starter and starter diets contained 0 or 10% Tower rapeseed meal (RSM), Candle RSM, a combination of Tower and Candle RSM (50:50), and 0 or 20% of these RSM treatments, respectively. Grower, developer, and finisher diets contained 0 or 30% of these RSM treatments, respectively. The light treatments tested were continuous (23L:1D), intermittent (4L:2D), and total darkness. Tower and Candle RSM, singularly or in combination, when included in turkey diets resulted in significantly lower mortality, higher liveweights, improved feed conversion, higher percentage Grade A carcasses, and improved monetary returns. There were no significant differences observed for any of these traits for turkeys raised under continuous or intermittent lighting or total darkness. There was, however, some indication that the turkeys tended to perform better under intermittent lighting. No light \times diet interaction was observed for any of the traits measured, indicating that the turkeys responded in a similar manner regardless of the diet or light treatment. It is concluded that RSM is a nutritious and efficacious source of dietary protein for turkey broilers.

Sheep

Artificial rearing of lambs. The addition of a low level of sodium bicarbonate (1% wt/wt) to the milk replacer increased daily feed intake and gain of lambs weaned at 1 day of age when the energy content of the diet was supplemented with corn oil or corn oil plus lactose, but not when lactose only was added. The addition of 1 or 2% sodium bicarbonate to the concentrate fed to 56 days of age also increased daily feed intake and rates of gain. There was high mortality (40%) among lambs fed a low fat (12% fat) milk replacer with

supplemental energy supplied by lactose with or without the addition of 1% sodium bicarbonate. Mortality was lower (10%) for lambs fed the same replacer with energy supplied by corn oil or corn oil plus lactose. Only a limited amount of lactose can be digested by the young lambs.

Cement kiln dust for lambs. In two earlier trials the addition of 2% (wt/wt) sodium bicarbonate or cement kiln dust to mash-type diets for growing lambs has increased daily gains. In this experiment the addition of 3% cement kiln dust to pelleted diets containing either 15 or 45% ground roughage did not give a response. There was little difference in the daily gains of lambs fed the 15% roughage (0.22 kg) or the 45% roughage diet (0.20 kg) but those fed the high roughage consumed more feed per day and converted feed to gain less efficiently (9.0 versus 7.4 kg feed per kilogram of gain).

Dehydrated alfalfa pellets for ewes. Previous work has shown that dehydrated alfalfa pellets (DAP) and limited long hay make a satisfactory diet for pregnant and lactating

ewes. In this experiment a standard hay and grain diet was compared with limited or ad libitum DAP with long hay. Highest total feed consumption and lowest weight loss to weaning were obtained by the ewes fed DAP ad libitum. The ewes fed limited DAP consumed more feed than those fed the hay and grain but had slightly greater weight losses. There were no significant differences in lamb weights due to the feeding treatment of the ewes. With the materials used, about 1.4 kg of DAP were required to equal the energy value of 1 kg of barley for the ewes.

Early weaning of lambs. Lambs born in February were weaned at either 5–6 or 9–10 wk of age, and feed consumption was compared for both ewes and lambs until 2 wk after the late weaning. Early weaning did not result in a large difference in weight gains (0.22 kg/day early weaned versus 0.24 kg/day for those late weaned). After weaning, the early weaned ewes were fed only long hay and lost weight (0.1 kg/day). The ewes nursing lambs were fed slightly more than necessary to maintain weight (gain average 0.01 kg/day). Feed costs were lower for the early weaned lambs and ewes.

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Research Station

Fredericton, New Brunswick

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Departures

W. B. COLLINS, B.Sc., M.Sc., Ph.D. Promoted to Program Specialist (Atlantic Region), 25 August 1980	Potato physiology
C. F. EVERETT, B.Sc., M.Sc., Ph.D. Retired 30 December 1980	Weed control
G. R. JOHNSTON, B.Sc., M.S.A. Retired 29 December 1980	Potato breeding and evaluation
M. E. MACGILLIVRAY, B.A., M.Sc., D.Sc., F.E.S.C. Retired 26 December 1980	Potato insect ecology, aphid physiology

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INTRODUCTION

The Fredericton Research Station is the main potato research center for the Research Branch of Agriculture Canada. Scientists of diverse disciplines concentrate their efforts on breeding, pathology, pest management, physiology and nutrition, and handling and storage procedures. While our research continues to support the industry in the Canadian market, it is now being called upon to provide new technology for the production of high-quality seed potatoes for export, including new cultivars to meet the special needs of importing countries.

The livestock program deals with cattle and sheep, and our researchers are in close collaboration with workers at the Nappan Experimental Farm of the Kentville Research Station.

The vegetable and berry crops program is receiving more emphasis since the acquisition of the Michaud Experimental Farm in 1978. Extensive field trials were commenced in 1980.

The environmental quality program has a broad spectrum of activities, dealing as much with maintaining the quality of the agricultural land base as with preventing cultural practices from polluting either the soil, the waterways, or the crops.

In 1980, four of our colleagues departed; Dr. C. F. Everett, G. R. Johnston, and Dr. M. E. MacGillivray retired, and Dr. W. B. Collins accepted a new challenge as Program Specialist (Atlantic Region) in Halifax.

The present report deals briefly with some of our recent research results. 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

Formaldehyde-treated protein supplements

Formaldehyde treatment has been employed as a method to increase the rumen bypass of protein supplements and possibly enhance the utilization of the large amount of nonprotein nitrogen in grass silage. Twenty-four cows were divided into two groups and fed ad libitum total mixed rations (13% crude protein) composed of grass silage and concentrates in a 60:40 ratio on a dry matter basis by weight for 8 wk. The protein supplement for each concentrate consisted of untreated or formaldehyde-treated soybean meal. The group fed untreated soybean meal had higher ($P < 0.05$) total daily dry matter intake (19.0 versus 18.1 kg per cow) but the level of milk production and percentages of milk fat, protein, and lactose were not affected by the treatment. Formaldehyde treatment significantly ($P < 0.01$) reduced rumen acetate and propionate levels as well as the percentages of rumen ammonia nitrogen and blood urea.

The digestibility of dry matter and nitrogen by sheep fed the two rations were similar,

whereas nitrogen retention was markedly increased by formaldehyde treatment. Although no differences in milk production were detected, formaldehyde treatment of the soybean meal favorably altered the rumen fermentation pattern and reduced ammonia nitrogen levels.

Plasma β -carotene levels in dairy cows

β -Carotene has been linked with reproductive performance in dairy cows. Twenty-four cows in early lactation were randomized into three groups to monitor plasma β -carotene levels over a 16-wk period on three different forage feeding programs. Group A was pastured, group B was fed grass silage, and group C was fed timothy grass hay that had been stored for approximately 12 mo. In addition to the forages, the cows received a barley-based concentrate fed in proportion to milk production. Jugular blood samples were collected and analyzed at 14-day intervals.

All cows had been fed grass silage for several months prior to the trial. Plasma β -carotene levels at the beginning of the trial averaged 10.4 $\mu\text{g/mL}$. Levels in cows on pasture increased continuously and averaged 13.2 $\mu\text{g/mL}$ of plasma, whereas levels in cows

receiving silage declined during the 1st mo of feeding, then remained constant at 7.3 $\mu\text{g}/\text{mL}$. Levels in cows fed stored hay dropped sharply after 1 mo and averaged only 1.9 $\mu\text{g}/\text{mL}$ of plasma during the last 2 mo of study, which is below the level of 3–5 $\mu\text{g}/\text{mL}$ suggested for optimum dairy cow fertility.

Acidification of milk for calf feeding

Newborn calves were fed whole milk (C), or whole milk treated with formalin (F), propionic acid (PA), or formic acid (FA) to meet ad libitum consumption. The C group consumed the most milk and grew fastest while on milk. They also used milk more efficiently, consuming 10.2 kg/kg of growth, versus 11.5 (F), 11.6 (PA), and 11.6 (FA). There was little difference among the four groups in consumption of calf starter or chopped timothy hay before or after weaning. After weaning, the C group grew slowest, whereas the FA group grew fastest. Although this is not an economical feeding program, it did demonstrate that restricted intake and growth before weaning may be compensated by superior feed efficiency after weaning.

Densely seeded corn for silage

Dense-seeded (200 000 seeds per hectare) corn for dry matter production and weight gains of animals fed the silage. Densely seeded corn gave 16% higher dry matter yield (9710 versus 8350 kg/ha), lower grain yield (1760 versus 2230 kg/ha), lower dry matter content of the ear (30.6 versus 39.5%), and lower silage dry matter digestibility by sheep (60.7 versus 65.8%). Beef cattle fed the normal silage consumed more dry matter per day (4.2 versus 4.0 kg) and gained significantly faster (1.14 versus 1.06 kg/day). Based on the feed conversion figures obtained, without making allowance for the contribution of the supplement fed, the densely seeded silage would support more beef production per hectare (2092 versus 1825 kg).

Bird damage to the ears of corn grown for silage is a serious problem. About 30% of the grain from the ears of the corn in both of the above seeding treatments was removed by birds. However, because the grain made up a smaller percentage of the total dry matter with the densely seeded corn, dry matter loss to birds was less with this treatment.

Ratio of potatoes to hay for silage

Good silage can be made from 5:2 or 3:1 ratios of potatoes to hay, but producers would like to use a higher ratio to use more potatoes and to increase the energy content of the silage dry matter. We compared ratios of 3:1 and 5:1. There was considerable seepage from the silo containing the 5:1 silage, but both silages were well preserved and readily accepted by beef cattle. Ten animals were fed on each of (1) 3:1 silage plus 2.5 kg concentrate, (2) 5:1 silage plus 2.5 kg concentrate, or (3) 5:1 silage plus 0.5 kg concentrate.

Silage dry matter consumptions were 6.81^b, 6.53^b, and 7.32^a kg/day for treatments 1, 2, and 3; weight gains averaged 0.94^b, 1.12^a, and 0.86^b kg/day. Treatment 3, because of the more economical use of supplement, gave the highest return over feed costs. It was concluded that 5:1 ratio of potatoes to hay is satisfactory for silage but does lead to some seepage from the silos. The optimum ratio of potato to hay for silage is about 4:1.

Weight loss of cattle on turnout to pasture

When cattle are turned out to pasture in the spring they can lose up to 20% of body weight in the first few days. It has been suggested that the transition causes an increased excretion of potassium resulting in a reduction of body water content.

Twenty-seven heavy yearling cattle were grouped by three's and assigned to: (1) remain indoors on haylage and supplement, (2) pasture with a control supplement at 1.0 kg/day, or (3) pasture with a supplement containing potassium at 1.0 kg/day. At slaughter it was found that approximately half the weight loss on turnout to pasture was accounted for by changes in gut fill. The other half was carcass weight loss. The supplemental potassium did not have any apparent beneficial effect on the weight changes.

Mineral content of New Brunswick forages

Over 500 samples of forages were collected in New Brunswick in each of 1978 and 1979 and analyzed for nine minerals of nutritional significance. The samples were separated into grasses, legumes, and weeds and each fraction was analyzed separately. Of the nine minerals assayed, only potassium and iron were present in amounts adequate for ruminant animals in most New Brunswick forages. Calcium and magnesium were adequate in legumes but not

in grasses. Minerals that require supplementation include sodium, phosphorus, zinc, copper, and manganese. A mixture of commercial trace mineralized salt and dicalcium phosphate should supply adequate mineral supplementation. No major differences were found in mineral content of forages from different areas of the province.

Transformations of potato glycoalkaloids by rumen microorganisms

The increased use of cull potatoes and of wastes from processing plants for animal feed and renewed interest in the potential feeding value of potato vines prompted an investigation into the fate of potato glycoalkaloids in ruminant animals. Incubation of potato glycoalkaloids with rumen microorganisms resulted in initial hydrolysis to the alkaloid solanidine. A substantial portion of the solanidine was then reduced to the 5,6-dihydro analog 5 β -solanidan-3 β -ol. No evidence of subsequent esterification with fatty acids or metabolism of the nitrogen moiety was detected.

Improved nylon bag technique reduces variation in evaluating forages

Forage samples may be enclosed in bags made of indigestible nylon fabric and several of them suspended in the rumen of one fistulated animal to be removed as required. The extent and rate of digestion of many forages can then be determined with only a few fistulated animals. A newly standardized technique includes use of a standard mesh nylon-monofilament fabric, presoaking the bags, careful rinsing after removal from the rumen, and uniform treatment of the animals.

Variance components of digestibilities of dry matter (DM) and neutral-detergent fiber (NDF) were determined for three forages when run in triplicate bags for both 48 and 72 h durations and repeated on two different weeks. This plan was repeated in each of four fistulated cows.

The variance between cows, different weeks, and triplicate bags was exceptionally low. As expected there was more extensive digestion and lower variation after 72 h than after 48 h. The components of variance were used to calculate the expected standard errors of the mean (SEM) digestibilities for several combinations of numbers of animals, bags, and weeks of replication. For example, the expected SEM for DM digestibility (%), after

72 h, using duplicate bags in one cow on one or two different weeks, respectively, for wheat straw was ± 2.1 and ± 1.7 ; for alfalfa hay, ± 1.0 and ± 1.0 ; for timothy hay, ± 1.0 and ± 0.7 . With this nylon bag technique, two bags used at the same time (week) with one cow gave acceptable SEM for DM and NDF digestibility for forage evaluation.

POTATO BREEDING

Predicting performance of potato clones in different environments

It is difficult to carry out international trials of potato clones because of the problems involved in raising quantities of disease-free seed and delivery to collaborators. Several biometric models were examined for predicting performance of potato clones in different environments. Most promising was the sending of a small group of genotypes (10) as controls to all regions for trial. The average yield of the controls in a trial serves as a measure of productivity, namely an environmental index, for that region. The main group of clones was tested in a few chosen regions, and the data for each clone regressed on the environmental indexes to establish a regression equation. This equation was then used to predict performance of the clone in regions where it had not been tested. Yield data of an international series of trials sponsored by the International Potato Center and Agriculture Canada were used for testing the prediction model. The accuracy of prediction appears to be satisfactory for most of the testing sites.

Utilization of diploid germ plasm in potato genetics

Diploid potato germ plasm is being used both to broaden the genetic base of the breeding population and in potato genetics research. In a genetic study on tuber russeting on the diploid level, progenies from crosses where neither, one, or both parents were classified as 'russet' were analyzed. The observed segregation ratios fit a hypothesis of complementary action by three independently segregating dominant genes. It is possible, therefore, that progenies from nonrusset parents will contain some russet clones when, among both parents, all three complementary genes are present. The genotypes of several russet and nonrusset clones have been determined.

An *Andigena* population changed by mass selection

Andigena potatoes adapted to long days, and selected for disease resistance, have been crossed at Fredericton with *Tuberosum* cultivars to exploit the heterosis of the F_1 hybrids.

In the meantime the base *Andigena* population, first obtained as true seed from the 1968 and 1969 crops at the Scottish Plant Breeding Station, has been subjected to five cycles of recurrent mass selection. In each cycle at Fredericton 25–30% of a single-hill population was selected for haulm type and vigor, and intercrossed using cut stems, labeled for identification, and bulked pollen. At harvest, 20–40% of the cutting 'mother' plants in the field were selected for maturity, yield, and tuber type. Seed that had set on the cut stems of these clones was used to make up the next generation. Thus a cycle was completed in 12 mo with no overlapping of generations and very little selfing. There were five cycles of such selection. Some true seed from each generation was saved for later comparison.

In 1977 some of the Scottish seed and seed from each Fredericton generation were planted in the greenhouse. After a multiplication stage in the field in 1978, cultivars from these six groups were compared in field trials during 1979 and 1980. Early plant vigor increased markedly between the parental and first generation, whereas haulms improved in maturity only in the last two generations. Rhizomes were less persistent in attachment to tubers in the later generations in the 1979 trial, but showed no differences among generations in 1980. Total yield increased almost 30% (663 g to 850 g per hill) from parental to fifth generation, reflecting an increase in tuber number but little change in mean tuber weight. During the five cycles of selection, tuber dormancy was shortened. This resulted in increased sprouting in storage and need for sprout-removal before planting and, in turn, more stems and tubers, effectively maintaining the small tuber size.

To correct these deficiencies, superior clones are being used as to start a new selection program, with more emphasis on early bulking, tuber size, and longer dormancy.

POTATO ENTOMOLOGY

Monitoring arthropod fauna on potatoes in New Brunswick

Potato fields in 10 New Brunswick counties were sampled in 1979 and 1980 for different arthropod fauna. Particular note was made of native predators and parasites that might be useful in biological control. Five sampling techniques were compared. Populations of Diptera and Hymenoptera were best monitored by yellow pan traps. Ground cloth and sweep net sampling were equally satisfactory for the Hemiptera and most families of Coleoptera. Nocturnal arthropods such as Carabidae, Staphylinidae, and Araneidae were best monitored by pitfall traps, although the dispersal of the flying species could be followed with the yellow pan traps. Visual observation of arthropods provided a further qualitative assessment of populations.

Arthropod populations were at highest levels in late July to early August. Only nocturnal insects and spiders were present in large numbers throughout the season. Spiders were more numerous than other predator groups. Six species of primary parasites and four species of hyperparasites were reared in the laboratory from potato-infesting aphids. Though relatively scarce, these parasites were found in July and August, almost exclusively on *Macrosiphum euphorbiae* (Thomas), the aphid most abundant during this period.

POTATO PATHOLOGY

Physalis angulata as local lesion test plant for potato virus A

Further testing has revealed that *Physalis angulata* is the more useful of three *Physalis* species reported as local lesion hosts for potato virus A (PVA). It grows rapidly and produces large smooth leaves over a period of several months. Local lesions developed in 4–5 days on detached leaves and 7–10 on intact plants. Unlike *P. floridana*, *P. angulata* does not react with distinct local lesions to potato virus X (PVX); and it is not necessary to detach leaves to avoid lesions due to potato virus Y (PVY). These two viruses do eventually cause systemic mosaic symptoms, so on intact plants, all suitable leaves should be used for testing on one occasion. In comparative tests, accuracy of *P. angulata* diagnosis of

PVA was equal to enzyme-linked immunosorbent assay (ELISA). Local lesion production of *P. angulata* was not significantly affected by varying the light intensity between 2476 and 6458 lx or the temperature between 15° and 25°C.

Effect of sprays on the detection of PVA and PVY by ELISA

Assay of PVA and PVY by ELISA was not affected by a number of agricultural sprays. A fungicide (chlorothalonil), an insecticide (methamidophos), and an oil emulsion were each applied at 2-wk intervals, from 4 July, to 50 plants of Netted Gem potatoes infected with PVA or PVY. A fourth plot was sprayed with water. Foliage samples were collected on four occasions, between 8 July and 24 August.

Control of PVY by mineral oil sprays

Control of PVY by oil sprays varied from 34 to 64% in trials during 1979 and 1980. Degree of control depended largely on concentration of the oil, but to a lesser extent on rate and pressure of application. There was no significant difference between eight commercial oil formulations.

No significant phytotoxic effect resulted from applications of Corntrol Oil®, except when a combination of high oil concentration (3% water emulsion) and rate of application (2240 L/ha) was used.

When fungicides were mixed with oil or applied immediately after oil, more phytotoxicity occurred than when they were applied 24 h later than oil. Fentin hydroxide was the most phytotoxic, followed by chlorothalonil, captafol, metiram, and mancozeb in that order.

There were no significant differences between oil deposits on leaves exposed to natural rainfall and those sheltered by plastic sheets or on leaves exposed to 3 cm versus 1 cm of artificial rain. Nor did timing of the artificial rain have any significant effect.

Resistance to potato virus Y

Since 1968, we have maintained field exposure plots to evaluate resistance to PVY in potato cultivars. We used healthy seed of the cultivars on trial and PVY-infected seed between plots. On the basis of data collected over 5 yr (1972–1976), we separated 32 'standard' cultivars into four groups by means of cluster analysis: (a) resistant, (b) moderately resistant, (c) susceptible, and (d) very

susceptible. Although all of the 32 'standard' cultivars were not present in the plot every year since 1968, there was always a sufficient number to provide a mean percentage of infection for each of the four classes. There was considerable fluctuation in the overall level of infection from year to year, but the relative order of the group means, a, b, c, and d, has been maintained without exception for each year, 1968–1979. There were many additional cultivars in the plot each year. Most of these can be assigned to a particular group on the basis of 3 yr of testing, not necessarily in succession.

Potato leaf roll virus

A separate trial to evaluate cultivar resistance to the potato leaf roll virus (PLRV) has been maintained since 1971. Data for 4 yr (1973–1976) was used to separate 21 cultivars into four groups similar to those used for PVY, above. And here, too, the means of each group have maintained the relative order a, b, c, and d for the years 1971–1979.

Unlike PVY, the overall levels of infection in the PLRV plot have followed two clear trends: an increase from moderate in 1971 to a maximum in 1973 and a decline each year to a very low level in 1977, followed by a slight increase in 1978 and 1979. The trend in our trial appears to have anticipated by a year or two the leaf roll 'epidemic' in the New Brunswick commercial crop in the early 1970's.

Latent bacterial ring rot

It has been suggested by European workers that *Corynebacterium sepedonicum* may remain at subclinical levels (latent) in potatoes for several years before producing symptoms typical of bacterial ring rot (BRR). In two field experiments, one near Fredericton and the other near Bologna, Italy, symptoms were expressed within a single growing season when infected symptomless tubers were used as seed. Seed for both trials was derived from a table-stock field of the cultivar Kennebec, diagnosed in 1979 as positive to BRR. The stem ends of 3000 healthy-appearing tubers were tested individually for the presence of *C. sepedonicum* by latex agglutination; approximately 10% of those found to be latex positive were checked and verified by either or both the Gram stain and immunofluorescence microscopy. Virtually 100% of the 'latent-infected' tubers produced plants or tubers or

both with definite visible symptoms. Symptom severity ranged from slight wilting of the plants and small initial external lesions on the daughter tubers to complete wilting and early death of the plants with no tuber production.

Immunoreactive component from potato tubers infected with BRR

A heat-stable, nondialyzable component was isolated by ethanol precipitation and column chromatography from aqueous extracts of tubers infected with *C. sepedonicum*. An analysis of crude extracts, based on their capacity to cause flocculation of latex beads sensitized with antibodies to *C. sepedonicum*, gave titers of up to 300 000. Prolonged digestion of the purified latex-positive component with pronase at 60°C had no effect on its reactivity with latex beads. The purified material was also devoid of any absorption spectrum in the ultraviolet and gave a negative reaction with ninhydrin. Preliminary attempts to elicit the production of antibodies to the purified component were indeterminate.

Elution of the immunoreactive material from Bio-gel columns (P-200) as monitored by the anthrone reaction and the latex test showed that the active component was present exclusively in the void volume. Sedimentation analysis in sucrose density gradients also attested the high molecular weight of the latex-positive component: It cosedimented with a marker tRNA as a single, discrete band. Hydrolysis with dilute HCl followed by paper chromatography revealed three major sugars with R_f values corresponding to arabinose, galactose, and glucose.

A component identical in its properties and composition was also isolated from cell-free filtrates of *C. sepedonicum* grown in aseptic shake cultures.

Potato late blight forecasting

Computer programs developed at Fredericton were used to provide New Brunswick potato growers with forecasts on the probability of late blight occurring within a 2-wk period, an index of how favorable conditions were for disease development, and advice on spray schedules. The programs made use of temperature and humidity data obtained from both Environment Canada weather offices and weather stations in growers' fields together with disease incidence reports from potato inspectors of the Plant Quarantine Division. Forecasts were issued twice a week through

the New Brunswick Agriculture Information Service.

An alternative method of forecasting was developed based only on hourly weather data from Environment Canada weather offices. Records of late blight occurrence from Agriculture Canada sources and weather data covering a 24-yr period were compared by statistical analysis. A significant relationship existed between blight occurrence and two factors: the duration of rainfall and the opacity of cloud cover. Other data considered included amount and frequency of rainfall, rain index, amount of cloud cover, duration of fog, and dew point temperatures.

Thiabendazole residues on potato tubers

Six months after an initial analysis of 39 samples of potatoes from nine different farms where tubers had been sprayed with thiabendazole (1979 report), 10 duplicate samples from four of these farms were reexamined. Two of the new samples showed evidence of storage blight. Thiabendazole analysis of these two samples revealed 0.52 and 0.64 ppm of tuber weight, respectively, considerably less than the 3 ppm considered necessary for control.

SMALL FRUITS

Yellow sticky traps for monitoring blueberry maggot adults

Although there is considerable evidence that adults of the blueberry maggot are attracted to yellow sticky traps, these commercially available traps are not being recommended for general use. Field trials have shown only weak correlation ($r = 0.357$) between trap collections and level of fruit infestation, and fly activity may be missed in some fields. Except where infestations were heavy, traps were not sufficiently effective in detection of early emergence of flies to be useful in the timing of insecticide applications.

Leaf tiers—a new threat to blueberry production

Infestations of leaf tiers (Tortricidae and Gelechiidae) are becoming more common in lowbush blueberry fields, particularly in second-crop or neglected fields. There are at least five species that infest blueberry. Two species cause damage by feeding within the fruit buds

in early spring, and all species cause losses by defoliation. Greatest losses have occurred in Newfoundland where burning is irregular. In second-crop fields in New Brunswick in 1980, there was an average fruit bud loss of over 10%.

Control of blueberry thrips

Effective control of blueberry thrips, *Frankliniella vaccinii* Morgan and *Catantopids kainos* O'Neill, was obtained in small plot trials with single applications of methidathion with active ingredient (ai) at 1 kg/ha or the synthetic pyrethroids Ambush and Pounce at 0.07 kg ai/ha. The treatments were applied on 22 May when blueberry sprouts were less than 10 mm high. The number of infested plants was reduced by 93%. There was no significant difference in number of thrips per infested shoot, between treated and untreated plots. Thus, the insecticides had no effect on thrips survival after they had moved into the foliage.

Evaluation of vine pulling

Vine pulling by a commercial machine was evaluated by measuring tuber discoloration, desiccation of stems and leaves, stems missed and rerooted, and tubers exposed. Tuber discoloration was low in each 4 yr, including 1978 when significant discoloration was noted in tubers of plants killed by means of a chemical desiccant. Vine killing of several cultivars by machine pulling was rated 89–98% for leaves and 79–98% for stems. Tubers exposed amounted to 0.13–0.81 t/ha. A number of the surviving stems rerooted, though they were actually separated from their tuber progeny.

POTATO PHYSIOLOGY AND CROP MANAGEMENT

Tuber dormancy and changes in abscisic acid

The levels of abscisic acid (ABA), one of the growth-inhibiting hormones known to have an important role in dormancy, were monitored for 5 mo after harvest in tubers of three potato cultivars that exhibited a short (Sebago), intermediate (Kennebec), and long (Nooksack) dormancy period. Levels of 'free' and 'bound' (i.e. alkali hydrolyzable) ABA were determined (micrograms per gram fresh

weight) by means of a modified solvent partition and gas chromatographic technique.

During the postharvest period in cold storage, 'free' ABA increased. The rate and duration of this increase was proportional to the length of the tuber dormancy period in the three cultivars. When tubers were held at a constant 21°C, sprout elongation rates were inversely proportional to initial 'free' ABA concentrations. As sprouting progressed, 'free' ABA declined two- to three-fold. Small amounts of 'bound' ABA were detected during this period.

Evaluation of the plant growth regulator Ergostim®

Ergostim®, reputed to increase tuber set and yield in potatoes, had no significant effect when applied twice during early tuberization (0.35 L/ha) to plants of the moderate yielding cultivar Fundy. Nor did it have beneficial effect on the higher-yielding cultivars Netted Gem and Superior. Factors considered were marketable yield, dry matter, size distribution, shape, and harvest index.

SOILS

Effects of compacting peat soils on carrot production

Compaction of New Brunswick organic soils by rolling before or before and after seeding of carrots increased water-holding capacities and resulted in improved germination, but did not increase marketable yield except where water table was lowest, namely at 90 cm below the surface. Improved germination over water tables of 70 and 80 cm below the surface was probably offset by decreased aeration of the compacted peat.

Bulk densities of surface soils (0–7.6 cm) were 0.176 and 0.178 g/cm³, respectively, for once- and twice-compacted seedbeds, against 0.137 g/cm³ for uncompacted control seedbeds. The saturated hydraulic conductivities of the compacted surface soils were 8–10 times less than control soils. Compacted soils retained 20–25% more water than controls at a matric water potential of –80 cm of water. During the growing season compacted surface soils (0–3 cm) contained 6% more water than control samples, and within the same compaction treatments the soil 70 cm above the water table had 12% more moisture than that 90 cm above the water table.

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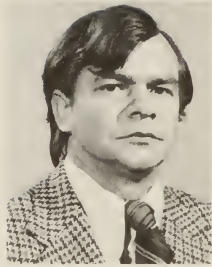
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QUEBEC REGION
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PRÉFACE

La région du Québec compte trois stations de recherche et trois fermes expérimentales. Ces établissements ont comme mission de desservir l'ensemble de l'industrie agricole du Québec. En 1980, le budget de la région était de \$11 millions avec un personnel scientifique de 76 chercheurs et un effectif total de 300 personnes. Jusqu'en août 1980, le Québec faisait partie de la région administrative de l'Est. La province est maintenant constituée en une région administrative distincte possédant sa propre administration.

L'agriculture de la région repose sur les productions animales et son potentiel de production fourragère dicte en grande partie l'évolution de ses industries. Actuellement, il y a une augmentation constante des productions céréalières et horticoles. La production laitière demeure la première production agricole du Québec. Toutefois, la stabilisation de la production nationale de lait force les agriculteurs à diversifier leurs produits vers de nouveaux secteurs. La production porcine est la deuxième en importance dans la région et le Québec se classe au premier rang au niveau national.

Dans les différents établissements de la région, on poursuit 11 programmes de recherches qui ont trait à la productivité des sols, aux cultures céréalières et horticoles, et aux productions animales. Les recherches sont orientées vers la solution de problèmes que les producteurs agricoles de la région rencontrent tout en tenant compte des aspects de complémentarité avec les programmes nationaux.

La qualité des fourrages joue un rôle important dans l'économie de la production du lait et de la viande étant donné l'impact des fourrages sur l'utilisation des suppléments fabriqués à partir de céréales qui doivent être importés de l'extérieur. La station de Sainte-Foy vient d'homologuer un cultivar de luzerne appelé Apica qui possède des caractères supérieurs de rusticité. Deux nouvelles

variétés de blé et une d'orge ont été homologuées, soit Anka et Casavant pour le blé et Sophie pour l'orge. On a réalisé des progrès importants au niveau de l'inoculation de la luzerne et de la survie des plantes à l'hiver.

Les recherches fruitières sont orientées vers la pomme, la fraise, la framboise et le bleuets. Les activités de la station de Saint-Jean sont suivies de très près par les horticulteurs du Sud-ouest québécois qui y reçoivent un support technique constant. Les perspectives d'avenir de ces productions sont très intéressantes. Quelques projets touchent la production de la prune et de la poire. La région assume également la responsabilité du programme national de gestion des sols organiques. La station de recherches de Lennoxville a mis au point un système intégré pour la production de veaux lourds à partir de veaux mâles issus du cheptel laitier. Plus de 35 000 veaux seront engraisés jusqu'au poids de 165 kg selon un programme d'alimentation «aux grains» par de nouveaux producteurs au Québec. On a entrepris un programme de recherches en floriculture à la ferme expérimentale de L'Assomption. Les fermes expérimentales de Normandin et de La Pocatière, en plus de fournir un support de recherches à la station de Sainte-Foy, sont actives dans les secteurs propres à l'agriculture de leur milieu géographique.

Les programmes de recherches réalisés en stations sont appuyés par un programme dynamique de recherches à contrat qui permet à l'industrie agricole de s'engager dans le secteur de la recherche et du développement et dans la prise en main de la solution de leur problème technologique.

Il est possible de rejoindre le personnel du bureau régional en s'adressant à Agriculture Canada, Direction générale de la recherche, 3194 chemin Sainte-Foy, Sainte-Foy, Québec, G1X 1R4.

J.-J. Jasmin

PREFACE

The Quebec Region comprises three research stations and three experimental farms. These establishments are designed to serve the whole of Quebec's farm industry. In 1980, the Region's budget amounted to \$11 million. The scientific staff consisted of 76 researchers, and total staff numbered 300. Until August 1980, Quebec belonged to the Eastern Region. The province now forms a separate region with its own administration.

Agricultural activity in the Region is based on livestock production, and the Region's forage production potential dictates to a great extent the development of its industries. The production of grain and horticultural crops is constantly increasing. Dairy production remains the leading agricultural industry in Quebec. However, the stabilization of domestic milk production is forcing farmers to diversify into new areas with their product. Hog production is the second most important industry in the Region, and Quebec ranks first in the country as a whole.

The Region's various establishments are carrying out 11 research programs, centering on soil productivity, grain and horticultural crops, and livestock production. Research is geared to solving problems faced by farm producers in the Region, while taking into account national programs.

Forage quality plays an important role in the milk and meat production economy, because it affects the need for supplements (which are manufactured from imported grains). The Sainte-Foy Station has just released an alfalfa cultivar called Apica, which has superior hardiness characteristics. Two new varieties of wheat (Anka and Casavant)

and one of barley (Sophie) have been released. Significant progress has been made in alfalfa inoculation and the winter survival of plants.

Fruit research is centered on apples, strawberries, raspberries, and blueberries. The activities of the Saint-Jean Station are watched closely by horticulturists in southwestern Quebec, who receive the Station's continuous technical support. The prospects for these crops are very attractive. A few projects concern the production of plums and pears. The Region also assumes responsibility for the national organic soils management program. The Lennoxville Research Station has developed an integrated system for heavy-calf production using bull dairy calves. New producers in Quebec are expected to fatten more than 35 000 calves to a weight of 165 kg under a grain-feeding program. A floriculture research program has been undertaken at the L'Assomption Experimental Farm. The experimental farms at Normandin and La Pocatière, in addition to supporting research at the Sainte-Foy Station, are active in projects specific to the agriculture of their geographic areas.

The research programs carried out in the stations are supported by a dynamic contract research program, which enables the farm industry to become involved in research and development and to take charge of its technological problems.

The staff of the regional office may be contacted by addressing inquiries to: Agriculture Canada, Research Branch, 3194, chemin Sainte-Foy, Sainte-Foy, Quebec, G1X 1R4.

J.-J. Jasmin

Station de recherches Lennoxville, Québec

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INTRODUCTION

La station de recherches à Lennoxville concentre ses efforts sur la production animale, notamment l'évaluation des croisements de bovins, l'amélioration des systèmes d'alimentation des vaches laitières, les techniques d'élevage de jeunes ruminants et l'amélioration de la prolificité des races de moutons au Québec. On poursuit également des recherches en productions végétales et en sols dans le but de développer des pratiques culturales susceptibles d'augmenter les rendements du maïs ensilage et des fourrages.

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

Yvon Martel
Directeur

PRODUCTIONS ANIMALES

Bovins laitiers

Qualité du foin de mil et quantité de moulée sur la performance de la vache laitière. On a évalué l'effet de deux stades de maturité du foin de mil et de deux niveaux du concentré dans la ration de vaches en lactation sur l'ingestion et la digestibilité de différents nutriments et sur la production et la composition du lait. L'allocation journalière du concentré était faite soit au taux de 1 kg pour 4 kg de lait produit par jour ou de 1 kg pour 6 kg. Le foin 1 en était au début de l'épiaison à la récolte qui a eu lieu à la mi-juin tandis que le foin 2 en était à la fin de la floraison lorsque récolté au début de juillet. Le foin haché était le seul fourrage et était servi à volonté. Les pourcentages de la protéine brute (12,4 contre 7,8%) et de la lignocellulose (39,8 contre 41,4%) démontrent qu'il existait une différence assez importante entre les foins.

On ne retrouvait aucune différence dans la production totale du lait entre les deux apports du concentré. Les performances des vaches recevant le foin 1 ont été de 15 à 35% supérieures ($P < 0,05$) à celle du foin 2. Ceci était surtout vrai pour la production du lait corrigé à 4% de matière grasse et ajusté pour le nombre de jours en lactation (17,3 contre 12,7 kg/jour). Aucune différence significative n'a été enregistrée pour les pourcentages du gras et de la protéine.

La qualité du foin a eu un effet significatif sur les coefficients de la digestibilité apparente des nutriments tandis que les niveaux du concentré n'en ont eu aucun. Nous avons

observé une forte amélioration de la digestibilité du foin de mil récolté au début de l'épiaison en comparaison de celui récolté en fin de floraison. Le calcium était le seul nutriment où la différence entre les deux foins n'était pas significative.

L'efficacité de l'utilisation de l'énergie brute était de 11% plus élevée pour la ration au foin 1 que celle au foin 2. L'ingestion d'énergie digestible de la ration au foin 1 était plus élevée d'environ 50 MJ par jour que de celle du foin 2. Les vaches recevant le foin 1 et le concentré au niveau de 1 pour 4 ont consommé une quantité plus élevée d'énergie digestible sans produire plus de lait. Cette consommation s'est traduite en un gain corporel plus élevé des vaches soit 45 kg pour celles de ce groupe contre 32 kg pour celles des trois autres groupes.

Les résultats indiquent donc que le stade de maturité du foin de mil s'avère très important dans la valeur nutritive du fourrage pour la vache laitière. La digestibilité des nutriments est meilleure et la production laitière est optimale.

Influence du niveau d'énergie de la ration sur la production et la composition du lait. L'effet des niveaux d'énergie durant les périodes pré-partum et post-partum sur la production et la composition du lait a été mesuré chez 90 vaches laitières. Durant la période de tarissement, qui était d'environ 60 jours, les vaches recevaient de l'ensilage d'herbe à volonté et des concentrés dosant 14% de protéines. Les quantités de concentrés allouées par vache étaient 0,25 et 0,75% du poids vif de l'animal pour les groupes bas (B) et haut (H)

respectivement. Durant la période de lactation, les vaches étaient alimentées avec 4,5 kg de foin, de l'ensilage de maïs à volonté et des concentrés dosant 18% de protéines. Les quantités de concentrés, pendant les 112 premiers jours de lactation, étaient les suivantes: 0,25% (B), 0,75% (M) du poids vif de l'animal et à volonté (H). À partir du 112^e jour jusqu'à la fin de la lactation, les concentrés étaient donnés sur une base de production laitière journalière. Les vaches recevaient 1 kg de concentré pour chaque 4 kg de lait produit.

Les niveaux de concentrés durant la période pré-vêlage n'ont pas eu d'influence significative sur la production laitière et sur la composition chimique du lait. Par contre, une augmentation des niveaux du concentré durant la période post-partum a favorisé significativement non seulement une plus grande production laitière mais aussi une augmentation des quantités produites de protéines et de gras. La production laitière a augmenté de 12 et 23% en augmentant les niveaux du concentré. Les rendements en protéines et en gras étaient de 16 et 30% plus grands pour les niveaux M et H respectivement. Les pourcentages de protéines et de gras du lait ne variaient pas de façon significative entre les traitements. La durée de la lactation a varié entre 256 jours pour les vaches alimentées au haut niveau du concentré durant la période pré-vêlage et au bas niveau durant le post-partum (groupe HB) et 302 jours pour celles du groupe HM. À partir de ces résultats, il n'est pas nécessaire de suralimenter les vaches durant les 60 jours précédant le vêlage. L'addition de concentrés à la ration devrait donc se faire durant la période de lactation.

Alimentation du veau lourd d'abattage nourri d'aliments d'allaitement ou de grains. On a mesuré les effets de trois modes d'alimentation du veau sur le taux de croissance, l'efficacité alimentaire et les caractéristiques de la carcasse à 88 ou 108 kg. Une première diète consistait exclusivement en un aliment d'allaitement; la deuxième était un aliment d'allaitement jusqu'à 5 semaines et du concentré du début jusqu'à l'abattage; et la troisième diète était un aliment d'allaitement jusqu'à 5 semaines, du concentré du début jusqu'à 8 semaines et par la suite du maïs entier et un supplément protéique-minéral-vitaminé jusqu'à l'abattage. Les traitements alimentaires n'ont pas eu d'effet significatif ($P > 0,05$) sur le gain quotidien. L'efficacité

alimentaire était 8% meilleur pour les veaux abattus à un poids plus léger. Les veaux nourris au maïs entier ont été significativement ($P < 0,01$) plus efficaces que les veaux nourris au concentré (2,84 contre 3,07). Le rendement de la carcasse a été significativement ($P < 0,01$) plus élevé pour les veaux à l'aliment lacté que pour les veaux au grain (56,4 contre 53,8%). La viande des veaux nourris d'aliments d'allaitement a été plus pâle ($P < 0,01$) que la viande des veaux au grain (66,7 contre 48,2 unités). Les veaux abattus à un poids plus léger avait une coloration du muscle plus pâle ($P < 0,01$) que ceux abattus plus lourd (58,8 contre 50,0 unités). L'introduction de grain dans les diètes a réduit respectivement de 37 et 46% le coût de l'alimentation des veaux abattus au poids de 88 et 108 kg de carcasse.

Bovins de boucherie

Possibilité de gémellage grâce à une ration riche en énergie avant une alimentation au P.M.S.G. chez la taure. Nous avons essayé de produire des ovulations multiples limitées (de deux à quatre corps jaunes) chez les taures, en les alimentant avec une nourriture riche ou pauvre en énergie, pendant un cycle oestral, et en leur injectant une faible dose de P.M.S.G. au 16^e jour de ce cycle. Nous avons obtenu des ovulations multiples chez 52% des 19 taures croisées laitières \times bouchères, auxquelles on avait injecté 1200 U.I. de P.M.S.G. La relation du nombre de taures qui ont ovulé entre deux et quatre follicules par rapport à celles qui en ont ovulé un et plus de quatre a été plus élevée ($P < 0,05$) chez les taures alimentées avec un régime riche en énergie que chez celles nourries avec un régime pauvre. Durant la période de 36 à 96 h après l'injection de P.M.S.G. et avant l'oestrus, la concentration de $E_2-17\beta$ fut moindre chez les taures ayant un follicule en croissance se développant et un corps jaune que chez celles en ayant deux ($P < 0,01$). Les taures ayant plus de deux follicules se développant en corps jaunes ont eu plus de $E_2-17\beta$ que celles qui éventuellement en formaient deux ($P < 0,01$). De plus, chez les taures ayant plus de deux follicules, la concentration de $E_2-17\beta$ augmentait régulièrement jusqu'à au moins 96 h après l'injection de P.M.S.G., tandis que chez les taures ayant un ou deux corps jaunes, la concentration se stabilisait à 60 h après l'injection. La concentration de progestérone était plus faible chez les taures qui développaient plus de deux

corps jaunes que chez celles en ayant un ou deux ($P < 0,05$).

L'influence de l'ouverture pelvienne et de la taille du veau sur les difficultés de vêlage de vaches croisées. On a utilisé, dans deux expériences, 164 vaches croisées représentant huit croisements issus de taureaux Charolais, Hereford, Limousin et Maine-Anjou et de vaches Holstein et Ayrshire pour étudier les difficultés de vêlage à la première et deuxième mise-bas. Les vaches croisées étaient saillies la première fois à 12 mois par un taureau Angus, un taureau Limousin, ou un taureau Chianina représentant, respectivement, un petit, moyen et grand format. Pour la seconde mise-bas elles étaient saillies par deux taureaux de grand format, soit le même Chianina et un Simmental. Le but de l'étude était de mesurer l'influence de la morphologie de la mère et de son veau sur l'incidence des difficultés de vêlage.

Au premier vêlage, il a fallu assister 23,1% de toutes les parturitions, sans toutefois y détecter de différence parmi les groupes génétiques; alors qu'au deuxième vêlage 4, 12, 20 et 36% ($P < 0,05$) d'assistance fut nécessaire aux croisements où le père de la vache appartenait aux races Limousin, Charolais, Hereford et Maine-Anjou respectivement. Les vaches qui ont eu des difficultés de vêlage à chacune des deux mises-bas avaient une ouverture pelvienne plus petite à la première saillie, à 150 et 270 jours de la première gestation que celles qui n'ont pas eu de difficulté. Le rapport entre l'ouverture pelvienne et le poids de la vache était toujours plus petit pour les vaches nécessitant des assistances aux deux vêlages consécutifs.

Les vaches dont l'ouverture pelvienne était normale et dont le premier ou deuxième vêlage était difficile avaient des veaux qui pesaient environ 5 kg de plus à la naissance que celles dont les vêlages étaient faciles. La taille du père du veau augmentait, au premier vêlage, l'incidence des difficultés de vêlage ($P < 0,05$), de 24 et 21 points pour les taureaux de grand et moyen format respectivement par rapport au taureau de petit format. Les veaux mâles de la deuxième parité ont nécessité quatre fois plus d'assistance à la naissance que les veaux femelles ($P < 0,05$). Les premières et secondes parturitions ont nécessité respectivement 54,2 et 13,8% d'assistance chez les vaches qui avaient été saillies les deux fois par le même taureau Chianina ($P < 0,05$). Les dimensions du veau les plus reliées

aux difficultés de vêlage étaient la circonférence du nez et de la tête qui étaient, respectivement, de 1,3 et 1,6 cm de plus que chez les veaux nés sans difficulté de vêlage ($P < 0,01$).

L'intervalle moyen entre le vêlage et la première chaleur a été de 88,0 jours et le nombre moyen d'inséminations par conception a été de 2,3 après un vêlage difficile, soit 14 jours ($P < 0,05$) et 0,4 insémination de plus ($P < 0,05$) qu'après un vêlage sans difficulté.

Moutons

Paramètres génétiques de la date d'agnelage chez les moutons D.L.S. Nous avons commencé, en 1965, un programme de sélection ovine de sujets croisés, en combinant des gènes de la race Dorset d'Australie et des races Leicester et Suffolk du Canada. Nous avions comme objectif de créer une nouvelle race ayant une longue saison d'accouplement et pouvant se reproduire en tout temps de l'année. Nous avons utilisé un seul critère de sélection, c'est-à-dire, un index basé sur la date de parturition des deux premiers agnelages consécutifs aux périodes d'accouplement qui s'étendent entre juin et novembre. On sélectionnait, d'une part, en ligne directe chez les mâles, puisqu'on n'utilisait que les béliers issus des brebis les mieux quotés et, d'autre part, en ligne indirecte chez les femelles, puisqu'on ne sélectionnait que les brebis de la meilleure moitié de la population gardée pour un troisième agnelage. On a recueilli des données sur environ 1300 brebis qui représentaient quatre générations de sélection. Nous nous sommes servis de différentes méthodes pour calculer la répétabilité et l'héritabilité de la date d'agnelage.

Nous avons trouvé une corrélation pour la date d'agnelage de 0,33, 0,25 et 0,13, respectivement, entre le premier et le second, le premier et le troisième, et le deuxième et le troisième agnelage. Nous avons estimé l'héritabilité à 0,14 chez les demi-frères paternels et à 0,43 chez les demi-frères maternels. La corrélation entre 86 paires de frères a donné une héritabilité estimée de 0,70. On a aussi estimé à $0,40 \pm 0,07$ l'héritabilité obtenue de la régression entre-pères de 693 paires de mère-fille.

PRODUCTIONS VÉGÉTALES ET SOLS

Pollution et agriculture dans le bassin de la rivière Saint-François. La station de recherches à Lennoxville a poursuivi une étude pour évaluer la teneur en azote, phosphore et potassium dans les cours d'eau du bassin de la rivière Saint-François et pour préciser l'implantation de l'agriculture dans la pollution des eaux du bassin par ces éléments. De mai à novembre 1979, 69 sites ont été visités six fois chacun. En plus des échantillons d'eau, on a recueilli des échantillons de sol et de plantes chez quelques cultivateurs de la région afin de pouvoir établir un bilan. On a aussi échantillonné le fond des rivières de manière à suivre le cycle de ces éléments. Les analyses chimiques effectuées (N total, N-NO₃, P total et K) sur chacun des échantillons d'eau ont permis d'établir la condition des eaux du bassin Saint-François en fonction de la variabilité spatiale (évolution des concentrations de la source à l'embouchure) et de la variation temporelle (mensuelle). Des résultats complémentaires ont été de plus obtenus du ministère des Richesses naturelles, des bureaux régionaux de Rock Forest et de Nicolet (MAPAQ) et en consultant l'annexe de statistiques du ministère de l'Agriculture du Québec.

Les résultats obtenus démontrent une augmentation significative des concentrations en éléments nutritifs dans les eaux de la Saint-François pour les secteurs urbains de Sherbrooke et de Drummondville. La région du lac Saint-Pierre, plus précisément entre Saint-Joachim et Saint-Elphège, contient des quantités de phosphore et de potassium plus élevées que celles observées à Drummondville. Par contre, la rivière Saint-François en amont de Sherbrooke contient les plus basses concentrations en N, P et K. Cette région à caractère agricole, récréatif et forestier surtout ne semble pas détériorer ses eaux par les applications d'engrais vu la teneur faible en P.

Le bilan des éléments nutritifs pour le bassin Saint-François démontre clairement que les engrais azotés et potassiques épandus en 1979 ne couvrent pas les prélèvements des cultures, c'est-à-dire que le sol a dû fournir une certaine quantité d'azote et de potassium. Pour les engrais phosphatés, l'application faite en 1979 correspond à 2,5 fois les prélèvements. Mais les sols acides retiennent fortement la majeure partie de ce phosphore qui s'est transformé en une forme insoluble. Les

bilans particuliers des producteurs visités appuient ces observations. En effet, les bilans calculés prouvent que les engrais sont retenus par les sols ou utilisés par les plantes qui doivent puiser à même les réserves plutôt moyennes du sol les compléments à leurs besoins. Ceci indique donc que les fertilisants peuvent difficilement atteindre les cours d'eau puisqu'ils sont captés soit par les cultures soit par les sols. L'étude démontre de plus que les engrais organiques doivent entrer dans les préoccupations des chercheurs agricoles de façon à établir leur niveau d'efficacité une fois appliqués au sol. Les producteurs, avec une information d'appoint, pourraient tirer les avantages de ces engrais peu coûteux tout en évitant d'altérer l'environnement. Enfin, il est démontré une fois de plus qu'il est urgent de construire des usines de filtration dans les centres urbains et au niveau des industries pour améliorer la qualité des cours d'eau qui servent trop souvent d'égouts à ciel ouvert.

Évaluation de la qualité du maïs-ensilage au cours de sa maturation. L'évolution de la teneur en glucides non-structuraux (*total nonstructural carbohydrates*— T.N.C.) a été suivie chez des cultivars de maïs hâtifs, moyens et tardifs, pendant une période s'étalant de la mi-août à la fin de septembre. La teneur en T.N.C. des tiges et des feuilles a chuté de son niveau initial de 30% à une teneur inférieure à 10% tard à l'automne. Au cours de la même période le T.N.C. moyen des épis s'est accru de 60% à 70% en fin de septembre. Cependant, le contenu en T.N.C. a régressé graduellement à son niveau initial suite à une gelée mortelle. La teneur en T.N.C. des tiges et des feuilles a augmenté jusqu'au début de septembre mais a diminué graduellement pendant le reste de la saison. Chez les cultivars moyens et tardifs, ces diminutions ont été plus que compensées par les accroissements de rendements en T.N.C. des épis qui se sont continuées jusqu'aux dernières gelées mortelles. La teneur en T.N.C. des épis et le rendement total en T.N.C. des cultivars hâtifs ont atteint leur optimum après le stade pâteux-dur, au début de septembre.

On a poursuivi cette expérience pendant trois ans et on a observé une variation considérable du niveau de T.N.C. d'année en année. Ces niveaux étaient bas chez tous les cultivars en 1979, année pendant laquelle le maïs-ensilage a souffert d'une pauvre fermentation.

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INTRODUCTION

La station de recherches de Sainte-Foy et ses fermes expérimentales de La Pocatière et Normandin forment un imposant groupe d'établissements voués au progrès de l'agriculture de l'est du pays et surtout du centre du Québec, du Bas Saint-Laurent et du Saguenay-Lac-Saint-Jean. Les principaux intérêts de recherches portent sur les plantes fourragères, les céréales et les sols. On poursuit également d'importants travaux de recherches en génétique des ovins et des bovins laitiers de même qu'en horticulture aux fermes de La Pocatière et de Normandin.

On compte parmi les principales réalisations de la station l'homologation de trois variétés d'avoine, l'homologation d'une variété d'orge en collaboration avec l'université Laval et l'homologation d'une quatrième variété d'avoine en coopération avec la station de recherches à Charlottetown. La découverte d'une nouvelle souche de *Rhizobium meliloti* a également révolutionné le domaine des inoculants pour la luzerne au Québec. À l'automne 1981, un nouveau cultivar de luzerne sera homologué. Ce dernier offre une bonne résistance aux maladies et aux conditions hivernales néfastes.

Des renseignements plus complets sont disponibles en vous adressant à: Station de recherches, Agriculture Canada, 2560 boulevard Hochelaga, Sainte-Foy (Québec) G1V 2J6.

S.J. Bourget
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LES PLANTES

Les légumineuses fourragères

De nouveaux cultivars de luzerne soumis aux essais d'évaluation ont été proposés au comité des herbages du C.P.V.Q. pour être inclus dans les recommandations. Un cultivar expérimental créé à la station à Sainte-Foy, SQ Syn-2, sélectionné pour la survivance à l'hiver, a montré 10% plus de persistance que le cultivar (cv.) Iroquois, 14% plus que le cv. Saranac et 20% plus que le cv. Thor. Un champ a été établi à la ferme expérimentale à Indian Head (Sask.) pour la production de semence de sélectionneur. L'homologation de ce cultivar sous le nom Apica a reçu l'approbation du comité canadien d'experts en plantes fourragères. Un second cultivar expérimental, Mn Syn-2, également soumis aux mêmes essais a montré beaucoup de vigueur et une bonne survivance à l'hiver. Son évaluation sera poursuivie.

L'évaluation de lots de semence de luzerne vendue dans le commerce et en provenance d'Australie et d'Argentine a révélé que ces luzernes ne persistaient à peu près pas sous nos conditions. Une mise en garde fut émise aux producteurs.

Au cours du printemps, plus de 200 plants de luzerne furent prélevés dans les champs fortement endommagés par l'hiver pour constituer une nouvelle pépinière de plants qui serviront dans de futurs croisements.

La sélection pour la résistance au flétrissement bactérien s'est poursuivie. Les plants résistants sélectionnés en 1979 du cv. Grimm furent soumis à des croisements, et des pépinières de discordance furent établies à La Pocatière et à Normandin en vue de développer de nouvelles populations.

Une méthode, mise au point pour la sélection de luzerne résistante au pourridié fusarien, est maintenant utilisée pour la sélection des cultivars Angus, Iroquois, Saranac AR et Titan. Le progrès réalisé par deux cycles de sélection chez ces quatre cultivars sera évalué. L'évaluation du degré de résistance à cette maladie, réalisée chez 12 cultivars et 2 lignées, montre une différence entre les cultivars quant au niveau de résistance à cette infection. Cette résistance semble fortement reliée au potentiel de survivance à l'hiver des cultivars.

L'évaluation au champ de la résistance à la tache leptosphaerulinienne a révélé une très légère augmentation chez la descendance de plants sélectionnés, comparativement à une population non sélectionnée à cette fin.

La sélection pour la résistance à la tige noire a rapporté jusqu'ici 122 plants montrant de la résistance.

L'enquête sur le flétrissement verticillien n'a pas révélé la présence de cette maladie au Québec en 1980.

Les études d'influence réciproque de l'infection et de la résistance au froid montrent

d'une part que le pourridié et le flétrissement fusarien affectent l'endurcissement au froid de la luzerne, d'autre part que les dégâts causés par le gel est un facteur important dans la pénétration des champignons dans la racine et le développement de la maladie.

Mauvaises herbes. Les études sur la biologie de l'ortie royale montrent que: a) le poids sec par plant est fonction du moment d'apparition de celui-ci, les plants hâtifs étant les plus lourds; b) le poids sec et la quantité de graines produites par plant varient de façon inversement proportionnelle à la densité de la population; c) les plants tardifs produisent davantage de graines par unité de poids sec que les individus hâtifs; l'effort de reproduction serait donc plus grand chez les plants tardifs; d) les individus tardifs, bien qu'en apparence plus chétifs, atteignent la maturité au même moment que les plants hâtifs, ils complètent donc leur cycle vital en un temps plus court que les hâtifs; e) la production de matière sèche par unité de surface augmente de façon constante jusqu'au moment de la floraison, peu importe la densité.

Les résultats d'essais d'herbicides dans les mélanges fourragers montrent qu'aucun des herbicides utilisés ne donne un contrôle satisfaisant, à l'exception du 2,4-DB et du TF-1169 en mélange.

Fixation d'azote. Nous avons déterminé qu'il n'existe pas de lien génétique direct entre l'activité du nitrate réductase chez *Rhizobium meliloti* et son activité nitrogénasique en symbiose avec la luzerne. Cependant, l'efficacité symbiotique à fixer de l'azote est en corrélation avec l'efficacité métabolique des *Rhizobium* en système hétérotrophe en culture pure. Le soufre et le niveau d'azote minéral influencent la nodulation et la fixation dans le système luzerne-*Rhizobium*. Nous avons aussi identifié l'antifongique endomycine, produit par un actinomycète, dans le système écologique pour contrôler la fusariose chez la luzerne.

La survivance à l'hiver

Influence du climat. L'endurcissement au gel de la luzerne est en relation étroite avec l'abaissement de la température de l'air. La plante continue à s'endurcir sous la neige. Le maximum de résistance est atteint entre janvier et mars. La perte de résistance commence à la disparition de la neige, dépend de la température de l'air et du sol, et s'échelonne sur quatre à six semaines ce qui empêche les

dommages causés par les gelées tardives. L'humidité des sols argileux ne varie que de 24 à 35% au cours de l'automne. La luzerne dont les racines sont prises dans la glace à -2°C résiste trois semaines à ce traitement, le blé d'hiver, une semaine.

Il y a corrélation entre l'accumulation de la proline dans les collets de la luzerne et la résistance à la gelée à l'automne jusqu'à la perte du feuillage ainsi qu'au printemps. La perte du feuillage arrête l'accumulation de la proline et du pourcentage de la matière sèche des collets. Le dosage de la proline ne peut cependant être utilisé comme mesure de la résistance au gel, mais pourrait être utilisé dans un programme de sélection. La proline s'accumule dans les collets maintenus à 1°C , même si le feuillage est à 20°C . Le contraire n'est pas vrai. Après une semaine d'endurcissement, la proline ne s'accumule plus dans les collets séparés des parties aériennes et maintenus à 1°C pendant deux semaines. Cependant elle continue à s'accumuler dans ces parties aériennes après séparation.

Au chapitre de la télédétection, le radar et la photo infrarouge ont été comparés. L'infrarouge a permis d'établir des concordances avec la température des sols.

Physiologie de la résistance. Une méthode de germination des plantules de luzerne a été mise au point en conditions aseptiques en présence de Sisthane, un fongicide systémique. Des plantules âgées de 2 jours peuvent être endurcies de cette façon.

La gelée favorise le développement de la pourriture des racines et de la flétrissure fusarienne, et ces maladies réduisent la résistance à la gelée de la luzerne.

La résistance au gel de 16 lignées de dactyle est en corrélation avec leur résistance à l'hiver.

Biochimie de la résistance. Le sucrose stabilise directement la fixation de la phosphatase acide aux membranes cellulaires au cours de l'endurcissement au gel du blé d'hiver. Les méthodes d'ultragel rapide des tissus et de coupes cryogéniques au moyen de microtomes cryostatiques ont été étudiées dans le but d'observer directement des plants gelés par congélation programmée ou ramenés du champ en hiver. Une méthode enzymologique, le dosage de la phosphatase acide, est en bonne voie d'être mise au point pour la sélection génétique de plantes qui résistent au gel.

Quand la plante s'endurcit au gel, les protéines qu'elle élabore sont de plus en plus

résistantes à l'hydrolyse par les enzymes de la plante non endurecie. Un pic d'hydrolyse des protéines provenant de plantes endurecies, après 2 à 3 jours de désendurcissement, suggère que certaines protéines synthétisées par la plante sont essentielles au maintien de la résistance au gel.

Les céréales

Amélioration du blé. Deux nouvelles variétés de blé ont été homologuées en 1980, soit Ankra et Casavant. Ces variétés sont prometteuses pour l'agriculture québécoise. Ankra est une variété adaptée à toutes les régions; son rendement est supérieur à ceux de Opal et de Glenlea tandis que sa maturité, sa hauteur, son poids de 1000 grains, sa densité et la force de sa paille sont intermédiaires entre ceux de Opal et de Glenlea. La variété Casavant offre un rendement de 3% supérieur à Laval 19 et de 8% supérieur à Concorde; ces deux variétés ont un meilleur rendement qu'Opal. De plus, son grain est lourd et dense, sa paille a la force de celle de Concorde et elle arrive à maturité 2 jours plus tard.

La variété Laval 19 a été inscrite dans les recommandations du Conseil des productions végétales car son comportement dans 18 sites d'essais pendant deux ans a démontré sa supériorité sur les témoins déjà recommandés au Québec.

Amélioration de l'orge et de l'avoine. Une nouvelle variété d'orge, Sophie, a été homologuée en 1980. Elle provient d'un effort conjoint de la station à Sainte-Foy et de l'université Laval. Cette variété offre un rendement de 2% supérieur aux témoins et elle est de 4 jours plus tardive. Ses caractéristiques en font une candidate idéale pour les mélanges céréaliers avec des variétés de blé et d'avoine, telles Casavant, Lamar et Manic, dont les maturités sont plus tardives.

Deux lignées évaluées en 1980, QB179.95 et QB513.101, semblent très prometteuses car elles ont donné un rendement de 7% supérieur au meilleur témoin sur une paille plus forte tout en étant 2 jours plus hâtives.

Pour l'avoine, les variétés Manic et Oxford ont été recommandées aux agriculteurs par le Conseil des productions végétales du Québec. Dans les Maritimes, la lignée QO151.103, produite à la station à Sainte-Foy, est une amélioration substantielle car toutes les caractéristiques importantes, telles le rendement, la force de paille, la grosseur et le poids

des grains, le pourcentage d'écale et sa tolérance à *Septoria* sont améliorées. Elle fera l'objet d'une homologation en 1981.

Résistance aux maladies. Une importante source de résistance au virus de la jaunisse nanisante de l'orge (V.J.N.O.) a été identifiée dans la variété Norrland. Les efforts visent à transférer cette résistance dans les variétés adaptées à nos conditions de croissance.

Les espèces voisines de nos céréales communes font l'objet de recherches intensives pour trouver d'autres gènes majeurs de résistance au V.J.N.O. La production d'antisérums spécifiques au V.J.N.O. permet une identification rapide et efficace de la présence du virus dans une plante.

Les recherches effectuées sur les maladies fongiques ont permis d'identifier l'immunité de OA421.7 à la rouille tandis que Fiddler est résistant. Le développement de la tache septorienne de l'avoine et de la rayure réticulée de l'orge est moindre dans des mélanges 50% d'avoine et 50% d'orge. Le fongicide Q-5177 est le plus valable chez l'orge et l'avoine pour le contrôle des *Fusarium* spp.

Biologie et écologie des mauvaises herbes. Les régions 04 et 12 du Québec ont fait l'objet d'inventaire et d'évaluation de pertes en 1980. Les résultats sommaires démontrent un faible taux d'utilisation d'herbicides, l'importance des antécédents culturels sur les populations de mauvaises herbes et aussi l'importance du chiendent, des mauvaises herbes à feuilles larges et des graminées vivaces dans les champs de céréales.

LES SOLS

La fertilité

Amendements organiques. Une expérience a été menée en serre pour étudier l'effet d'un compost fait de sciure de bois et de lisier de porcs sur les rendements du mil. L'équivalent d'une application de 224 t/ha de compost sur un loam sablo-graveleux Saint-André a fait passer les rendements résultant de 3 coupes de mil de 3,5 g/pot pour le traitement témoin à 12,3 g/pot. Lorsque le compost seul a été utilisé comme milieu de culture, le rendement a été de 22,0 g/pot.

La valeur fertilisante d'un compost forestier a été comparée à celle du fumier de vache dans une expérience en serre sur le sol Kamouraska. Des doses de 0, 100, 200, 400 et 800 kg N/ha ont été ajoutées au sol. La plante

témoin est le mil. Pour la première coupe faite sur les pots ayant le compost, les rendements décroissent de 3,78 à 2,28 g/pot pour les pots ayant reçu 0 et 800 kg N/ha, alors que pour la deuxième coupe, les rendements diminuent de 2,41 à 1,88 g/pot. Après la deuxième coupe, il y a eu addition d'engrais et lors de la troisième coupe, les rendements ont augmenté de 6,9 à 8,46 g/pot pour les doses de 0 et 800 kg N/ha sous forme de compost. Dans le cas du sol ayant reçu des doses croissantes de fumier de vache, il y a eu un effet positif lors des trois coupes. Ainsi, lors de la première coupe, les valeurs augmentent de 3,78 à 5,37 g/pot pour les doses de 0 et 800 kg N/ha, les rendements passent de 2,41 à 3,60 g/pot pour ces mêmes doses lors de la deuxième coupe et enfin lors de la troisième coupe, mais après addition d'engrais, de 6,90 à 9,02 g/pot pour les mêmes quantités de fumier. Les rendements obtenus avec le fumier de vache sont dans tous les cas supérieurs à ceux obtenus avec le compost forestier.

La pédogénèse

Sols à texture légère. L'effet du modelage des champs en planches sur l'hétérogénéité des propriétés des sols a été évalué dans six champs de maïs en monoculture. L'épaisseur de l'horizon Ap varie de 15 à 41 cm. La teneur en matière organique varie de 10 à 250 t/ha et influence la densité apparente et réelle du sol. La teneur maximale en eau disponible entre 33,3 kPa et 1,5 MPa dans les horizons Ap est comprise entre 0,5 et 4 cm d'eau. Pour l'ensemble des champs, les rendements en grain varient de 1626 à 10 231 kg/ha. À l'intérieur d'un champ, les différences atteignent cependant 74%. Les rendements les plus élevés ont été observés sur les sites élevés, moyens ou intermédiaires des planches et ne peuvent être expliqués de manière satisfaisante par l'hétérogénéité du sol.

Le travail entrepris sur les sols sableux d'origine éolienne et deltaïque, et dont il avait déjà été question dans le rapport précédent, a été poursuivi. On a ajouté trois autres séries de sols. Sur les treize profils étudiés, neuf ont été classés dans l'ordre podzolique et quatre dans l'ordre brunisolique.

Cependant, pour 12 profils, la valeur du pH mesuré dans NaF est supérieure à 10,2, qui est la limite pour les sols podzoliques. Diverses formes d'aluminium ont donc été identifiées dans les solutions de dithionite-citrate-bicarbonate, oxalate et pyrophosphate. Ce

sont les valeurs de Al dans l'oxalate qui sont le mieux reliées au pH NaF. Le développement des profils est relié à la composition minéralogique et à la migration plus ou moins rapide des complexes organo-métalliques. Pour les 13 sols, le taux d'absorption du phosphore varie de 23 à 397 $\mu\text{g P/g}$ de sol dans les horizons A, de 301 à 1578 $\mu\text{g P/g}$ de sol dans les horizons B et de 71 à 296 $\mu\text{g P/g}$ de sol dans les horizons C. Ces valeurs sont reliées à Al_o et Al_p dans les horizons A, à Al_p et C_{org} dans les horizons B et à $(\text{Al} + \text{Fe})_o$ dans les horizons C.

Les valeurs de la capacité d'échange de la matière organique passent de 168 méq/100 g dans l'horizon A, à 293 méq/100 g dans l'horizon B et à 138 méq/100 g dans l'horizon C. Les valeurs ont été comparées à celles obtenues pour les sols gleysoliques de basses terres. Elles sont plus élevées à cause d'un plus grand degré de transformation de la matière organique. Pour la fraction argileuse, les valeurs moyennes de la C.É.C. dans les horizons A, B et C sont de 76, 40 et 53 méq/100 g. Elles sont plus élevées dans l'horizon A à cause de la présence de minéraux 2/1 gonflants à charge élevée.

Mise en culture des sols. Des mélanges de sols, en proportions diverses, ont été effectués à partir d'horizons L-H, Ae, Bhf et Bf de deux sols podzoliques, afin de simuler l'effet du labour à différentes profondeurs. Les mélanges ainsi obtenus au départ avant tout amendement possèdent les caractéristiques suivantes:

- pH (H_2O) de 3,79 à 4,85
- carbone organique de 2,4 à 31%
- cations échangeables (K, Ca, Mg) de 0,15 à 11,82 méq/100 g
- phosphore assimilable de 45 à 580 kg/ha
- azote total de 0,12 à 1,36%
- Fe et Al (dans dithionite) Fe_d de 0,22 à 3,52%; Al_d de 0,06 à 1,70%
- Fe et Al (dans oxalate) Fe_o de 0,14 à 3,00%; Al_o de 0,05 à 2,46%
- Fe et Al (dans pyrophosphate) Fe_p de 0,13 à 2,24%; Al_p de 0,04 à 1,84%

Les mélanges ont été subdivisés avant d'être amendés à pH 5,5 dans certains cas, pour être ensuite incubés à une température de 40°C au taux de saturation, ou mis en pot pour semis d'orge. Un dispositif expérimental destiné à tenir compte des paramètres à étudier (mélange, chaulage, fertilisation) a été mis au point et une première récolte a été obtenue.

Les rendements en grain varient de 0,14 à 15,86 g/pot pour le sol Laurentide et de 0 à 20,25 g/pot pour le sol Leeds. Les rendements les plus élevés correspondent aux mélanges les plus riches en matière organique.

Propriétés physiques des sols. L'analyse statistique des propriétés physiques de 21 sols du Québec a montré que la matière organique a un effet significatif sur les propriétés suivantes: densité réelle des particules, rétention d'eau à 33,3 kPa et 1,5 MPa, limites de liquidité et de plasticité, densité maximum lors de la compaction et minimum lors du tassement, teneur en eau pour le maximum et le minimum de densité. D'autre part, le contenu en argile a un effet significatif sur la rétention d'eau à 33,3 kPa et 1,5 MPa, l'indice de plasticité, les pourcentages d'agrégats stables dans l'air et dans l'eau, les densités maximum et minimum en compaction et tassement, sur la conductivité hydraulique saturée au minimum de tassement.

FERME EXPÉRIMENTALE LA POCATIÈRE

Les céréales

Biologie et écologie des mauvaises herbes. Un inventaire des mauvaises herbes présentes dans les cultures céréalières du comté de Kamouraska a débuté en 1980. Cent six champs ont été visités et 120 espèces de mauvaises herbes identifiées. Les espèces retrouvées dans plus de 50% des champs sont le chiendent, la vesce jargeau, le chénopode blanc, l'ortie royale, le pissenlit, la stellaire graminioïde, la renouée liseron et la spargoute. Le chiendent était présent dans 90% des champs avec une densité moyenne de 39 tiges par mètre carré.

Régie. L'azote dans l'orge a quadruplé la phytomasse du chénopode blanc alors que celle de la spargoute et de l'ortie royale a été peu affectée. Le propanil (1,0 kg/ha), le metribuzin (0,3 kg/ha) et le diclofop-méthyl (0,7 kg/ha) ont assuré une excellente répression de la sétaire glauque dans l'orge.

Les plantes fourragères

Chiendent. La répression du chiendent a amélioré l'établissement et la persistance du trèfle rouge et de la luzerne. En 1980, la couverture des légumineuses était de 35% dans la parcelle témoin et de 88% dans la parcelle où le chiendent avait été réprimé avec

le BAS 9052 en 1979 à l'établissement. Sur les semis de 1980, à la première coupe, la couverture de la luzerne était de 52% dans le témoin et de 97% lorsque le chiendent a été réprimé avec le BAS 9052 ou le TF 1169. En septembre, la couverture de la luzerne était de 35% dans le témoin et de 93% dans les parcelles traitées avec les herbicides.

Biologie et écologie des mauvaises herbes. Un inventaire des mauvaises herbes présentes dans les prairies de première année de production dans le comté de Kamouraska a été mené en 1980. Le chiendent, la céréiste vulgaire, le plantain majeur et la stellaire graminioïde étaient présents dans tous les champs visités. Le chiendent était la mauvaise herbe la plus importante avec une densité de 224 plants par mètre carré.

Dans le maïs à ensilage, 52 espèces de mauvaises herbes ont été dénombrées. Le chiendent est la mauvaise herbe la plus importante (29 tiges par mètre carré) suivi de la prêle des champs (27 tiges par mètre carré). Les autres espèces relativement importantes sont la sétaire glauque, la vesce jargeau, le pissenlit, le chénopode blanc, le pied-de-coq et l'ortie royale.

Régie du semis. En semis direct, l'étude du degré d'établissement de quatre espèces fourragères effectuée en période de sécheresse sur trois types de sol a été variable. Sur le loam graveleux Saint-André, le mil et le trèfle rouge se sont les mieux implantés, la luzerne s'y est très peu implantée et le brome pas du tout. Sur l'argile Kamouraska, c'est le trèfle rouge qui s'est le mieux établi, suivi de la luzerne et du mil, avec une absence quasi totale du brome. Sur l'argile Du Creux, la meilleure espèce a été le mil suivi de près par le trèfle rouge, puis de la luzerne et finalement du brome dont la présence a été encore une fois très faible. Il semble que le brome soit l'espèce la moins apte à s'implanter en semis direct.

Régie de coupe. Les semis de trèfle rouge du printemps de 1978 soumis à différents régimes de coupe ont subi au cours de l'hiver 1979-1980 des dommages très sérieux. Sur l'argile Kamouraska la destruction du semis a été complète. Les résultats obtenus sur le loam graveleux Saint-André ont montré que la survie du cultivar Hungaropoli était supérieure à celle de Lakeland.

Besoins en azote. Les besoins en azote des graminées fourragères peuvent être satisfaits

soit par des applications d'engrais azotés soit en les cultivant en présence de légumineuses. Le mil et la luzerne ont été semés selon différents modes de semis et ont reçu des doses variables d'azote minéral. Le rendement de la luzerne pure a été légèrement influencé par les applications d'azote peu importe le mode de semis. La réponse du mil pur aux applications d'engrais azotés a été linéaire. Toutes les associations mil-luzerne ont répondu faiblement aux applications d'azote minéral.

Les pommes de terre

Les herbicides. Le buttage à la levée a réduit l'activité du metolachlor d'un mois. L'activité de l'EPTC n'a pas été réduite. Le buttage à la levée a fait augmenter les mauvaises herbes surtout entre les rangs par rapport au buttage au début de la floraison. Plusieurs herbicides, tels que l'alachlor et le metolachlor, donnent une excellente répression des graminées annuelles lorsqu'appliqués avant la levée. Après la levée, nous avons obtenu des résultats très prometteurs avec le diclofop-méthyl, le BAS 9052 et le TF 1169.

Les défanants. Il est encore difficile de prévoir les effets des défanants d'année en année. Leur activité est réduite par une fertilisation élevée en azote. L'éthephon n'a pas réussi à corriger cette situation.

Sélection de lignées. L'essai avancé d'adaptation et l'essai d'adaptation auront quatre et onze lignées provenant des lignées sélectionnées à La Pocatière en 1979 et 1980. En 1980, 1579 nouvelles lignées provenant de Fredericton (N.-B.) et sélectionnées au stade de quatre buttes (F₂) ont été plantées sur deux sols. À l'arrachage, 162 lignées ont été sélectionnées.

L'essai hâtif effectué en collaboration avec les stations provinciales a permis de tester 22 lignées. Les résultats de rendement et de croustille comparés aux quatre témoins ont permis de déterminer les meilleures (7) à La Pocatière.

Les arbres fruitiers. Les pommiers ont produit des fruits de très bonne qualité en 1980. Les meilleurs rendements sont obtenus lorsque la greffe est faite l'année après l'implantation du porte-greffe.

Les pruniers ont eu une très bonne floraison mais les fleurs ont avorté entraînant des rendements pratiquement nuls (quelques fruits par arbre). De plus, les cultivars Crescent,

Greenville, Lanark et Pipestone ont été les plus sensibles à la criblure des feuilles.

Les poiriers plantés en 1944 ont donné de bons rendements (221,3 kg/arbre) et c'est Phileson qui a produit le plus (302,0 kg/arbre).

FERME EXPÉRIMENTALE NORMANDIN

Les céréales

Blé de printemps. Un peu plus de 3200 sélections d'épis ont été faites dans du matériel en générations F₂ à F₃ et elles viennent s'ajouter aux 9 lignées en essais préliminaires, aux 26 observations avancées et aux 21 en essais coopératifs et qui ont été identifiées pour leur précocité et leur rendement en grain. Quelques sélections ont produit plus que le groupe témoin, ce qui laisse prévoir des possibilités d'homologation à court terme.

Le blé Glenlea est moins exigeant en fumure azotée que le blé Opal, d'après les résultats de 3 ans. En effet, son rendement a été le plus élevé à la suite d'un apport de 90 kg/ha de N fractionné à parts égales au semis et au tallage, alors qu'Opal a mieux répondu avec 120 kg/ha de N apportés aux mêmes périodes. Les deux cultivars ont produit plus de grain à la suite de ce mode de fertilisation qu'à des taux supérieurs ou inférieurs de N au semis seulement ou en application fractionnée. La qualité du grain n'a pas été affectée par les taux et périodes de fumure.

L'orge. Les rendements de l'orge cv. Laurier ont été de 2605 et 2970 kg/ha pour des taux de semis respectifs de 130 et 90 kg/ha; le taux de semis le plus élevé a fait diminuer la production de 12,3% par rapport au taux normal.

L'influence de quatre époques de labour, soit le 15 août, 15 septembre, 15 octobre et 15 mai, n'a pas été significative sur la production de l'orge cv. Loyola, mais le labour de printemps a fait diminuer la qualité du grain par rapport aux labours de fin de saison. Par ailleurs, il y a eu augmentation de la biomasse de mauvaises herbes annuelles avec le retard des dates de labour et une diminution parallèle des vivaces. La densité des mauvaises herbes était de 121, 119, 79 et 98 plants par mètre carré respectivement, pour les dates mentionnées.

La régie de laourgane. Depuis 1978, on a démontré que sous nos conditions climatiques

il est préférable de semer laourgane entre le 10 et le 20 mai, car plus tôt, la production de graines diminue de 400 kg/ha et, après le 20 mai, la diminution atteint 900 kg/ha par rapport à la période précitée.

Des observations sur la production de graines et certaines données météorologiques ont été faites dans le but d'établir une corrélation possible entre production et facteurs climatiques, entre autres, la pluviométrie et la nébulosité.

L'exploitation de trois graminées fourragères. On a étudié l'influence de cinq stades de croissance durant trois années sur les rendements et les compositions organique et minérale des fléoles Climax et Drummond, des bromes Saratoga et Canadien et des dactyles Hercules et Rideau. Au premier cycle de végétation, le rendement en matière sèche des

six cultivars a augmenté progressivement jusqu'au stade de la grenaison. La plus haute production annuelle a été atteinte chez la fléole et le brome lorsque la première coupe a été prélevée au stade de la floraison. Chez le dactyle, il n'y a pas eu de différence significative dans les rendements totaux du stade de la montaison au stade de la grenaison. La protéine brute, les matières grasses et les cendres ont baissé, et la fibre brute a augmenté graduellement avec l'avancement en âge des plantes. Tous les cultivars, en vieillissant, contenaient de moins en moins de phosphore et de potassium. En règle générale, les variations dans les teneurs en calcium, sodium, fer, cuivre, manganèse et zinc n'étaient pas reliées aux stades de croissance. À l'intérieur de chaque espèce, il n'y a eu que quelques différences significatives entre les cultivars au point de vue rendement et composition chimique.

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²Actuellement en Haïti sur un projet de l'ACDI.

INTRODUCTION

Ce rapport résume les principaux résultats de recherches obtenus à la station de recherches à Saint-Jean-sur-Richelieu et à la ferme expérimentale de L'Assomption. Saint-Jean est responsable de la recherche sur le maïs, les légumes, les fruits et les petits fruits ainsi que sur la gestion des sols organiques et poursuit ses travaux à Sainte-Clothilde, Frelighsburg, L'Acadie et Farnham. La région de Saint-Jean, située au sud de Montréal, est caractérisée par la présence de sols organiques et minéraux dont une partie est située en bordure des Appalaches, ce qui favorise une agriculture variée. La ferme expérimentale de L'Assomption, située à quelque 80 km au nord de Saint-Jean, est responsable de la recherche sur le tabac, les plantes ornementales et l'amélioration du maïs; la ferme à L'Assomption possède du terrain à Lavaltrie pour ses travaux sur le tabac.

L'année 1980 a été marquée par l'attribution de contrats à des conseils pour préparer les plans du nouvel édifice laboratoire-bureau qui devrait être terminé en 1983. Ce rapport donne les grandes lignes de nos réalisations en 1980. Ces réalisations sont caractérisées par des progrès substantiels dans l'amélioration des crucifères et du tabac, la gestion du maïs et la protection des arbres fruitiers et des légumes. Pour de plus amples renseignements sur nos réalisations, pour des tirés-à-part de nos publications, vous pouvez communiquer avec la station de recherches, Direction générale de la recherche, Agriculture Canada, Saint-Jean-sur-Richelieu, C.P. 457, Province de Québec, J3B 6Z8.

Claude B. Aubé
Directeur

ARBRES FRUITIERS

Conduite des pommiers nains et semi-nains

À Frelighsburg, on trouve les cultivars McIntosh et Spartan greffés sur M9, M7, Ottawa 3 et M26 qui composent des pommiers plantés à 740, 1480 et 2960 unités par hectare. Ces arbres formés en «cloche étroite», «palmette oblique», «palmette de Van Roechoudt» et «cône de plein vent» ont donné leur quatrième récolte en 1980.

Cette année, les plus hauts rendements proviennent d'arbres de Spartan/Ottawa 3 plantés à 2960 unités par hectare et formés en cloche étroite. Cette combinaison qui permet d'obtenir un bénéfice net de \$3438/ha atteint presque le seuil de rentabilité avec un rendement de 23 051 kg/ha. La combinaison Spartan/M9 à 2960 unités par hectare en cloche étroite est la deuxième en importance. Son rendement est de 20 424 kg/ha. Par contre, McIntosh/M9 en palmette de Van Roechoudt à 740 pommiers par hectare avec un rendement de 555 kg/ha est la combinaison la moins rentable. Les pommiers de Spartan en cône de plein vent à 1480/ha donnent une moyenne générale de 13 500 kg/ha.

Évaluation de cultivars

Poiriers. À Frelighsburg, en 1980, des poiriers de 11 ans provenant de cultivars ou sélections Kröl Sobiesky, Beauté Flamande, Phileson, Enic, Miney, Moe, Meney, 066-0361, Patten, O-301 et Païersmith ont rapporté respectivement 54, 50, 38,4, 29,6, 26,5, 22,8, 16,2, 5,2, 5,0 et 1,5 kg en moyenne par arbre. Cet automne à La Pocatière, des poiriers âgés de 20 ans provenant de cultivars Favorite de Clapp, Beurré Bosc et Bartlett donnent respectivement une moyenne de 76, 28,4 et 9,6 kg par arbre tandis que d'autres poiriers âgés de 36 ans provenant de cultivars Phileson, Miney, Favorite de Clapp, Menie, O-291 ont une récolte de 287,9, 264, 196,1, 157,8 et 48,8 kg en moyenne par arbre. Dans le but d'évaluer 25 nouveaux cultivars, des parcelles de poiriers sont plantées à Frelighsburg et Rockburn cette année.

Pruniers. L'hiver de 1979-1980 s'est avéré l'un des plus destructeurs des pruniers de la région de Frelighsburg. Ainsi dans un verger expérimental de 3 ans contenant 30 cultivars et sélections, 10 ont subi de très graves pertes par le froid. Aucun de ces arbres n'a encore commencé à rapporter. Dans un autre verger expérimental composé de pruniers de 5 ans à La Pocatière, les cultivars et sélections qui

commencent à rapporter cette année sont: Reine Claude, Damas Bleue, V-33024, Bradshaw, V-33028, Early Italian et Grosse Bleue. Les quatre premiers se montrent particulièrement précoces et rapportent une moyenne de 3 à 5 kg par arbre.

Griottiers. À Frelighsburg, des arbres de 10 ans provenant de cultivars Marasca di Ostheim, Montmorency, Suda Hardy, North Star et English Morello rapportent respectivement une moyenne de 33,4, 29,3, 28,9, 16,6 et 4,1 kg par arbre. Le cultivar North Star se montre très sensible au mildiou. Les deux cultivars dont les noyaux des fruits s'enlèvent le mieux sont Marasca di Ostheim et Montmorency.

Protection des pommerais

Maladies. Chacun des sept différents programmes de fongicides appliqués en éradication à six reprises au cours de la saison ont réussi à réprimer suffisamment la tavelure sur le feuillage des pommiers, mais seuls le Baycore 50 WP utilisé aux taux de 1,2 et 1,6 kg/ha et le CGA 64251 10WP à 1,0 kg/ha ont pu fournir plus de 95% de fruits sains à la récolte. Dans une autre série d'essais, ces deux mêmes produits ont manifesté un pouvoir d'éradication de la maladie comparable à celui du fongicide Easout 70WP.

Insectes. Observée sur le pommier surtout au printemps, la punaise terne s'attaque alors aux bourgeons. Les dégâts sur les fruits plus tard dans la saison seraient attribuables principalement aux larves de la punaise de la pomme et de la lygide du pommier ainsi que, à un moindre degré, à celles de *Heterocordylus malinus* (Reuter) et de la punaise de la molène. Toutefois, l'imputation des piqûres à une espèce de punaise en particulier demeure souvent difficile.

Appliqués aux stades du pré-bouton rose et du calice, les pyréthrinoides Ambush, Belmark et Ripcord se sont avérés également efficaces pour réduire simultanément les dégâts des punaises et du charançon de la prune sur les pommes, mais le fait d'effectuer une troisième application 2 semaines après le calice n'a pas amélioré la répression des punaises.

Suite à l'application du diméthoate sur des pommiers Cortland au stade du bouton rose pour prévenir les dégâts de la punaise terne sur les bourgeons à fruit, le nectar extrait des fleurs 5 et 6 jours après le traitement contenait respectivement 5,20 et 3,32 ppm du

produit insecticide. Comme la dose létale de diméthoate pour les abeilles est estimée à 95 ng par ouvrière, un taux de 3 à 5 ppm de cet insecticide dans le nectar des fleurs serait considéré comme fatal aux abeilles butineuses. En conséquence, pour protéger ces insectes pollinisateurs, l'emploi de ce produit en période pré-florale sur les pommiers devrait se faire au moins une semaine avant l'éclosion des fleurs, c'est-à-dire normalement avant l'apparition du bouton rose.

Par ailleurs, une étude effectuée dans un verger expérimental à Frelighsburg a permis de démontrer la grande importance des insectes pollinisateurs (abeilles domestiques et abeilles sauvages) pour l'obtention d'une récolte commercialement rentable et de déterminer l'influence de certains facteurs abiotiques, comme la température, l'humidité relative, le vent, et autres, sur l'activité de ces précieux auxiliaires.

PETITS FRUITS

Bleuet. Même après un hiver sans neige et des températures minimum atteignant -26°C , la productivité de la plupart des cultivars de bleuet en corymbe à l'essai s'est accrue en 1980 pour atteindre des rendements allant jusqu'à 25 000 kg/ha. Les cultivars Bluecrop, Blueray et Berkeley s'avèrent toujours les plus productifs. Les observations cytologiques de plusieurs clones indigènes de bleuet en corymbe ont révélé que ces derniers étaient tétraploïdes, mais que certains semblaient posséder une certaine instabilité à ce niveau.

Framboise. Le cultivar Festival s'est encore avéré le plus productif suivi de 70-11, 69-4 (sélection de Kentville), Matsqui et Haida. Newburg, le cultivar le plus répandu au Québec, a été le moins productif. Le courbage des tiges durant l'hiver, la production bis-annuelle, l'irrigation et l'apport de fumier n'ont pas modifié de façon significative la productivité de Willamette, Newburg et Festival. Les traitements de fertilisation à l'azote ont été les seuls à contribuer à une augmentation des rendements.

LÉGUMES

Amélioration génétique des crucifères, résistance à la hernie

Deux lignées, issues d'une troisième génération de rétrocroisements entre le rutabaga,

Brassica napus L., et le chou, *B. oleracea* L. var. *capitata* L., ont produit plus de 70% de plants résistants aux races 2 et 6 de *Plasmiodiophora brassicae* Wor., organisme causant la hernie des crucifères, lors d'essais en plein champ en 1980. Ces plants résistants avaient une pomme de grosseur moyenne, ferme, et de couleur vert bleu foncé. De plus les tissus foliaires de la pomme contenaient moins d'ions thiocyanate (SCN^-), précurseurs à la formation de la goitrine qui peut causer le goitre, que les tissus de plants infectés par la hernie. Nous espérons produire à la station à Saint-Jean des cultivars de crucifères résistants à la hernie et à basse teneur en SCN^- .

Des croisements résistants à plusieurs races de *P. brassicae* ont été effectués avec le brocoli et le chou-fleur, et il reste à en améliorer les qualités horticoles.

L'irradiation aux rayons gamma de semence de la lignée consanguine 8-41 qui est résistante à la race 6 a produit un mutant résistant à la race 2 de l'organisme causant la hernie. La progéniture issue de cette mutation a donné des plants résistants aux deux races au cours des essais effectués en plein champ en 1980.

Il est à noter que les gènes responsables de la résistance et qui ont été transférés du rutabaga au chou sont dominants tandis que ceux produits par l'irradiation aux rayons gamma sont récessifs. La production d'hybrides F_1 pour l'industrie sera plus facile en utilisant le transfert de gènes résistants dominants.

Gestion des sols organiques

De meilleurs rendements de carottes ont été obtenus par le contrôle des niveaux de la nappe phréatique et l'emploi de méthodes culturales appropriées tout en réduisant l'affaissement du sol organique. Les rendements d'oignons vendables ont été augmentés en irriguant les cultures. L'insecticide isofenphos appliqué sous forme granulaire au semis a été très efficace pour contrôler la mouche de l'oignon dans différents sols organiques et persiste à 50% de la dose appliquée à la récolte. À la récolte, 0,003 et 0,010 ppm d'isofenphos sont retrouvés dans les bulbes d'oignon alors que 3 et 8 ppm sont retrouvés dans les racines traitées aux taux respectifs de 2 et 4 kg i.a./ha. Le manque d'oxygène crée un stress aux cultures de carottes et ce stress a été repéré au Northern Arm Bog et à Colinet

à Terre-Neuve ainsi qu'à Farnham et Sainte-Clothilde au Québec. Ce stress dû au manque d'oxygène est diminué par un meilleur drainage et un meilleur choix des pratiques culturales comme la culture sur billon.

Protection des légumes

Le Birlane s'est avéré supérieur à cinq autres insecticides à l'essai pour la répression de la mouche du chou. Tous les insecticides testés incluant le Birlane ont été efficaces contre la mouche de l'oignon.

Les populations de doryphore de la pomme de terre des différentes régions du Québec sont toutes résistantes au DDT et certaines au carbaryl (Sevin). Les populations de la région de Compton sont résistantes à tous les pesticides à l'exception des pyréthrinoides de synthèse.

Les nématicides oxamyl et aldicarb appliqués dans le sillon pour la carotte et à la volée pour la laitue ont donné les meilleurs résultats pour la répression du nématode cécidogène. Pour une même population de nématodes, la carotte GoldPak est la plus sensible, l'épinard, la laitue et l'oignon sont plus tolérants.

MAÏS

Gestion de la production

Parmi les façons culturales, ce sont la méthode conventionnelle, le semis sur billon et le non-travail du sol qui ont donné les meilleurs rendements en comparaison de ceux obtenus avec le labour-hersage fait soit à l'automne, soit au printemps; cependant avec la méthode conventionnelle, un plus faible pourcentage d'humidité des grains à la récolte fut observé.

TABAC

Production

Cultivars. Lors d'essais préliminaires de 22 lignées de tabac à cigare, les lignées L64-224 et L64-279 ont démontré une plus forte résistance au pourridié noir que le cultivar RH211.

Fertilisation. On a démontré que sur le sol Soulanges, les engrais azotés influencent le rendement, la qualité et le revenu. Le nitrate de potasse procure le moins bon rendement. Pour la qualité, l'urée et le phosphate d'ammoniaque donnent des revenus identiques. Les

sources de phosphore et de potassium n'ont pas eu d'influence sur les critères étudiés.

Sur le sol Uplands, les sources d'azote, de phosphore et de potassium n'ont pas eu d'influence significative sur le rendement, la qualité et le revenu.

Protection

Nématodes. Des essais de quatre nématicides chez cinq producteurs démontrent que les nématicides fumigants améliorent nettement le rendement lorsque la population est élevée. Lorsqu'il y a association nématodes-champignons, les nématicides qui contiennent de la chloropicrine s'avèrent les meilleurs.

La multiplication de *Pratylenchus penetrans* (Cobb) Filipjev et Stekh. dans 10 types de sol à tabac à cigarette semble être reliée directement au type de sol. La multiplication des nématodes dans la rhizosphère des plants de tabac suite à l'application de nématicides fumigants est demeurée inexistante dans les premiers 8 cm de profondeur durant toute la saison de végétation. Dans la bande traitée, la population augmente peu, mais beaucoup dans celle non traitée.

Vers gris. Nous avons poursuivi et amélioré l'élevage massif des vers gris au laboratoire en vue surtout de la production des virus en quantité suffisante pour les travaux en plein champ et au laboratoire. De plus, nous avons

poursuivi l'étude de paramètres pouvant améliorer la production de virus pour infection de cultures cellulaires. La pathogénicité du virus de la polyédrose nucléaire d'*Agrotis segetum* pour les larves de vers gris en fonction des stades I, III et V a été évaluée et quantifiée au laboratoire.

Les effets synergétiques antagonistes de mélange de virus ont été évalués au laboratoire. Des larves ont été infectées simultanément par le virus de la polyédrose cytoplasmique (C.P.V.) d'*Euxoa scandens* (Riley) et par le virus de la polyédrose nucléaire (N.P.V.), d'*A. segetum*. La mortalité des larves a été évaluée et comparée à celle due à un seul virus.

Des larves du troisième stade d'*E. scandens* ont été infectées au laboratoire par le C.P.V. et traitées par un insecticide (Ambush) à différents temps post-infection (de zéro à 3 semaines). Des mortalités dues à l'insecticide ont été significativement plus élevées dans le cas des larves infectées en particulier depuis 4 à 7 jours.

Pour la première fois, le virus de la polyédrose nucléaire d'*A. segetum* a été expérimenté en plein champ sur les larves d'*E. scandens* de troisième stade. Des traitements en tuyau par différentes doses de virus ont été pratiqués et les mortalités larvaires ont été enregistrées à différents temps. Les résultats prouvent l'efficacité du N.P.V. pour tuer les larves.

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ONTARIO REGION
RÉGION DE L'ONTARIO





Dr. J. J. Cartier



Dr. H. Baenziger



Mr. G. B. Matthews

EXECUTIVE OF THE ONTARIO REGION
L'EXÉCUTIF DE LA RÉGION DE L'ONTARIO

Director General
Directeur général

J. J. CARTIER, B.A., B.Sc., Ph.D.

Program Specialist
Spécialiste en programmes

H. BAENZIGER, Ing. Agr., M.Sc., Ph.D.

Chief, Finance and Administration
Chef, finances et administration

G. B. MATTHEWS

PREFACE

In the reorganization of the Branch in August 1980, the research stations at Harrow, Delhi, Vineland, and Ottawa; the London and Animal research institutes; and the experimental farms at Smithfield, Kapuskasing, and Thunder Bay were brought together to form the new Ontario Region. The two research institutes were renamed research centres. Dr. J. J. Cartier was named Director General. The total staff of the region numbers about 780; the total budget is approximately \$27 million.

The Animal Research Centre conducts research in nine program areas, including animal waste utilization, trace mineral and beef cattle nutrition, dairy cattle breeding and production, dairy cattle nutrition, swine production, poultry breeding, poultry nutrition, sheep production, and animal feed safety and nutrition. Beef cattle nutrition is carried out cooperatively with the Experimental Farm at Kapuskasing, and one of the thrusts of this research is to develop improved systems of beef production in the clay belt of northern Ontario and western Quebec.

The Ottawa Research Station carries out plant breeding programs in cereal crops, forage crops, soybeans, and ornamentals. These programs are supported by research in various aspects of production technology and feature disciplines such as plant pathology and physiology, entomology, cytogenetics, and weed science. A highlight during 1980 was the substantial strengthening of the genetic engineering team, to provide needed backup for the breeding programs of the future.

The London Research Centre's major objectives are in the areas of integrated pest management and environmental quality. Integrated pest management research aims to improve methods for the control of important insect pests in field crops and stored products while reducing the amount of chemicals used. Improvements are also developed in plant disease control methods. Environmental quality research aims at elucidating factors that influence pesticide behavior, persistence, and ultimate fate in the environment. It also attempts to clarify the effects of pesticides on nontarget organisms in the soil and to assess the ecological impact of these effects.

The Vineland Research Station research program focuses on integrated pest management procedures for orchard and vegetable crops, grapes, and some forage crops. The primary objective is to reduce the amount of chemical pesticides used while maintaining the quality and quantity of produce. A 1980 highlight for Vineland was the organization and successful staging of the seventh meeting of the International Council for the Study of Viruses and Virus Diseases of the Grapevine.

The primary mandate of the Delhi Research Station is to provide research support to the tobacco industry in Ontario. However, results of research are often applicable to tobacco production in Quebec and in the Maritime Provinces. The program at Delhi is directed toward development of more efficient production technology, improved cultivars, and improved tobacco quality. During 1980 plans were formulated and approved for a research program on alternate crops for tobacco soils. Initially, this research will focus on peanut production technology and on certain aspects of peanut quality.

The Harrow Research Station has one of the most diverse programs in the Ontario Region. It features breeding and production research in corn, soybeans, winter wheat, field beans, and burley tobacco, as well as in a variety of horticultural crops including several tree fruit and vegetable species. Improvement of pest control procedures, including those for weed control, are important objectives of research in most of these crops. During 1980, Harrow Research Station scientists organized an international workshop on peach canker, in an effort to find new approaches to this serious problem.

Two Ontario Region establishment directors retired at the end of 1980: Dr. J. M. Fulton, Director at Harrow; and Dr. A. J. McGinnis, Director at Vineland. Dr. S. R. Miller was appointed Superintendent at the Smithfield Experimental Farm.

Detailed information on the various station programs may be obtained by writing to the establishments concerned or by addressing inquiries to Ontario Region Headquarters, Research Branch, Agriculture Canada, Experimental Farm, Ottawa, Ont. K1A 0C6.

J. J. Cartier

PRÉFACE

Lors de la restructuration de la Direction générale, en août 1980, les stations de recherche d'Harrow, de Delhi, de Vineland et d'Ottawa, l'Institut de recherche de London, l'Institut de recherche zootechnique et les fermes expérimentales de Smithfield, de Kapuskasing et de Thunder Bay ont été regroupés pour constituer la nouvelle région de l'Ontario. Les deux instituts de recherche seront dorénavant appelés centres de recherche. M. J.J. Cartier a été nommé directeur général de cette région. Le nombre total d'employés s'établit à environ 780 et le budget se chiffre à environ \$27 millions.

Le Centre de recherche zootechnique englobe neuf grands domaines de recherches: la valorisation des déchets d'origine animale; les oligo-éléments et la nutrition des bovins de boucherie; l'élevage et la production des bovins laitiers; la nutrition des bovins laitiers; la production du porc; l'élevage de la volaille; la nutrition de la volaille; la production du mouton et l'innocuité et la valeur nutritive des aliments pour animaux. Les recherches sur la nutrition des bovins de boucherie réalisées en collaboration avec la Ferme expérimentale de Kapuskasing ont notamment pour objectif de mettre au point des systèmes améliorés de production du boeuf dans la région de l'enclave argileuse du Nord de l'Ontario et de l'Ouest du Québec.

La station de recherche d'Ottawa s'intéresse à l'amélioration des céréales et des cultures fourragères, du soja et des plantes ornementales. La réalisation de ces programmes est appuyée par des travaux intéressants divers aspects des techniques de production et utilisant des disciplines telles que la pathologie et la physiologie végétales, l'entomologie, la cytogénétique et la malherbologie. Un des faits saillants de l'année 1980 a été le renforcement substantiel de l'équipe de recherches en génétique destinée à appuyer les futurs programmes d'amélioration.

Les principaux objectifs poursuivis par le Centre de recherche de London relèvent de la lutte antiparasitaire intégrée et de la qualité de l'environnement. La recherche sur la lutte antiparasitaire intégrée vise à améliorer les méthodes de lutte contre les ravageurs les plus importants des cultures et des produits entreposés, tout en diminuant la quantité d'insecticides chimiques utilisés. Des améliorations sont aussi apportées dans les méthodes de lutte contre les maladies des plantes. Les recherches dans le domaine de la qualité de l'environnement visent à déterminer les facteurs qui influent sur le comportement des pesticides, leur rémanence et leur devenir dans l'environnement. Elles cherchent aussi à déterminer les effets des pesticides sur les organismes inoffensifs ou utiles du sol et à évaluer l'incidence écologique de ces effets.

Le programme de la station de recherche de Vineland met surtout l'accent sur les méthodes de lutte antiparasitaire intégrée dans les vergers, les cultures maraichères, les vignobles et certaines cultures fourragères. Le principal objectif visé est de diminuer la quantité de pesticides chimiques utilisés tout en maintenant la qualité et la quantité du produit. Un des faits saillants en 1980 à Vineland a été l'organisation et la tenue de la septième conférence du Conseil international sur l'étude des virus et des viroses de la vigne.

La station de recherche de Delhi s'occupe principalement du tabac, au profit de l'industrie du tabac de l'Ontario. Toutefois, les résultats de ses recherches s'appliquent souvent à la production de tabac du Québec et des Maritimes. La station concentre ses efforts sur la mise au point de méthodes de production plus efficaces et de cultivars améliorés, ainsi que sur l'amélioration de la qualité du tabac. L'année 1980 a vu la planification et l'approbation d'un programme de recherches portant sur les cultures de rechange pour les terres à tabac. Au début, la recherche mettra l'accent sur les techniques de production d'arachides et sur certains aspects de la qualité de ce produit.

Le programme de la station de recherche d'Harrow est un des plus diversifiés de la région. Il comporte la recherche sur l'amélioration et la production du maïs, du soja, du blé d'hiver, du haricot de grande culture, du tabac Burley ainsi que toute une gamme de cultures horticoles, dont plusieurs espèces d'arbres fruitiers et de légumes. L'amélioration des méthodes de lutte antiparasitaire, notamment contre les mauvaises herbes, compte parmi les objectifs importants de la recherche pour la plupart de ces cultures. En 1980, les chercheurs de la station ont organisé un atelier international sur le chancre de la pêche, afin de trouver de nouvelles méthodes pour lutter contre cette grave maladie.

Deux des directeurs de la région ont pris leur retraite à la fin de 1980: M. J.M. Fulton, directeur de la station d'Harrow; et M. A.J. McGinnis, directeur de la station de Vineland. M. S.R. Miller a été nommé régisseur de la ferme expérimentale de Smithfield.

Pour de plus amples renseignements sur les programmes des diverses stations de notre région, prière d'écrire aux établissements de recherche concernés ou de s'adresser à l'Administration centrale de la région de l'Ontario, Direction générale de la recherche, Agriculture Canada, Ferme expérimentale, Ottawa (Ontario) K1A 0C6.

J.J. Cartier

Animal Research Centre

Ottawa, Ontario

PROFESSIONAL STAFF

Administration

R. S. GOWE, B.S.A., M.S., Ph.D.	Director
S. C. THOMPSON, B.Sc., M.A., Ph.D.	Deputy Director
D. A. LEGER, B.Sc.	Assistant to the Director
D. L. BLAKELY, B.A.	Chief, Administration and Resources
J. R. HARRISON, B.Sc.	Administrative Officer, Finance
G. R. FORD	Administrative Officer, Personnel

Scientific Support

K. G. HILSON, ¹ B.Sc., M.Sc.	Project Manager; Computer services
K. B. LAST ¹	Systems and programming
H. M. MUCHA ¹	Systems and programming
A. SABOU ²	Systems and programming
I. G. SMITH, ³ B.Math.	Systems and programming
S. G. DYKSTRA, ⁴ B.A., B.L.S.	Librarian
K. E. HARTIN, D.V.M.	Veterinarian

Animal Waste Utilization Program

N. K. PATNI, B.Ch.E., M.Sc., Ph.D.	Program Chairman; Livestock waste utilization and farm pollution abatement
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Trace Mineral and Beef Cattle Nutrition Program

M. IVAN, ⁵ Ing., M.Sc., Ph.D.	Program Chairman; Nutrition and metabolism of trace minerals, Mn, Cu, Zn, Fe
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M. HIDIROGLOU, D.V.M., Dip. Nutr.
D. M. VEIRA, B.Sc., M.Sc., Ph.D.

Vitamin D nutrition
Beef cattle nutrition

Dairy Cattle Breeding and Production Program

A. J. McALLISTER, B.S., M.S., Ph.D.	Program Chairman; Dairy cattle breeding and production, applied quantitative genetics
T. R. BATRA, B.V.Sc., M.V.Sc., M.S., Ph.D.	Dairy cattle breeding, applied quantitative genetics
A. J. HACKETT, D.V.M., M.Sc., Ph.D.	Female reproductive physiology
A. J. LEE, B.Sc. (Agr.), Ph.D.	Dairy cattle breeding and production, applied quantitative genetics
C. Y. LIN, ⁶ B.S., M.S., Ph.D.	Dairy cattle breeding, applied quantitative genetics
G. J. MARCUS, B.A., Ph.D.	Maternal-embryonic physiological interactions
J. NAGAI, B.Sc., D.Agr.	Quantitative genetics, mice

Dairy Cattle Nutrition Program

F. D. SAUER, D.V.M., M.S., Ph.D.	Program Chairman; Rumen metabolism and nutrition
A. S. ATWAL, ⁷ B.Sc. (Agr.), M.Sc., Ph.D.	Forage evaluation and nutrition
J. D. ERFLE, B.S.A., M.Sc., Ph.D.	Rumen metabolism and nutrition
K. J. JENKINS, B.S.A., M.Sc., Ph.D.	Calf nutrition
J. R. LESSARD, B.A., B.S.A., M.S., Ph.D.	Forage conservation and nutrition
S. MAHADEVAN, B.Sc., M.Sc., Ph.D.	Rumen physiology and ruminant nutrition
R. M. TEATHER, B.Sc., Ph.D.	Rumen microbiology

Swine Production Program

J. I. ELLIOT, B.S.A., M.Sc., Ph.D.	Program Chairman; Sow nutrition and artificial rearing
A. F. FORTIN, B.Sc. (Agr.), Ph.D.	Carcass evaluation
D. G. FRASER, ⁸ B.A., Ph.D.	Animal behaviorism—swine, sheep, cattle
D. W. FRIEND, B.Sc., M.Sc., Ph.D.	Sow nutrition and reproduction
H. A. ROBERTSON, ⁹ B.Sc., Ph.D., C.Chem., F.R.I.C., F.R.S.E.	Female reproductive physiology
N. K. SARKAR, B.Sc., M.Sc., D.Sc.	Protein biochemistry

Poultry Breeding Program

J. S. GAVORA, Ing., C.Sc.	Program Chairman; Egg stock breeding and management, broiler breeding, disease resistance genetics
J. R. CHAMBERS, B.Sc., M.Sc., Ph.D.	Broiler breeding, goose research
R. W. FAIRFULL, B.Sc., M.Sc., Ph.D.	Egg stock breeding and management
R. S. GOWE, B.S.A., M.S., Ph.D.	Egg stock breeding and management
A. A. GRUNDER, B.S.A., M.Sc., Ph.D.	Broiler breeding, eggshell quality genetics, goose research, disease resistance genetics
K. G. HOLLANDS, B.A., B.S.A., M.S.A.	Eggshell quality genetics, disease resistance genetics
C. P. W. TSANG, B.Sc., M.Sc., Ph.D.	Eggshell quality genetics

Poultry Nutrition Program

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, ¹⁰ B.Sc. (Agr.), M.Sc., Ph.D.	Avian energetics and feedingstuff evaluation

Sheep Production Program

D. P. HEANEY, B.S., M.S., Ph.D.	Program Chairman; Nutrition and intensive management
L. AINSWORTH, B.Sc., M.Sc., Ph.D.	Female reproductive physiology
P. S. FISER, B.Sc., M.Sc., Ph.D.	Male reproductive physiology
G. A. LANGFORD, B.Sc., M.Sc., Ph.D.	Male reproductive physiology
J. N. P. SHRESTHA, ¹¹ B.V.Sc.A.H., M.S., Ph.D.	Breeding and intensive management

Animal Feed Safety and Nutrition Program

H. L. TRENHOLM, B.Sc., Ph.D.	Program Chairman; Mycotoxins, toxicology
M. H. AKHTAR, B.Sc., M.Sc., Ph.D.	Pesticide metabolism and residues
E. R. FARNWORTH, B.Sc., M.Sc., Ph.D.	Lipids and mycotoxins nutrition and biochemistry
T. S. FOSTER, B.Sc., M.Sc., Ph.D.	Pesticide metabolism and residues
J. K. G. KRAMER, B.Sc., M.Sc., Ph.D.	Lipid chemistry and biochemistry

Departures

- J. P. CHESNAIS, B.Sc., M.Sc., Ph.D.
Transferred to Animal Production
Division, Food Production and Inspection Branch,
January 1980
Dairy cattle breeding, applied
quantitative genetics
- W. A. JORDAN, B.S.A.
Retired December 1980
Beef cattle management

VISITING SCIENTISTS

- K. SAIO, B.Sc., B.Agr., D.Agr.
Faculty of Agriculture,
University of Tokyo, Tokyo, Japan
Biometric aspects of animal
breeding programs
- M. J. SCHANG, Ing., M.Sc.
Instituto Nacional de Tecnologia Agropecuaria,
Pergamino, Argentina
Feedingstuff evaluation

Agriculture Institute of Canada exchange fellow

- H. C. PATTERSON, B.Sc., M.Sc.
Ministry of Agriculture, Food and Consumer
Affairs, St. Michael, Barbados
Sheep and goat production

Canadian Executive Service overseas fellow

- L. A. F. DE AVILA, D.V.M.
Sadia-Concordia S.A. Industriae
Comercio, Concordia, Brazil
Swine and broiler chicken
production

International Atomic Energy Agency training fellow

- B. SAKALA
National Council for Scientific
Research, Lusaka, Zambia
Hormone radioimmunoassay
procedures

Natural Sciences and Engineering Research Council postdoctorate fellow

- R. J. BOILA, B.S.A., M.Sc., Ph.D.
1978-1980
Nonprotein nitrogen sources and
ruminant function
- P. M. HOCKING, B.Agr., Ph.D.
1980-1981
Dairy cattle crossbreeding
- C. SHORROCK, B.Sc., M.Sc., Ph.D.
1980-1981
Beef cattle nutrition and
management

Graduate students

J. A. CARNEGIE, B.Sc., M.Sc., Ph.D.	Reproductive physiology
D. V. GILL, B.Sc., Ph.D.	Reproductive physiology
F. LEVINE, B.Sc.	Reproductive physiology

¹Seconded from Data Processing Division, Finance and Administration Branch.

²Appointed May 1980.

³Appointed June 1980.

⁴Seconded from Libraries Division, Finance and Administration Branch.

⁵On transfer of work at Laboratoire des Maladies Nutritionnelles, l'Institut National de la recherche agronomique, Beaumont, France, from August 1980 to July 1981.

⁶Appointed September 1980.

⁷Appointed December 1980.

⁸Appointed December 1980.

⁹On leave at the Faculty of Veterinary Science, University of Kartoum, Kartoum, Sudan, from February to March 1980.

¹⁰On transfer of work at the Animal Research Council, Poultry Research Centre, Edinburgh, Scotland, from August 1979 to July 1980.

¹¹Appointed September 1980.

INTRODUCTION

The Animal Research Centre (ARC) is the main Canadian center for breeding and genetics research with dairy cattle, sheep, and poultry; it also has major research programs in the nutrition of dairy cattle, swine, sheep, beef, and poultry; as well, ARC has research programs in animal waste utilization and management, trace minerals, ruminant digestive physiology, and animal feed safety and nutrition. The nine research program teams are multidisciplinary and are comprised of scientists with a broad range of scientific expertise. Both applied research and basic research that is directly related to the solution of the problem is carried out within these teams.

The Animal Research Centre continues to devote a large effort to studying the problems of intensively housed and managed cattle, sheep, swine, and poultry. Scientists of several disciplines—in particular genetics, nutrition, and reproductive physiology—are involved in both multidisciplinary as well as unidisciplinary studies to resolve the numerous problems associated with improving the productivity of intensively housed animals.

Increasing emphasis is being placed on animal behavior and its relationship to intensive housing systems. An ethologist position was added to the scientific staff of the Centre in 1980.

Research staff have also been added to the Dairy Cattle Nutrition Team to augment the applied program, to the Sheep Production Team to include a quantitative geneticist, and to the Dairy Cattle Breeding and Production Team to include another geneticist. This will strengthen the work on forage utilization for dairy cattle and the breeding programs for dairy cattle and sheep.

Increasing effort is being devoted to the transfer of results from the researcher to the farmer-user. This thrust is typified by the publication this year of a technical bulletin entitled *Research for an intensive total confinement sheep production system*, which summarizes the research program in sheep production over the last 10 yr and relates it to on-farm use. Many of the techniques on controlled reproduction that were developed at the Centre are now being evaluated in field trials in two Canadian provinces. They are being widely accepted by sheep producers.

This annual report highlights research progress in the various scientific programs. Significant advances were made in 1980 in the following areas: formic acid-preserved alfalfa silage can replace soybean meal in dairy cattle rations and produce significant savings in feed costs per lactation; urea can substitute for soybean meal in higher protein dairy cattle feeds and yield major savings; dietary protein can be reduced toward the end of the laying cycle in hens without decreasing poultry egg production; a minimal-disease sheep flock has been established by hysterectomy, which will be a vital tool in assessing the effects of clinical and subclinical diseases on sheep production; reentrant cannulas have been developed and tested for sheep and calves to substantially increase information on ruminant digestive physiology; research with soluble fish protein concentrate shows its usefulness in swine and calf diets; and research on mycotoxins was expanded from a program in zearalenone to include vomitoxin, a fungus toxin contaminant of wheat of current concern in Eastern Canada.

The staff at the Centre are the scientific authorities for a number of federal contract research programs and projects with private companies and universities. Contract research plays an important role, together with government in-house research, in solving problems facing Canadian agriculture. The Centre supervised contract research programs in the areas of reproductive physiology, swine nutrition, ruminant nutrition, and livestock feed from waste. Some of this work is described in this report.

Two of the Centre's researchers received major honors in 1980. In July, the Gustav Bohstedt Award was presented to Dr. Michael Hidioglou by the American Society of Animal Science on behalf of the Salt Institute. The award recognized his significant contributions in mineral and trace mineral research. In October, the Minister of Agriculture presented the federal government's Merit Award to Dr. Robb S. Gowe. This major award recognized his outstanding scientific achievements as a poultry geneticist as well as his management and leadership of the Animal Research Centre and the development of the Centre's facilities at the Greenbelt Farm.

Detailed information on the research accomplishments, methodology, and results can be obtained from the publications listed at the end of this report. Reprints of these publications and copies of this report are available on request from the Animal Research Centre, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R. S. Gowe
Director

WASTE UTILIZATION PROGRAM

Pipeline transportation of liquid manure

Field trials on pumping dairy cattle liquid manure (DCLM) from a livestock barn to a remote, plastic-lined and plastic-covered 1000 m³ field storage were conducted. Four different commercially available pumps were used to pump DCLM, with 4.8–9.7% total solids content, through a buried 900-m long, 100-mm diameter high-density polythene pipeline. Only one pump with 1100 kPa discharge pressure was able to pump DCLM with a solids content greater than 8%. Pressure drops due to friction ranged from 31 to 99 m of water column per 1000 m of straight pipe and were greater than previously published values for 100-mm diameter plastic pipes. The remote field storage was found to be unsuitable for use in very cold weather owing to freezing in the manure-removal pipes.

Effect of rate and time of manure application on soil, drainage water, and corn crop

In a 6-yr cooperative study with Engineering and Statistical Research Institute and Land Resource Research Institute, DCLM was applied yearly at three rates of manure nitrogen (N) (224, 560, and 879 kg/ha) and four different schedules (spring, fall, winter, and half in spring – half in fall) to sandy clay loam soil in continuous corn production. Two control plots, one with chemical fertilizer N at 134 kg/ha and the other with no treatment, were also studied. At harvest inorganic N in the top 120-cm soil layer was related to both cumulative and annual N inputs. Bicarbonate extractable P and exchangeable K increased in the surface soil of the plots with the two higher rates of DCLM. Tile effluent nitrate N concentration in the plot that received the highest rate of DCLM was little different from the plot receiving chemical fertilizer N. Neither rate nor time of application of DCLM significantly affected corn yields.

Groundwater quality near concrete manure tanks and under heavily manured cropland

Leakage of nitrate and ammonia N, orthophosphate, and K from below-grade, reinforced concrete liquid-manure storages, which were built with unsealed wall-to-floor joints, was found to be small after 10 yr of continuous use. However, heavy applications of liquid manure for 3–4 yr to well-drained sandy soil resulted in nitrate and ammonia N concentrations in groundwater well above drinking-water standards.

Feed from waste

Contract research was conducted on waste utilization for feed. At the University of Waterloo, a process for converting crop residues into fungal (*Chaetomium cellulolyticum*) single-cell protein (SCP) for animal feed was further refined. The SCP nutritive quality compared favorably with casein in feeding trials on rats and mice. Nutritional evaluation of steamed cereal straw by STAKE Technology Ltd. established that processed straw could be successfully incorporated into rations for dairy cows and beef steers. Processing conditions were established.

TRACE MINERAL AND BEEF CATTLE NUTRITION PROGRAM

Beef production in the northern clay belt area of Ontario

In studies at the Kapuskasing Experimental Farm, Shorthorn × Hereford steers and bulls were fed ad libitum from weaning until market weight on direct-cut formic acid-treated grass silage (DFGS) (first cut) with supplements of high-moisture barley at levels of 0, 0.5, 0.9, and 1.3 kg dry matter (DM) per 100 kg liveweight. Based upon final weights taken at slaughter and allowing for losses due to shipping, these levels of barley supplementation resulted in daily liveweight gains of 0.72, 0.84, 1.03, and 1.12 kg; and in feed-to-gain ratios of 8.47, 8.05, 6.95, and 6.55. The

animals required 257, 217, 193, and 171 days to reach market weight, respectively. At all levels of dietary energy, bulls grew 9.0% faster and required 7.8% less feed per unit gain. It was possible on all feeding programs to attain a carcass grade of Canada A1 or A2 with both bulls and steers.

The potential of growing Holstein steers to 240 kg was examined during a 98-day summer feeding trial. Pasture was fertilized with N at 80 kg/ha and stocked at the rate of 3.0 or 4.2 steers per hectare. The higher stocking rate resulted in lower average daily gains (1.05 versus 1.22 kg) but greater output per hectare (431.9 versus 354.3 kg). At the same time, another group of steers was fed in a feedlot on either DFGS (first cut) or on a 40:60 mixture of the DFGS plus barley. Average daily gains were 1.32 and 1.6 kg and feed-to-gain ratios were 5.70 and 5.40 on the two diets, respectively. Considering only the yield of the first cut of DFGS (DM at 3.37 t/ha), the liveweight gain from the DFGS fed to the feedlot group was 453.4 kg/ha, which was 5% greater than best gain of the two pasture groups.

Digestion of corn and alfalfa silage

The digestion of silage in the stomach and small intestine was investigated with sheep prepared with reentrant cannulas in the proximal duodenum and proximal ileum. The silages studied were corn silage (CS); CS with 0.6% urea added on a fresh-weight basis at the time of ensiling; direct-cut alfalfa silage treated with formic acid, which was added at 5 g of acid per kilogram of fresh alfalfa at the time of cutting; and wilted alfalfa silage. Urea treatment of CS increased the crude protein (CP) from 8.1 to 13.2% and had no effect on organic matter digestion but increased digestion of protein in the small intestine by increasing microbial synthesis in the stomach. The alfalfa silage was made from first cut (bud stage) and contained 23% CP. Compared to wilting, treatment of alfalfa with formic acid reduced the digestion of protein in the stomach and increased the small intestine protein digestion, but this shift in protein digestion site was not due to changes in microbial output from the stomach.

Manganese studies

Three groups of wethers were each fed a practical diet containing 20, 300, or 3000 ppm Mn for 8 wk. Average daily gains and feed-to-gain ratios of sheep fed the 20 and 300 ppm Mn diets were similar, but gain was lower and the ratio higher for the 3000 ppm Mn diet. Feed intake was approximately the same for all treatments. Increased dietary Mn raised its concentration in soft tissues and bile. Liver concentration of Cu increased and concentration of Zn decreased with increasing dietary Mn.

Metabolism of vitamin D₃ in sheep

The major form of circulating vitamin D₃ is its metabolite 25-hydroxyvitamin D₃ (25-OH D₃), as determined from the metabolic profiles of sheep plasma 3 days after administration of either isotopically labeled vitamin D₃ or 25-OH D₃ or both. The uptake of radioactive 25-OH D₃ by the plasma was more rapid in sheep housed indoors than outdoors. Plasma and tissue radioactivities were greater in sheep dosed with labeled 25-OH D₃ than with equivalent amounts of labeled vitamin D₃. Placental transmission of intravenously administered label given as vitamin D₃ and its 25-OH D₃ metabolite was studied in gestating ewes. Radioactivity concentrations were higher in tissues of animals dosed with vitamin D₃ than in tissues of animals given 25-OH D₃. Tissue concentration was greater in the ewe than in the fetus. The amount of isotope transferred to the fetus varied greatly among individual ewes and this may be related to the state of vitamin D nutrition of the dams.

DAIRY CATTLE BREEDING AND PRODUCTION PROGRAM

National cooperative dairy cattle breeding project (NCDCBP)

Further comparisons of bulls used in the pure line foundation matings have been completed for the areas of heifer body measurements, heifer calving ease, and lactation yields through three lactations. The highly selected bulls of the breed groups in the Ayrshire-based A line (Research Branch, Finnish, U.S., and Canadian Ayrshire, Brown Swiss, and Norwegian Red) and the Holstein-based H line (Research Branch, U.S., and Canadian Holstein) were chosen to broaden

the genetic base of the two-parent pure lines and were not a random sample of the populations from which they were chosen.

Heifers from the H line were significantly larger than those of the A line for all body measurements (withers height, heart girth, chest width and depth, hook width, and shoulder-to-hook length) at all ages except for rump length at 82 wk of age. The volume of data permitted statistical detection of very small differences between the lines because there were 496 H line heifers and 344 A line heifers. Generally, differences were small in the various body measurements among the daughters representing the different Holstein strains in North America and of little practical importance. Progeny of the two Brown Swiss bulls tested were consistently larger than progeny of other sire groups in the A line, but only significantly so for withers height at all ages and 82-wk rump length. They were followed closely by progeny of the Norwegian Red and Finnish Ayrshire sires with daughters of Research Branch, Canadian, and U.S. Ayrshire being similar but slightly smaller in size. The daughters of the Canadian Ayrshire bulls tended to be a little larger than Research Branch and U.S. Ayrshire progeny.

The average superiority of the Holstein-based H line over the Ayrshire-based A line over the first three lactations was 1400 kg for mature equivalent (ME) milk yield, 39 kg for ME protein yield, and 56 kg for ME butterfat yield. There were no significant differences in these traits among the bull groups in the A line but in the H line both the U.S. and Canadian Holstein groups had significantly higher yields than the Research Branch Holstein groups. There was wide variation among bulls within a group. Some of the Norwegian Red progeny were intermediate between the Holstein- and Ayrshire-based lines. Much between-herd variation was observed in these data but within-herd first-lactation yields were good predictors of subsequent milk yields.

Calving difficulty was associated with higher percentage of calves born dead and subsequent higher frequencies of retained placenta in both A and H line heifers. H line heifers requiring no assistance at time of calving had 4% of calves born dead compared to 24% when some kind of assistance was required. Corresponding values for A line heifers were 4% and 19%, respectively. The

incidence of retained placentas was significantly smaller when calves were born alive in both H line (5%) and A line (14%) heifers. This incidence increased to 21% in H line and 33% in A line heifers when calves were dead at birth.

The California mastitis test (CMT) was done on 6609 and 4206 quarter samples from H and A line cows, respectively, to study the effects of line, parity, month-of-freshening, and month-of-lactation. The incidence of subclinical mastitis as judged by CMT score was similar in both lines, and older cows tended to be more positive to the mastitis-screening test than younger cows. The incidence of positive quarters was higher for the cows calving during summer months, and there was an increase in the CMT score in the later months of the lactation period. Microorganisms were isolated from 21.5, 31.5, 42.3, and 53.0% of the samples showing a CMT reaction of trace, 1, 2, and 3, respectively. *Klebsiella* spp. were found in 40.5% of the samples and *Streptococcus* spp. were isolated in 36.8%. Other organisms isolated were *Staphylococcus aureus* (14.9%) and coliforms (6.4%).

Breeding studies using record of performance (ROP) data

Records-in-progress from Ayrshire, Guernsey, Holstein, and Jersey cows calving after 35 mo of age were used to predict 305-day milk and fat yields using U.S. Department of Agriculture (USDA) extension factors introduced in 1965. The differences between the actual and projected yields were positive, indicating that USDA extension factors were underestimating both milk and fat yields for the four breeds. For the Holstein breed, phenotypic correlations between the projected records-in-progress and actual 305-day milk yields increased from 0.54 for up to 29 days in milk to 0.98 for 270–304 days in milk. Similar correlations were also observed for the other breeds. The results of this study suggest that the USDA extension factors used on Canadian data underestimate 305-day milk and fat yields from shorter partial records.

A simple procedure was used to modify the 1965 USDA extension factors for use in Canada. The 1965 and revised USDA extension factors were compared on 84 075 complete lactation records accumulated by ROP during 1979. When the revised extension

factors were applied, the systematic bias was eliminated in records longer than 60 days.

Monitoring the reproductive status of the postpartum cow

Dairy cattle of the H, A, and crossbred lines, which are maintained year round in total confinement in either a loose-housing or a tie-stall barn, were monitored for estrous cycle activity and reproductive performance. Only 54% of the cows were observed in estrus at least once between parturition and day 55, whereas rectal palpation indicated that nearly all cows had been in estrus or had ovarian activity. There was a significant line-by-barn interaction in the detection of estrus. For A line cows, 74% were observed in estrus in the tie-stall barn compared with 48% in the loose-housing barn. Conceptions to either first, second, third, or fourth or greater services were 43, 44, 43, and 37%. Cows in the loose-housing barn had significantly more days open than those in the tie-stall barn. Failure to detect estrus was the major problem contributing to a greater than 12-mo calving interval.

Pilot genetic studies with mice and computer simulation

Genetic principles fundamental to the current dairy cattle crossbreeding experiments, but which are difficult to examine, were investigated using mice and computer simulation.

Lifetime lactational performance (TP) in mice was compared for several (second filial) populations produced by four lines of mice that were developed for increased milk production or adult weight. Each F_2 female was paired with a specific F_1 male for 200 days, and the number of litters produced during this time was recorded. Several F_2 populations were compared for TP, which consisted of two component traits, number of litters produced during 200 days (NL) and average 18-day litter weight (LW), where $TP = NL \times LW$ for individual F_2 females. Two F_2 female populations derived from a cross of a milk production line and an adult weight line but from two different base populations did not differ in TP but did for NL (3.32 versus 4.04). Another pair of F_2 female populations derived from a cross of a milk production line of one base population with an adult weight line of the other base population and its reciprocal differed for TP (516 versus 434) and NL (4.64 versus 3.90) but not LW. An F_2 female

population derived from a cross of two milk production lines from different base populations was superior to one derived from a cross of two adult weight for TP (4.88 versus 4.01), NL (5.15 versus 3.84), and LW (114 versus 105). Heritabilities estimated from the sire component of variance were 0.23, 0.26, and 0.44 for TP, NL, and LW, respectively, indicating that TP and its component traits are moderately heritable. It was concluded that TP could differ between random bred populations of different genetic origin, owing to the difference in its component traits, particularly number of litters produced in a lifetime.

A theoretical study with computer simulation was conducted to assess performance for a single character under two mating systems: crisscross (CC) and repeated hybrid male cross (RHMC). Both systems can be used for less prolific species such as dairy cattle, and the latter has been adopted in the current NCDCBP. Under CC, the expected performance fluctuated over generations, whereas under RHMC, the performance was constant starting with the F_2 generation. Comparison of the performance revealed that CC involving the first backcross to the better breed male (CC.1) was expected to be superior to RHMC for various degrees of heterosis (H) and differences in performance between the two breeds involved (D). The expected performance ratio of CC.1 to RHMC after a few generations of crossing approximated $2[1 + 2H/3 + (D/3)(2 - D)]/(2 + H)$. When D was small (10%) and H substantial (30%), CC.1 was expected to exceed RHMC by approximately 6% after a few generations of crossing. The results are under investigation experimentally with the use of mice.

Very early pregnancy detection

A very early pregnancy test based upon an immunological reaction of pregnant animals has been reported in sheep. Efforts to confirm this Rosette-inhibition test have been unsuccessful. This failure to reproduce the original results casts serious doubt on the validity of using this phenomenon to diagnose pregnancy.

DAIRY CATTLE NUTRITION PROGRAM

Urea in dairy cattle rations

The average 305-day milk production for cattle fed corn with urea added at ensiling was 6330 kg, which was equivalent to a similar diet with comparable (12–13%) crude protein (CP) provided by soybean meal supplementation (5920 kg) or urea added to the concentrate (5780 kg) but superior to a negative control with 9.4% CP (4420 kg). An experiment was designed to determine milk production when urea, added to corn at ensiling, was used to increase 12% CP soybean meal or fish meal supplemented diets to 15% total CP. Urea-supplemented rations were compared to a 12% CP negative control ration formulated with soybean meal and to two positive control rations supplemented with either soybean or fish meal to contain 15% total CP. Concentrates and corn silage were fed ad libitum as a complete feed. Preliminary results with cows milking 20–30 kg/day at peak lactation showed no difference in milk production between diets containing 12 and 15% CP nor between diets supplemented with urea or soybean or fish meal. The correction of milk production at 13–16 wk postpartum using the first 4 wk of lactation as a covariate did not alter the relative treatment responses. Daily feed DM intakes were similar for all treatments. Rumen ammonia concentrations were somewhat lower on the 12% CP diet as compared with the 15% CP diets. There was no clear indication that urea in the silage resulted in higher rumen ammonia levels than were found with soybean or fish meal rations. Preliminary results indicate that urea ensiled with corn is a highly effective protein supplement in dairy rations formulated to contain 15% CP.

Alfalfa silage as a source of proteins for lactating cows

Formic acid-treated alfalfa silage (FAS) was mixed with corn silage (CS) in proportions such that the protein content of the mixture was 13.5% on a dry basis. A grain mix containing 13% protein but with no oilseed meal was added to make a complete feed with a 60:40 forage-to-grain ratio (ration I). A second complete feed containing 38% CS, 15% wilted grass-legume silage, 7% hay, and 40% of a 21% CP concentrate was used as a control (ration II). Two groups of lactating

cows were fed each of two rations for three lactations. The cows fed ration I consumed less DM than those fed the control (16.0 versus 17.5 kg/day). Milk production for a 308-day lactation was the same for the two rations (4947 versus 4972 kg) from 1172 complete lactations measured in a mixed herd of Holstein, Ayrshire, and crossbred cows. Fat and protein content of the milk were not altered by the diets (3.39% versus 3.42%, and 3.21% versus 3.27%, respectively). Calving interval, days open, services-per-conception, and health status were not different between rations. However, significant savings in the cost of concentrates were realized from using FAS as the main source of proteins. These savings were estimated at \$100 per cow-lactation, using the respective prices per tonne for soybean meal, corn grain, and barley grain of \$420, \$160, and \$175. It is concluded that hay can be eliminated from the diet of lactating cows fed complete diets and that a large portion of the required protein can be supplied by FAS.

Protein degradation in the rumen

Chemical structures in proteins, which make them resistant or susceptible to degradation by a rumen proteolytic enzyme (protease from *Bacteroides amylophilus*), were investigated. It was found that disulfide (sulfur-sulfur cross-links) bonds in proteins make them resistant to degradation, and chemical bonds in proteins involving phenylalanine and leucine were more easily hydrolyzed by the protease than were other bonds. This information is being used to modify proteins in order to produce feed proteins of predictable and controllable rumen degradation.

Currently, crude rumen fluid or commercially available protease preparations from sources other than rumen microorganisms are used in in vitro procedures to determine rumen degradability of feed proteins. However, use of rumen fluid has many disadvantages, commercial proteases have properties different from those of rumen proteases, and rumen protease preparations are not available. Procedures were developed for the preparation of rumen protease for use in the in vitro protein degradation measurements. The rumen protease prepared in dry powder form with most of the interfering materials removed, has all the proteolytic activity of fresh rumen fluid, and can be stored dry for at

least 1 yr without loss of activity. With the use of this material, a procedure for measuring protein degradation has been standardized and degradation rates of common feed proteins are being determined.

Calf nutrition

Two feeding experiments were conducted to test the ability of a soluble fish protein concentrate (FPC) to replace skim milk powder in liquid diets for calves. In a 10-wk vealer trial, calves were fed one of three milk replacers: skim milk powder as a control, 50% of protein provided by FPC and 50% from whey and skim milk powder, and 80% of protein provided by FPC and 20% from whey protein. The average daily weight gains and feed-to-gain ratios for the control and the 50% FPC diets were similar (0.94 and 0.81 kg, and 1.4 and 1.4, respectively), but both diets were markedly better than the 80% FPC diet (0.61 kg and 1.9). The results showed that two-thirds of the skim milk powder in milk replacers for veal calves can be replaced with the FPC and whey, with approximately 40% saving in feed cost. At the high FPC level, several calves initially would not drink the diet and those that did performed relatively poorly.

In a second feeding trial, the same milk replacers were fed to newborn calves in a calf herd replacement early weaning program. The milk replacers were fed for the first 4–5 wk and then calf starter to 9 wk of age. As in the vealer experiment, several calves would not drink the 80% FPC. Those that did, however, suffered only a temporary (1 wk) setback in weight gains. Calf performance was similar for the control and 50% FPC diets for digestibility of DM, N, and lipid; weight gains; intakes of both milk replacer and starter ration; and age at weaning. As observed in the vealer trial, the economic benefit for the 50% FPC milk replacer over the control was a saving of approximately 40% of the cost of milk replacer ingredients.

Rumen bacteriology

A rumen bacteria culture collection has been established and optimal methods for long-term culture storage are being determined. At present 138 bacterial strains are being maintained. A previously unknown bacterial species, which plays a role in fiber degradation in the rumen, has been isolated and is being characterized.

The response of the rumen microbial population to supplementation of a basal CS diet (9.4% CP) with either soybean meal, urea, or urea ensiled with corn to bring total dietary N to 12.5% CP has been established. Increasing dietary N resulted in a considerable increase in bacterial numbers, ranging from 90% for urea to 230% for urea silage or soybean meal. The greatest increase was noted for those bacterial species known to require branch chain volatile fatty acids for optimum growth *in vitro*. It was concluded that urea ensiled with corn was as effective as soybean meal in supporting production of bacterial protein in the rumen. These studies are now being extended to higher levels of dietary N.

Methods have been developed for the selective isolation of the rumen bacterium *Butyrivibrio fibrisolvens* and for the labeling and isolation of plasmid DNA from this species. The general occurrence of plasmids in this species has been established, providing the first evidence for a role for plasmid-determined characteristics in the rumen fermentation.

SWINE PRODUCTION PROGRAM

Development and maintenance of a minimal-disease herd for intensive research

The minimal-disease herd established in 1977 is entering its fifth generation and continues to be free from rhinitis, virus pneumonia, internal and external parasites, leptospirosis, transmissible gastroenteritis, erysipelas, and parvovirus. Ninety bred, minimal-disease gilts were supplied to the University of Guelph and thirty-four to the University of Saskatchewan to assist in the establishment of their minimal-disease herds. Periodic performance checks on gilts and boars from the Animal Research Centre over the growing period of approximately 20–90 kg, indicate average daily gain and feed-to-gain ratios of 0.79 and 0.85 kg, and 2.60 and 2.53, respectively.

Energy and protein requirements for pregnancy in the once-bred gilt

A daily feeding level of 1.40 kg during early gestation followed by restriction to 0.45 kg for the last 30 days of gestation is required to produce a postpartum gilt carcass within the market weight range. This degree of

restriction results in reduced piglet birth-weight; however the carcass is of adequate composition and acceptability.

Nutrition and management of the neonatal pig

Under a research contract with the University of Guelph, the requirement of the very young pig for lysine, methionine, threonine, and histidine was found to be 12.0, 2.7, 6.0, and 4.5 g/kg diet, respectively. Work is continuing to establish the methionine-cystine and phenylalanine-tyrosine interrelationships.

The feasibility of using fish protein concentrate to replace a portion of the milk protein in piglet milk replacers is being examined. Preliminary results indicate that it can supply up to 20% of the protein and result in improved growth performance.

Initial data on the effect of a modified farrowing system, which automatically removes piglets from the sow at birth, on subsequent piglet viability indicate that suckling can be delayed for up to 10 h postpartum without visible effect upon the pigs.

Studies on a continuous-flow technique for the separation and concentration of porcine γ -globulin from abattoir blood continued with the development of a system based on differential precipitation of proteins using ammonium sulfate, coupled with continuous-flow centrifugation, electrodialysis, and spray drying with condensed milk.

Relationship between backfat thickness and total body fat in boars

The relationship between backfat thickness and total body fat is being assessed to establish if selection for decreased backfat thickness has in fact resulted in reduced total body fat or merely resulted in a shift in fat deposition from the subcutaneous depot to the abdominal cavity or intramuscular depots.

Reproductive physiology

The presence of immunosuppressive factors, which may play an important role in the establishment of pregnancy, have been reported by Australian workers in sheep. Research at ARC did not confirm the appearance of such a factor early in pregnancy in the pig. Studies were initiated to assess the possible role in immunosuppression of α -feto-protein, which is synthesized specifically by the fetal yolk sac and liver.

The occurrence of estrone sulfate in pig plasma after day 18 of pregnancy is a positive indicator of pregnancy. The plasma concentration of estrone sulfate is directly related to the number of viable fetuses in the pregnant pig.

POULTRY BREEDING PROGRAM

Genetics of poultry meat production

The development of genetic techniques to reduce obesity and to improve feed conversion of meat-type chickens continued with a search for predictors of carcass composition. Broiler body weight was the best predictor among live body measurements for total amounts and percentages of chemical components of the carcass (fat, protein, moisture, ash). Shank length and breast depth were somewhat useful, the latter being indicative of chemical component proportions. Nevertheless, the live measurements, considered individually or as a whole, did not predict carcass chemical composition with sufficient accuracy to allow their effective practical use in indirect selection for improved carcass quality.

Carcass weight or specific gravity or both were the best traits for predicting chemical component weights; however, carcass specific gravity was a better predictor of chemical component percentages. Specific gravities of carcass parts were not superior to specific gravity of the whole carcass for predicting carcass chemical composition. From the statistical analyses of the specific gravity data it was concluded that carcass specific gravity can be used for prediction of the chemical composition of groups of carcasses but it is not suitable for evaluation of individual carcasses.

Broiler feed conversion was tested on a weekly basis from 2 to 7 wk of age to determine the optimum test age and duration. Correlations between successive weekly feed conversion measurements were low (0.3 or less), and it was concluded that a 3-wk test interval at or near the end of the broiler growth period should be used to appraise efficiency of feed utilization.

'Sire' and 'dam' genetic base populations have been synthesized from 16 primary commercial breeder strains. The commercial stocks employed represent a unique assembly of contemporary genetic stocks used in the production of broiler chickens throughout the world. Besides the synthesis of the base populations for projected selection research,

data from the stocks were used to assess the variation available for future improvement of the world's broilers. For example, a study of the effects of strain and age of male (39 versus 59 wk) on hatching egg fertility and hatchability revealed only strain differences for duration of fertility. Within strains, differences among individual males were significant for all fertility traits, and fertility was also influenced by the age of the males. Hatchability declined between 39 and 59 wk of age of the males. Generally, the large variation among males within strains and the small variation among strain means implied that there is little additive genetic variation in the traits tested. This was consistent with the low heritability usually reported for such traits. Rapid decline of fertility observed after the eighth day postinsemination discourages the use of successive insemination intervals of more than 1 wk.

Selection studies in egg production chickens

Six strains have been under selection for high egg production and other economically important traits for up to 28 generations. The six strains performed well for hen-housed egg production, averaging from 234 to 264 eggs. For the hatch years 1971–1978, the selected strains had an average genetic gain of 18 eggs compared with unselected control strains maintained in parallel. The strains selected for hen-day rate of egg production from age at first egg to 273 days of age had later sexual maturity and higher rate of lay in the latter part of the laying year than the strains selected for hen-housed egg production to 273 days of age. However, the strains selected for hen-housed egg production had lower mortality to 273 days of age than the strains selected for hen-day rate of egg production. For the hatch years 1971–1978, the selected strains had average genetic gains of 2 g in egg weight, 3 Haugh units (albumen quality), 2 units in egg specific gravity (shell thickness), and 1% fewer blood spots. The selected strains maintained good performance levels for fertility and hatchability, averaging 95% and 86%, respectively.

Reconstitution of the above selected strains from inbred lines originally derived from these strains between 1970 and 1976, and selected for resistance to Marek's disease and high egg production, has been completed. Three such 'resistance-selected' strains are

now being compared with the original long-term selected strains to assess the efficacy of the new technique for simultaneous improvement of disease resistance and production.

Eggshell quality

Even after implementation of recommended management procedures, egg breakage causes serious economic losses to the producer, especially in older flocks. A study of the plasma levels of estrogens at 20 h after oviposition and of plasma calcium levels 6 h after the next oviposition indicated no relationship between the two parameters in 36-wk-old birds versus a positive relationship in 59-wk-old birds. This suggests that estrogens influence plasma calcium levels more in older birds, where shell quality is a bigger problem, than in young birds. After hens older than 60 wk had been immunized and had developed antibodies against the estrogen estradiol, these hens laid more shell-less eggs than nonimmunized hens. Thus estradiol seems to play a role in shell deposition.

Studies were initiated on an energy-related enzyme, ATPase, of the hen's uterus and its relation to shell quality. In two Leghorn strains, preliminary results indicated greater ATPase activity in the strain with better shell quality.

A polyurethane foam pad placed on the laying cage floor to reduce the impact when an egg is laid did not influence shell strength compared to eggs laid on the wire floor of laying cages. This indicated that the initial impact the egg receives when laid on the wire floor does not negatively influence the subsequent shell strength.

Disease-resistance genetics

Cooperative work with the Animal Diseases Research Institute in Ottawa on the effects of subclinical lymphoid leukosis, an egg-transmitted viral lymphoproliferative disease, on production in chickens was extended from layers to meat-type chickens. A reduction by up to 28 eggs in egg production per hen housed and an increase by up to 29% in mortality from causes other than lymphoid leukosis was observed in the lymphoid leukosis virus-infected meat-type birds, thus confirming similar findings reported earlier from Leghorns. In addition, meat-type chickens, crosses of dam lines in which lymphoid leukosis virus infection was detected, had the

mean broiler-age weight 5% lower than their test-negative counterparts.

Examination of the effects of lymphoid leukosis and diseases in general on variation resulted in the derivation of a formula for the estimation of the increase of variance in populations affected by disease. Egg transmission of the disease resulted in an increase in heritability estimated from dam variance components. The effect of the disease on sire heritability was small.

Green muscle disease appears to be a physiological problem of meat-type poultry such as adult meat-type chickens and turkeys. It occurs as a degeneration of the deep-laying breast muscle and cannot be positively identified by inspection of the live animal. Of serious concern is a 1980 report that green muscle disease has been identified for the first time in broiler-age stocks. Postmortem examination of birds between 49 and 68 wk old of both sexes from 20 commercial broiler breeder stocks, including both male and female parent strains, showed levels of the disease to be 0–43% in males and 0–22% in females. Research is continuing on economic and practical methods of identifying birds that are susceptible to this disease.

Geese

Four strains of geese, namely Hungarian, Pilgrim, Chinese, and a crossbred strain formed from these three breeds, were reproduced and compared for carcass weight and down and feather yield. Preliminary analyses indicated that Hungarian geese had the lightest carcass, whereas the other strains were similar to each other. Chinese geese had the lowest total feather yield.

POULTRY NUTRITION PROGRAM

Laying hens

A phase-feeding program for winter-housed White Leghorn hens reduced feed costs by saving 4.2% of the total protein consumed. The dietary protein level was reduced from 15.6 to 14.8% at 273 days of age and then to 14.0% at 384 days of age without decreasing percent hen-day egg production. Egg quality was also improved when compared with feeding a diet of constant protein content (15.6%). The number of visibly cracked eggs decreased and fewer eggs of extra large grade were obtained during the last 16 wk of the

laying year, when oversize eggs cause problems to the producer. Internal egg quality, as determined by Haugh units, was slightly higher for phase-fed hens, but there were no consistent effects of diet on incidence of egg blood spots nor on hen body weight or mortality.

Meat-type birds

Skip-a-day feeding procedures commonly used to control feed intake of chickens are too hazardous for use with young chicks under 21 days of age. A restricted feeding regimen consisting of 5% dietary hydrolyzed coconut oil fed from 1 to 21 days of age was imposed on broiler breeder replacement chicks prior to skip-a-day feeding. This resulted in higher hen-day percent egg production and greater efficiency of feed utilization than for broiler breeder hens, which were restricted as chicks by only skip-a-day feeding from 21 days of age. Egg weight was higher among hens restricted from 1 day of age.

Broiler breeder hens of two breeds exposed to a stimulation lighting program providing a rapid increase in daylight from 6 to 16 h of light per day between 139 and 168 days of age reached 50% egg production at an earlier age and had higher hen-day percent egg production than hens exposed to a slow increase to the same daylight duration between 139 and 245 days of age. Rapid change in day length was associated with smaller egg size, which was apparent also in a reduced percentage of eggs of incubation size. Lighting treatment had no effect on body weight or mortality.

Blood calcium and eggshell strength

Correlation coefficients indicated that there was no relationship ($r = -0.13$ to 0.18) between either whole blood ionized calcium or plasma total calcium of hens and specific gravity, nondestructive deformation, or quasi-static compression fracture strength of their eggs. The blood samples were obtained from force-molted hens that consistently laid eggs of low or high specific gravity.

Measurement of metabolizable energy

The metabolic plus endogenous energy and nitrogen losses of cockerels were independent of the amount (0–30 g) of fiber as cellulose or sawdust placed in the crops of fasted birds. This justifies the use of unfed negative control birds in the true metabolizable energy (TME)

and true available amino acid (TAAA) bioassays.

A comparative study showed the TME bioassay to be superior to a rapid metabolizable energy assay reported in *Br. Poult. Sci.* 19:303; 1978. Training birds to consume their ration within 1 h was not wholly successful, and even trained birds reduced their feed intakes when assay diets were introduced. The high variability in feed intake caused variation in metabolizable energy values, which could be controlled by making a correction for metabolic plus endogenous losses as is done in the TME assay.

Zinc deficiency and feed intake of chicks

Chicks fed a zinc-deficient diet grew as well as those fed an adequate diet when zinc sulfate was administered via the crop. However, chicks fed the adequate diet grew no better than deficient chicks when pair-fed. Although zinc may be involved in taste-bud formation and function, there was no evidence that zinc deficiency expresses itself by reducing diet palatability.

SHEEP PRODUCTION PROGRAM

Establishment of a minimal-disease flock

In order to start a minimal-disease flock, repopulation by hysterectomy of the entire ARC sheep flock was undertaken. Eradication of the debilitating disease, Maedi Visna, as well as the potential to eliminate other troublesome diseases such as pneumonia and sore mouth, should result in improved efficiency and economy of the intensive confinement system being developed. Special breedings for the hysterectomy project were designed to maintain the genetic base. Hysterectomy was performed on 1110 ewes producing 2336 lambs of which 1.4% were dead in utero. Of the 2304 lambs alive in utero, 92.6% survived the recovery process. Of those, 87.3% were weaned at 21 days of age from milk replacer and 78.6% survived to 70 days of age.

Development of synthetic sire and dam strains

Based on previous research and management experience, an estimate of the productivity that can be obtained by using the intensive system in a good commercial operation was summarized. For every 100 adult

ewes mated, with 5% death loss and 90% fertility, 86 would lamb. With a litter size of 2.45, 211 lambs would be born, 180 would be weaned, and 169 raised. The ewes would lamb at 8-mo intervals and with an average of 1.5 lamb crops per ewe per year; overall expected productivity would be 253 lambs raised per year per 100 adult ewes mated.

An economic study by the University of Saskatchewan indicated that a confinement system of lamb production can hold its own against traditional methods, although it does not yet present a clear advantage in terms of net farm income. The total confinement system being developed by the ARC research program provides an effective tool for obtaining information and results that are applicable to any degree of intensification chosen by a producer.

Artificial insemination

Research has shown that the use of progestagen to induce a synchronized estrus is necessary for the practical application of artificial insemination (AI) in sheep. Pregnant mare's serum gonadotropin (PMSG) to improve synchronization of ovulation is essential for good fertility when using AI.

Studies have continued on the use of pharmacological agents to improve sperm transport in the ewe reproductive tract in order to increase the fertility achieved with frozen semen and to reduce the number of sperm required with fresh or frozen semen. Estradiol-17 β , which was reported to facilitate sperm transport, did not improve fertility in ewes inseminated with frozen semen but did increase early embryonic mortality.

New diluents containing dextran in combination with buffers, sugars, and glycerol resulted in greater survival of frozen sperm in both straws and pellets and in increased fertility compared with commonly used diluents. Hypertonic skim milk diluents at 600 and 750 mOsm/kg provide adequate protection during freezing and thawing, and good fertility. The effects of penetrating cryoprotectants on sperm survival were evaluated. Glycerol at concentrations of 4–6% were found to be optimal using medium cooling rates. Dimethylsulfoxide, on the other hand, did not result in acceptable survival regardless of concentration or cooling velocity.

Straws thawed in water at 39°C resulted in significantly greater sperm survival than when they were thawed at room temperature. When

ram semen is frozen in pellets on dry ice, sperm survival is affected more by pellet geometry (ratio of area exposed to dry ice to volume) than by pellet volume.

Studies on seasonal variation in ram semen freezability showed that semen collected in early spring contained a larger proportion of abnormal sperm, but its freezability was comparable to fall-collected semen. Freezability decreased during the summer months. However, the effect of the ram on freezability appeared to be greater than the effect of the season.

Controlled lamb production

Supervised field trials have been carried out in Ontario to evaluate controlled lamb production under commercial flock conditions using progestagen impregnated intravaginal sponges to synchronize estrus followed by PMSG injections. Estrus was induced within 48 h after sponge removal in over 90% of ewes treated, irrespective of the breed used and the month of the year the treatment was applied. When adult ewes were bred after sponge treatment during August–November, 65% lambed to breeding at the synchronized estrus and a further 22% lambed to the follow-up estrus, which was comparable to that of untreated ewes during exposure to rams for 35 days. The treated ewes lambed over two distinct periods of 5 days. When adult ewes were bred after sponge treatment in April–May, the lambing results appeared to be dependent on the breed used and more specifically upon ram performance and the quality of semen produced. The use of AI in field trials with commercial flocks was initiated during the anestrus season using procedures developed at ARC. The results provided further indication that greater emphasis must be placed on management rams during the nonbreeding season to obtain good semen quality.

The results to date indicate that the progestagen sponge treatment can be applied successfully under commercial flock conditions. Similar field trials are under way in Newfoundland.

Pregnancy diagnosis

Results from several trials on ultrasonic pregnancy testing, using two commercially available instruments, indicated approximately 90% accuracy in diagnosing pregnant ewes at between 7 and 8 wk after conception.

Earlier testing may be useful, but will result in a higher proportion of false negative diagnoses, which must be retested later in gestation for accurate confirmation.

ANIMAL FEED SAFETY AND NUTRITION PROGRAM

Mycotoxins

Mycotoxins are produced by molds on plant crops in the field and during storage. When ingested by livestock and poultry, decreased performance or deleterious health effects or both may occur. Research efforts on mycotoxins continued to emphasize work on the toxicology and nutritional effects of the mycotoxin zearalenone (Z), although research included studies of other mycotoxins of concern to the Canadian agricultural community.

The development of a rapid, sensitive, high-performance liquid chromatographic method for detection of Z and its metabolites in blood enabled further research on the absorption, metabolism, and elimination of Z. When a single oral dose of Z was administered to young female pigs, free Z could be detected in the blood within 10 min. Free Z blood levels peaked within 30 min after dosing and returned to nondetectable levels by 24 h.

Vomitoxin (V) contamination of grain crops was of concern to the agricultural industry and health authorities in 1980. Pink discoloration typical of mycotoxin-producing mold was noted on the harvested crop of white winter wheat. V was detected in samples collected from various areas in Ontario. In collaboration with industry, samples were screened for mycotoxins, and a series of feeding trials to determine the effects of V on swine and poultry were initiated.

A preliminary report of a research contract with the Sibbald Group documented cases of ill effects in farm animals fed mycotoxin-containing feedstuffs and described facilities available in Canada where mycotoxin analysis can be carried out.

Cooperative work continued with Biosystematics Research Institute to establish a relationship between the mycological profile of a cornfield and resultant toxin levels. *Fusarium* molds have been isolated that are capable of producing Z, T-2 toxin, and diacetoxyscirpenol toxins under laboratory conditions.

Rapeseed oil nutrition

Male rats fed diets rich in fat for at least 4 mo develop myocardial necrosis. The incidence of this necrosis varies, depending on the type of fat or oil fed. Previous studies with swine, monkeys, and female rats at ARC and elsewhere have not been able to show a relationship between pathological lesions and the amount or source of fat in the diet. As a consequence, work is focusing on the peculiar cause of heart lesions in male rats. Specific cardiotoxins as well as erucic acid have been eliminated as the primary cause of the problem largely based on previous ARC studies.

Several investigators have observed that certain fatty acids were associated with a high, others with a low, incidence of heart lesions. A statistical analysis of published data on heart lesions in male rats identified a correlation between dietary fatty acids and heart lesions. Most of the variation within experiments could be explained by the level of saturated fatty acids and linolenic acid with their effects similar in magnitude but opposite in direction.

The statistical study provided a model to test the effect of several dietary fatty acids. Soybean and low erucic acid rapeseed (LEAR) oils were selected because both contained linolenic acid. The same level of saturated fatty acids in the form of cocoa butter was added to the oils. An equal amount of a synthetic triolein was added so that the addition of cocoa butter would not dilute possible cardiotoxins in the oil. The cardiopathological results showed that both soybean and LEAR oils developed a high incidence of heart lesions when fed to male rats. The incidence of lesions was significantly reduced by the addition of saturates, whereas the addition of triolein had no effect. These results do not support the hypothesis that the two vegetable oils contained cardiotoxins. Because both dilutions were identical, a similar reduction would have been expected if these lesions were caused by cardiotoxins in the oil. The results show that saturated fatty acids significantly reduced the incidence of heart lesions, even in the presence of linolenic acid. When oleic acid was added to the diet, there was little cardiopathogenic response, as predicted by the results of the statistical analysis.

These results provide experimental evidence that the heart lesions are related to the balance of dietary fatty acids. Studies are in

progress on male rats fed the test oils to relate the cardiopathogenicity observed in the rats to the absorption of specific dietary fatty acids and the resultant cardiac lipid changes.

Pesticide metabolism

Atrazine. Combined in vitro and in vivo studies in a cooperative project with the Chemistry and Biology Research Institute suggest that in the chicken, metabolism of atrazine proceeds mainly by partial *N*-dealkylation accompanied by hydrolysis. Further research indicates that the formation of 2-hydroxy, partly *N*-dealkylated metabolites occurs by the hydrolysis of the respective 2-chloro metabolites rather than by partial *N*-dealkylation of hydroxyatrazine.

Tetrachlorvinphos. In vivo studies with laying hens revealed that approximately 71% of the daily oral dose of ¹⁴C-labeled insecticide was eliminated via the excreta within 24 h. Radioactivity in parts per billion was also detected in eggs, tissues, and organs, but it gradually declined after dosing ceased. A metabolic pathway was postulated for tetrachlorvinphos in chickens.

Trichlorfon. A quantitative gas chromatographic method was developed for the analysis of trichlorfon, desmethyl trichlorfon, and dichlorvos in biological samples. The method involves silylation of extracts of the compounds with Tri-Sil followed by detection and quantitation of the derivatives by gas chromatography.

Fenvalerate. Preliminary data from in vitro studies indicated one or more enzymes in the crude preparation from chicken liver homogenates that produced at least two metabolites, which would have resulted from hydrolysis at the ether linkage. An in vivo trial in laying hens indicated that consumption of the insecticide at 100 ppm did not produce significant changes in egg production, body weight, or feed consumption. No adverse toxicological effects were noted. Radioactivity could not be detected in eggs. Approximately 100% of the total administered dose of ¹⁴C-fenvalerate had appeared in the excreta by 144 h after the seventh and final daily dose.

Cypermethrin and decamethrin. Cypermethrin, its optical and geometrical isomers, six possible metabolites, and ring-labeled ¹⁴C-cypermethrin have been synthesized. Spectroscopic and physical data for each compound has been collected. Similar work is proceeding

on the synthesis of decamethrin and its metabolites. The compounds and data will assist in the identification of residues and

metabolites of these synthetic pyrethroids in biological samples from in vivo and in vitro studies.

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Postgraduate Theses

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Carnegie, J. A., Ph.D. Thesis. 1980. Studies on the early ovine conceptus. A combined ultrastructural and histochemical investigation of the day 12 to 16 blastocyst and the immunofluorescent localization of ovine chorionic somatomammotropin in the day 14 to 55 trophoblast.

Gill, D. V., Ph.D. Thesis. 1980. The biosynthesis of estrogens and androgens by the developing chicken (*Gallus gallus*) embryo.

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INTRODUCTION

This report summarizes highlights of research carried out during 1980 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 only. 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 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 1980; 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

Biological control of the onion maggot. Modification of laboratory mass-rearing techniques permitted production and storage of more than 100 000 pupae of *Aphaereta pallipes*, a braconid parasite of onion maggot larvae. Laboratory and field-cage experiments showed *A. pallipes* to be an effective parasite. Initial release of approximately 50 000 parasites at each of two locations on the Thedford Marsh showed that the parasite survived and dispersed in the field and successfully parasitized at least some of the onion maggots in the

field at that time; release of parasitized onion maggot pupae proved more effective than field release of adult parasites. A comparison of three onion growing sites (Holland, Keswick, and Thedford marshes) with the Centre's field station regarding parasite-predator numbers of onion maggots showed that parasite and predator numbers were generally highest where insecticide spraying was least and hedgerows (as a cover) were available. An aestivation pattern in onion maggots was statistically identified, which suggests that some onion maggot pupae from each generation may arrest development for up to 1 yr. Consequently, there is always a small population of onion maggots emerging as a 'background' throughout the growing season.

Massive invasion by numerous predators and parasites resulted in collection of less than 50% of the projected goal of 2 000 000 onion maggot pupae from mass bed culture at the Centre's field station. A new site, 20 km from the station, has been established to evaluate productivity in 1981.

A bioassay procedure for assessing the toxicity of insecticides to the parasites was devised and some base-line data were accumulated.

Monitoring studies. In 1980 pairs of flight interception traps were set up at four locations on the Thedford Marsh, and populations of the onion maggot fly were monitored from April to November. Collected information was summarized and passed by Ontario Ministry of Agriculture and Food (OMAF) information bulletins to local growers, who then successfully modified spray programs according to population pressure.

Monitoring for the two strains of corn borer in Quebec allowed an accurate forecast of severe corn borer damage in field corn. Information on the timing of insecticide applications was rapidly given to farmers, and severe losses were averted.

Evaluation of a pheromone for monitoring populations of the common armyworm was extremely helpful in forecasting damage by this cutworm around North Bay, proving to be more useful than the degree-day method proposed by other workers.

It was demonstrated to extension personnel, canning companies, and fresh-market vegetable producers that pheromone traps efficiently monitored populations of corn borers, armyworms, and cutworms, and that better control could be obtained at a lower cost. Thus, in a 4-ha area, one fresh-market sweet-corn producer was able to effect a saving of more than 50% over a 2-yr period by using pheromone traps to time carbaryl applications for the control of corn borers.

Toxicity-resistance studies. Accumulation of base-line toxicity data for a number of organochlorine, organophosphorus, carbamate, and pyrethroid insecticides on onion, cabbage, and seedcorn maggots and the dark-sided cutworm was completed. Selection of a carrot rust fly strain from the Holland Marsh, with carbofuran, over nine generations indicated no increase in tolerance. Tests on a Michigan strain of onion maggot indicated that parathion resistance had increased by approximately $\times 15$ in 1980 ($\times 10$ in 1975;

$\times 5$ in 1972). Fonofos resistance increased from $\times 5$ in 1972 to $\times 10$ in 1980. Results obtained with this field strain were in good agreement with our laboratory selection program, which indicated that although parathion resistance develops quite rapidly, resistance to fonofos seems to develop more slowly. Studies on the resistant strain of the Colorado potato beetle (CPB) were completed. The Quebec CPB strain was resistant to all but two of the insecticides (permethrin, aldicarb) currently recommended. Tests conducted in cooperation with the pesticide industry indicated that the CPB in the Leamington and Alliston areas of Ontario is beginning to show the first indications of resistance to organophosphorus, carbamate, and pyrethroid insecticides. In cooperation with the University of Guelph, studies were continued on the development of multiple resistance to insecticides by the house fly. Base-line toxicity data were obtained on 32 insecticides; one house fly strain was resistant to all insecticides tested. At the request of the Food Production and Inspection Branch, Japanese beetles collected near Dunnville, Ont., were determined to be still susceptible to chlordane, thus allowing the Plant Quarantine Division to initiate an eradication program.

Evaluation of pesticides. Studies continued on the evaluation of new insecticides for control of agricultural insect pests; seven experimental insecticides submitted by chemical companies were evaluated in laboratory tests. Most were effective contact insecticides with broad-spectrum activity; none, however, showed promise as soil insecticides.

Chitin inhibitors such as diflubenzuron and Bay SIR 8514 have been tested and registered for several applications as alternatives to classical insecticides. Microplot evaluation of these materials for control of root maggots that attack onions, rutabagas, and radishes was carried out with mixed results. Other microplot trials showed the synthetic pyrethroids to be inadequate alternatives to parathion for control of root maggots attacking radishes. Further microplots were established to provide soil and crop samples to determine persistence of insecticides, including fenvalerate, carbofuran, aldicarb, isofenphos, isazophos, fenbutatin oxide, and the herbicide niclofen in mineral and muck soils. Information thus obtained is used for the support of initial or continued registration of these materials for commercial use.

Analytical studies. The long-term stability of carbofuran and 3-hydroxycarbofuran in freezer-stored chloroform extracts of acid-digested onions was demonstrated. A procedure was developed for the conversion of the phenolic degradation products of carbofuran and its metabolites to the corresponding *N*-nophyl carbamates without affecting the nonphenolic compounds. Final results on the persistence of CGA 12223 in mineral soil confirmed that it was a relatively nonpersistent compound like chlorpyrifos. Oxamyl and trichlorofon were found to be the most susceptible to alkaline hydrolysis of the 24 compounds so far examined in the effect of pH on hydrolysis study. Methomyl and aldicarb were only slightly hydrolyzed. Techniques were developed using high-pressure liquid chromatography (HPLC) for the analysis of dimilan and SIR 8514 in soil at 0.1 ppm and to at least 0.5 ppm in radishes, turnips, and onions.

Stored products

Increasing concern over the toxicological properties of many of the fumigants, together with emerging resistance problems, has led to the need for research on integrated methods of control aimed at delaying the onset of resistance and the use of controlled atmospheres. Mixtures of the two main fumigants used in Canada, methyl bromide and phosphine, have been found in certain ratios to have increased toxicity over that expected from a summation of each material alone. This synergistic action is of considerable interest for its potential practical application in terms of reduced dosages and shorter exposure times. The combination of the fumigants that appeared to give best control was in the ratio of 100:3 for methyl bromide – phosphine.

In an investigation of fumigants for the control of overwintering eggs of the European red mite on harvested apples, ethylene dibromide and carbon dioxide were found to give control at levels that caused no injury or off-flavor to the fruit. Other fumigants such as methyl bromide and hydrogen cyanide caused injury without controlling the mites. Carbon dioxide is a safe, effective agent for controlling mite eggs and other pests on harvested apples.

In the continuing studies on the mechanisms of resistance of the granary weevil to methyl bromide, the detoxification products

formed have been identified as *S*-methylglutathione, *S*-methylcysteine, and *S*-methylglutathione sulfoxide. The resistant insects had more glutathione than normal insects and they produced the metabolite *S*-methylglutathione sulfoxide not found in susceptible insects. Thus, in the metabolism of methyl bromide by the granary weevil, glutathione *S*-transferase-catalyzed conjugation with glutathione is a major detoxification pathway, and tolerance for this fumigant is related, at least in part, to the level of glutathione in the insect. These results hold out hope that the chemicals that deplete glutathione or inhibit glutathione *S*-transferase should synergize methyl bromide.

Phosphine is widely used for fumigation of cereal exports, and during the past year sorption and desorption of phosphine from cereal products was studied. A method was developed for analyzing very low concentrations of phosphine at ambient temperatures to upgrade procedures for detecting and measuring this fumigant in the working environment, especially for ships in transit. The simplified method developed can be used to measure concentrations of 10–100 times lower than those detected by present-day procedures.

Alternate pest control strategies

Plant diseases. A collaborative project with Harrow Research Station yielded some interesting results and the promise of further developments. The zoospore-soybean hypocotyl inoculation procedure that was developed here previously was adapted for studies of the genetics of resistance in soybean lines and crosses. The method provides advantages over methods currently used by soybean breeders throughout the world in that wounding is not required and a range of symptom intensity can be documented as opposed to the extremes of 'dead' or 'alive' provided by other, cruder procedures. Comparisons of soybean lines containing the *Rps*₁, *Rps*₂, or *Rps*₃ genes for resistance or the corresponding susceptible alleles indicated that the genes mediated significant differences in such symptom characteristics as lesion size, extent of necrosis, and glyceollin production. There was a differential in the effect of temperature, in that increased lesion size occurred with susceptible alleles but not with resistant alleles. Furthermore, the study has demonstrated for the first

time that races of the pathogen differ significantly in their aggressiveness against individual resistance genes. The results also showed that the background genotype can modify the response of a particular gene. There are indications that other factors, such as light and temperature, may also differentiate between Rps genes. The work, in fact, has many potential ramifications that should lead to a better understanding of the mechanism of gene action in resistance and susceptibility and eventually to the development of improved methods of control.

In experimental studies with the University of Western Ontario, $^2\text{H-NMR}$ (nuclear magnetic resonance) spectroscopy was used to demonstrate that the incorporation of three molecules of 4,4-dideuteriomevalonic acid into capsidiol proceeds with a loss of three deuteriums and migration of one. This largely confirms the predicted, favored biosynthetic route to this phytoalexin and eliminates others from further consideration; it is also the first instance in which such a hydride shift has been demonstrated for a *cis*-decalin system and only the second time for any eremophilane. Also in collaboration with the University of Western Ontario, the $^{13}\text{C-NMR}$ methodology was used to show that in potatoes, dihydrolubimin is a precursor of isolubimin and not the product of its metabolism, as claimed in the literature. In kinetic studies, it was shown for the first time that the long-known presumed phytotoxin, alternaric acid, from *Alternaria solani*, is formed in the trophophase and therefore is not a typical secondary metabolite.

Insect pests. Research in this area is directed toward gaining an understanding of basic life processes in the insect so that methods of selective, specific control can be developed that do not rely upon pesticides that are broad-spectrum poisons. A method was developed for the rapid and effective enrichment of cell and mitochondrial membranes with several types of phospholipids. This enrichment had a marked effect on membrane fluidity, which in turn had a striking effect on the ability of certain model pesticides to induce the transport of potassium ions across the enriched membrane. In general, membranes of low fluidity were refractory to the effect of DDT, but this effect was overcome by the synergistic action of piperonyl butoxide. The development of this model

system may provide clues as to the mechanisms of resistance, selectivity, and synergism.

Studies were continued that were aimed at assessing the status of the proctolin system as a potential site around which new pest control programs might be developed. Because the potent neuropeptide proctolin rapidly disappears from the hemolymph of the American cockroach, *Periplaneta americana*, in vivo, initial studies were directed to the mode of inactivation. By using enzymes from cockroach gut, experiments with synthetic [$^{14}\text{C-Tyr}^2$]-proctolin and unlabeled proctolin showed that the in vivo hydrolytic pathway differed from the in vitro. HPLC methods were developed to permit the separation and analysis of the products formed. The D(-)-isomer of the neurotransmitter octopamine was shown to be the one present in the nervous system of insects. This finding contributes to other studies by removing the uncertainty in a radioenzymatic assay of octopamine, which gives values for the D(-)-isomer that are 40 higher than for the L(+)-isomer.

Systemic fungicides. Of importance was the finding that molecular selection for mutated, carboxin-resistant succinate dehydrogenase complexes was influenced by replacement of the oxathiin by a thiophene heterocyclic ring and by the substitutive group on the amide nitrogen, thereby permitting different categories of carboxin-resistant mutant types of *U. maydis* (corn smut) and even mutants within a single category to be distinguished from one another. Thus, with all the structural combinations available, it appears quite possible, in terms of inhibition, to overcome any type of mutation in a fungal succinate dehydrogenase complex that arises through selection by carboxin or by other commercially used carboxamides.

A detailed study of the anatomy and pressure-flow characteristics of the roots of *Zea mays* was completed to provide clues as to the routes and the mechanism of uptake of water and solutes. Such information is important in the study of the uptake and translocation within the plant, not only of normal nutrients but also of agriculturally important compounds such as herbicides and systemic fungicides and insecticides. A mechanism has been proposed that predicts, with considerable accuracy, the flow rates of water and the concentration profile of solutes across the root as a function of the hydrostatic pressure.

Further studies have been made of the ability of the systemic fungicide Ridomil® applied to soybean seedlings to cause a response similar to natural resistance when the seedlings are inoculated with *Phytophthora megasperma* var. *sojae*. This can be brought about with applications of as little as 1 ppm to the roots. The phytoalexin glyceollin is produced in these reactions. To determine the relative contribution of the phytoalexin and the fungicide to inhibition at the site of inoculation, it was necessary to determine the concentration of Ridomil® in the infected tissue. A bioassay in which thin-layer chromatography is used was therefore developed that permits the detection of as little as 25 ng of the fungicide in the tissue.

ENVIRONMENTAL TOXICOLOGY

Effects of pesticides on nontarget organisms

Work continued on the effects of pesticides on populations of microorganisms and activities of enzymes in soils. In clay loam soil a decrease in microbial numbers was observed with some fungicide and fumigant treatments; recovery was rapid, however, and stimulatory effects were evident in many cases. None of the pesticides inhibited urease and dehydrogenase activities. Phosphatase activity was not inhibited except in the case of some fumigants. A temporary decrease in dehydrogenase activity was also observed in many cases. Enzymic activities in organic soils decreased temporarily after the addition of some pesticides. Activities of most of the soil enzymes were negatively correlated with the rate of pesticide application during the early stages of the experiment.

A collaborative study with the personnel of Delhi, Vineland, OMAF, and the chemical industry on undefined stunting of tobacco was completed. Information on the control of field stunting of tobacco was included in the 1980 OMAF publication 298. Work continued on the development of thiram-resistant strains of *Rhizobium japonicum*. These new strains were found to be weak in nitrogen-fixation activity, although growth and adaptation of thiram-containing media were improved substantially by the rhizobial nuclear conjugation technique. Treatment of alfalfa seeds with five broad-spectrum fungicides was examined regarding effect on rhizobial activity and germination. Results showed that captan, maneb, and thiram exhibited greater toxicity

to *Rhizobium meliloti* and alfalfa plants than do benomyl and zineb. At practical concentration levels, effects were minimal and recovery of the inhibitory effect was rapid. At lower concentrations, marked growth stimulation was observed with some fungicides. Studies were completed on the role of soil microorganisms in the degradation of the insecticides phorate and its metabolites (sulfone and sulfoxide) and carbofuran and its metabolites (2-hydroxycarbofuran and 3-ketocarbofuran) in sterile and fresh mineral and organic soils. A drastic reduction of soil fungi with repeated applications of Vorlex and linuron resulted in eventual linuron accumulation in muck soil, which was shown to be deleterious to the growth of Grand Rapids lettuce under laboratory conditions. Experiments on carbofuran persistence in natural and sterile mineral and organic soils showed that carbofuran persisted for 8 wk in natural loam and for 16 wk in natural muck. The 3-hydroxycarbofuran, the major metabolite found in plants, has not been detected to any extent in soils. The reason for this became apparent with the discovery that the 3-hydroxycarbofuran had disappeared in soil within 1 wk. Repeated experiments with incubation of 3-hydroxycarbofuran in natural soils showed that it disappeared within 2-3 days with a concomitant reduction of 3-ketocarbofuran. The 3-ketocarbofuran disappeared in 3 days from natural loam but persisted for more than 7 days in muck.

Environmental studies

A cooperative research project was completed on the behavior of fensulfothion, its sulfide, and sulfone in soil-water systems. The least soluble sulfide adsorbed the most and desorbed the least on the four adsorbents studied. Although the sulfone was less than 1/25 as soluble as fensulfothion, corresponding differences in adsorption by the mineral soils were not found. In another study, solubility values for 11 insecticides were related to LD₅₀ values for crickets in moist and dry soils. Because of the large differences in inherent toxicity to the crickets (direct contact), there was not a good correlation between solubility and toxicity. However, when the LD₅₀ values in the soil were corrected for their inherent differences in toxicity (LD₅₀ moist soil : LD₅₀ contact), an excellent correlation between solubility and corrected toxicity emerged. There was also a very good

correlation between solubility and the ratio of the LD₅₀ values in moist and dry soils. This finding provided some insight into the relationship that exists between the solubility of an insecticide and the amount that its toxicity changes between wet and dry soils. The larger the solubility, the less the toxicity changes between wet and dry soil and, in general, the less effective it is as a soil insecticide. These relationships should be most useful in selecting potential soil insecticides.

It was shown that the commonly used Freundlich adsorption equation had a basic flaw in its presentation, which produced some anomalous *K* values. Because regulatory agencies are beginning to use these *K* values as a reference to judge relative adsorption of pesticidal compounds, it is important to point out these anomalies and suggest remedial measures. A manuscript was prepared on the subject, pointing out the source of the problem and showing typical examples of anomalous results. The *K* value, in fact, was not actually constant but changed its value depending on the system of units selected. A modified Freundlich equation was suggested that plots mole fraction as the independent variable rather than concentration. An alternative means of comparing the relative adsorption of pesticides was also suggested so that the units of presentation are consistent and a quantitative value can be placed on each adsorption system (analogous to the *K* value).

Ongoing development of our gas chromatography – mass spectrometry (GC-MS) assay for residues of carbofuran and its two principal metabolites resulted in the identification of significant sources of carbamate loss during sample preparation. These losses were studied and quantitated: carbofuran suffers a 10–15% loss through the acid reflux that is universally used to hydrolyze plant conjugates. Hydroxycarbofuran is relatively stable in the hot acid but may undergo a 65–70% loss, depending on the method of extraction following hydrolysis; ketocarbofuran is not much affected by these same factors.

High concentrations of carbofuran were found in the Holland Marsh drainage ditch

water in the spring of 1980. In view of the relatively short life of this insecticide, the possible cause of the unexpected persistence was investigated. Incubation experiments were carried out using carbofuran-fortified water at 200°C and 5°C. Analyses at the experimental temperatures indicated a half-life of about 1 wk and 20 wk, respectively.

Pesticide toxicity and mode of action

A basic requirement of the effective use of pheromones in IPM is an understanding of pheromone reception systems in insects. Electrophysiological studies on the European corn borer antennal response to pheromones continued. Bioelectrical activities in the unit sensory dendrite of a sensory hair have often been described, but studies on integrated activities are lacking. Using multiple and surface electrodes, some properties of the excitable tissue in the antenna were examined. It was discovered that the olfactory excitation spread through the antenna unidirectionally, suggesting that the whole antenna functions as a single sensory cell dendrite.

Many natural phenolic compounds and the insecticide carbofuran and its metabolites affect enzymic oxidation of the plant hormone indoleacetic acid (IAA) and the growth of plant tissues *in vitro*. However, whether these compounds actually influence the metabolism of IAA *in vivo* is not known. For the first time, a dual effect of phenolic compounds and metabolites of carbofuran has been demonstrated on the formation of bound IAA and on the oxidative degradation of free IAA in plant cells. These results, together with those obtained from the study of structure-activity relationships for regulation of IAA oxidation by natural and synthetic phenolic compounds, will be useful for further studies of chemical regulation of plant growth.

Work continued on determining the mode of action of the broad-spectrum herbicide, glyphosate. Plant-tissue culture techniques established that glyphosate inhibits chlorophyll synthesis, accelerates chlorophyll degradation in the light, increases the level of IAA-oxidase, interferes with IAA metabolism, and interacts with another plant hormone, cytokinin, on phenolic metabolism.

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Delhi, Ontario

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Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Delhi Research Station is the primary center for research on flue-cured tobacco in Canada. Multidisciplinary research projects on the development of new varieties and crop production and crop protection practices are conducted. Emphasis is placed on improving the physical and chemical quality of Canadian flue-cured tobacco from the standpoints of usability by manufacturers, both domestic and foreign, and consumer acceptability and health. An engineering program funded by the Canadian Tobacco Manufacturers' Council and the Ontario Flue-Cured Tobacco Growers' Marketing Board also conducts research at the Station on the reduction of energy use in curing and on the mechanization of harvesting and handling of tobacco.

The disease blue mold (*Peronospora tabacina* Adam.), which caused major losses in 1979, was prevented in 1980 by the use of the fungicide metalaxyl, and no losses were recorded.

More extensive summaries of research activities are published in the annual *Tobacco Research Highlights*, which is prepared for extension workers and growers. Copies of the *Tobacco Research Highlights* and scientific publications are available from the Delhi Research Station, Research Branch, Agriculture Canada, P.O. Box 186, Delhi, Ont. N4B 2W9.

C. F. Marks
Director

TOBACCO PRODUCTION

Gray tobacco

Seedling culture

Adequate size of tobacco seedlings in Todd cells was attained by frequent addition of soluble fertilizers containing 50% or more of nitrogen in the nitrate form. A total of 22.5 g of actual nitrogen per 100 flats (20 000 plants) was required at each of 15 applications. Fertilization commenced 1 wk after germination in early April and the seedlings received three applications in April and three per week in May. At least 40 L of water per 100 flats was required to achieve good coverage.

Nutrition survey

On a 32-farm survey, soil P was positively related to Zn and negatively related to pH and levels of Ca and Mg in the soil. Soil K was positively related to base exchange, total colloids, and ethylenediaminetetraacetate-extractable Mn and Fe in the soil. The contents of Fe and Cu in the bottom leaves and N, Cl, and total alkaloids in the upper leaves correlated positively, and reducing sugars in the bottom and undertip leaves correlated negatively with soil K.

Samples of gray K grades from auction exchanges and farms indicated two distinct types of K tobacco, one related to minor element fertility and the other to maturity. The first type, which had a peppery appearance, had higher concentrations of Mn, Zn, Fe, and Cd and lower concentrations of Ca and Mg than the corresponding lemon or orange grades. The maturity-related K tobacco, which had a gray, spongy appearance, had normal levels of minor elements but lower total alkaloids and higher reducing sugars.

Sucker control

A short growing season and a long day length encourage rapid development of axillary buds. This rapid development of axillary buds is referred to as sucker pressure. The long-chain fatty alcohols provide excellent control of axillary bud growth when the plants are treated prior to or immediately after removal of the inflorescence; however, the high sucker pressure overcomes this control in 4–5 wk. The application of a systemic growth inhibitor to prevent the development of axillary buds when the top leaves are growing rapidly, which is usually the case under Canadian conditions, also will reduce leaf expansion and consequently crop yield.

Ripening agents

Ethephon (2-chloroethylphosphonic acid) at rates of 0, 3.2, and 6.4 L/ha was applied to the upper eight or nine leaves of field plants, varying in age and fertilizer regimen, 3 days prior to harvest of these leaves. Ethephon decreased grade index and yield, regardless of plant age or fertilizer regimen, reduced the percentage of undesirable green grades, and increased the percentage of undesirable K (gray) grades. The percentage of K grades, however, was insignificant with the 3.2-L rate. Though ethephon tended to darken the base color of leaves and to produce a higher percentage of desirable F (dark) grades than untreated tobacco, the shift to K grades more than offset the shift to F grades.

GENETICS AND PLANT BREEDING

New varieties for the Maritimes

Two breeding lines developed from Delhi 34 crossed with Virginia 115 and Speight G7 have been developed for use under the environmental conditions in Prince Edward Island. Line 77C15 (Islangold) is highly resistant to black root rot disease and in the 3 yr of testing has produced a high yield of orange-colored leaf, good in texture and aroma. The leaf tends to be lower in alkaloids and reducing sugars than commercial varieties. The line has grown well on farms with a black root rot problem but may be damaged somewhat by extreme winds although it has no leaf drop. A low-profile variety, 77C11 (Windel), appears to be well adapted to areas subject to high winds. The leaves are slightly narrower than existing commercial varieties, but they have a heavy midrib and fairly thick lamina, characteristics that provide them resistance to wind shattering. Though alkaloids are normal, reducing sugars are slightly low. Yield, leaf quality, and black root rot tolerance are about average without leaf drop.

Interspecific hybridization

Successful incorporation of genetic factors from *Nicotiana rustica* L. into *N. tabacum* L. has resulted in the development and release of the following flue-cured tobacco cultivars. (a) Nordel: developed from the cross [Delhi 34 \times (NRT \times Delhi 34) Delhi 34] \times Virginia

115 (\approx 3BCF₇). The variety has several improvements long desired in a Canadian flue-cured variety, i.e. early maturity, uniform and superior grade quality, higher nicotine, and lower tar-to-nicotine ratio. High total leaf alkaloids and lower tar-to-nicotine ratios are the two most salient features of this cultivar that influence domestic and export tobacco trade. (b) Delgold: developed from the cross [Hicks Broadleaf \times (Babor \times Virginia 115) \times Virginia 115] \times Virginia 115 (\approx 3BCF₈). The most notable characteristics of the cultivar are high yield potential (300–400 kg/ha higher than the common variety Virginia 115), higher leaf total alkaloids (3.38% for Delgold versus 2.28% for Virginia 115), and lower tar-to-nicotine ratio. Simultaneous gains in yield (10–12%) and leaf total alkaloids (15–18%) over the most prominent cultivar, Virginia 115, are due to increased vigor (genetic diversity) and transfer of nicotine genes from *N. rustica* to the *N. tabacum* genome.

CHEMISTRY

Method for the determination of plant pigments of flue-cured tobacco

A procedure using high-performance reversed-phase liquid chromatography was developed for the analysis of the plastid pigments of flue-cured tobacco. The method has been used for the separation of chlorophyll *a*, chlorophyll *b*, pheophytin *a*, pheophytin *b*, neoxanthin, violaxanthin, lutein, and carotene.

Effect of N fertilization on nonvolatile organic, fatty, and amino acids of tobacco

A comparison was made of four rates of N fertilization (0, 22.4, 44.5, and 67.2 kg/ha) on the levels of individual nonvolatile organic, fatty, and amino acids of flue-cured tobacco. Increases in N increased the concentration of the nonvolatile organic acids and amino acids, except oxalic acid and methionine, and decreased individual fatty acids, except myristic and linolenic acids. The nonvolatile organic acids decreased with ascending stalk position but the reverse was true for the amino acids. The influence of stalk position on the fatty acids was not pronounced.

Extraction of water soluble acidity

Tobacco quality is normally expressed in terms of measurable chemical, agronomic, and physical parameters. Studies were initiated to improve the speed and accuracy of extraction of the soluble acidity. The 16-h extraction interval for soluble acidity was reduced to 30 min at 50°C with results similar to those of the original procedure. A study of grade samples indicated that water-soluble acidity of Canadian tobacco was similar to that for U.S. tobacco. In any particular grade category the soluble acidity decreased with a decrease in grade quality. Green grades normally exhibited higher values for soluble acidity than their nongreen associated grades.

TOBACCO PROTECTION

Plant pathology

Blue mold. The potential for the overwintering of blue mold inoculum in Ontario in the form of oospores in decomposing plant debris and in soil was investigated. Mature oospores were found in infected bottom leaves that were in contact with the soil but not in the upper leaves where the lesions had become dry and brittle. Oospores were abundant in the samples in which they were found, but the structures were found in only a small number of the samples examined. Though oospore-like structures were found in decomposed plant tissue and in soil, bioassays failed to show any infection. In other parts of the world, oospores of *P. tabacina* have been found to be dormant in the soil for periods up to 5 yr; therefore, the negative results from our tests do not demonstrate, absolutely, that oospores cannot act as a primary source of inoculum for the disease in Ontario.

Air quality and curing of diseased tobacco. Tobacco infected with *Rhizopus arrhizus* (pole rot) showed an increase in production of CO₂ and C₂H₄ during curing. C₂H₄ increased the rate of yellowing of tobacco during the initial stage of curing, the effect being most noticeable on diseased tissue, which occurs in pockets throughout the kiln. An interaction between high CO₂ and C₂H₄ concentrations,

disease incidence, and humidity in the kiln accentuated the spread of the damage. Disease incidence and damage can be reduced by proper ventilation and air management during the first 3 or 4 days of the curing cycle.

Entomology

Aphids. The species of ladybeetles, predators of aphids, and the abundance of each species were monitored in tobacco fields. Nine species of ladybeetles were found in the fields. *Coccinella transversoguttata richardsoni* was most abundant; *Coleomegilla maculata lengi*, *Hippodamia tridecimpunctata tibialis*, and *H. convergens* were moderately abundant; *H. glacialis glacialis*, *H. parenthesis*, *C. trifasciata perplexa*, *Anatis ocellata*, and *Anatis quindecimpunctata* were found less commonly.

Cutworms. Three pyrethroids and three organophosphorus insecticides were applied to winter rye or tobacco seedlings in the field, and the residues on the foliage were bioassayed in the laboratory. The pyrethroids, namely cypermethrin, fenvalerate, and permethrin, were more effective and persistent and killed the larvae of *Euxoa messoria* (Harris) more rapidly than the organophosphorus insecticides, namely sulfopros, chlorpyrifos, and trichlorfon. The higher rate of cypermethrin and fenvalerate gave a longer period of protection than the lower rate of the same materials and both materials were more persistent than permethrin.

Weed control

Herbicide residues. Residues of diphenamid (*N,N*-dimethyl-2,2-diphenyl acetamide) ranged from 1.71 mg/kg in the sand leaves to 0.16 mg/kg in the tip leaves of flue-cured tobacco treated in 1978 and 1979 at the recommended rate of 6.75 kg/ha on a 25-cm band post-transplant. Only trace residues of the nonphytotoxic metabolite 2,2-diphenyl acetamide were detected. Mean residues of diphenamid and *N*-methyl-2,2-diphenyl acetamide in cured leaves collected from the three auction exchanges in Ontario in 1976 and 1977 ranged from 0.01–0.02 and 0.14–0.27 mg/kg, respectively. The data support the mechanism of stepwise demethylation of diphenamid in flue-cured tobacco.

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Research Station

Harrow, Ontario

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J. W. AYLESWORTH, B.S.A., M.S., Ph.D. Retired 26 December 1980	Officer in Charge, Soil Substation, Woodslee, Ont.; White bean breeding
H. T. M. COLWELL, B.Agr., M.Sc., Ph.D. Transferred; Regional Development and International Affairs Branch, Ottawa, Ont., 1 December 1980	Economics
T. R. FRANCIS, B.Sc., M.Sc., Ph.D. Resigned 30 May 1980	Corn breeding
J. M. FULTON, B.Sc., M.S.A., Ph.D. Retired 5 December 1980	Director
N. E. B. GIBSON-MACDONALD, B.A., M.A., M.L.S. Transferred; Research Station, Vineland Station, Ont., 1 September 1980	Librarian
S. LESAGE, B.Sc., Ph.D. Transferred; Canada Center for Inland Waters, Burlington, Ont., 27 June 1980	Pesticide chemistry
V. W. NUTTALL, B.S.A., M.S.A. Retired 25 November 1980	Vegetable breeding

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Fruit and vegetable crops

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³On a transfer of work, the East Malling Research Station, England, from August 1979 to July 1980.

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INTRODUCTION

The Research Station at Harrow is located in a region with a favorable climate and a long growing season. Fruits, vegetables, and field crops are included in our research programs. The climate in the area is characterized during the growing season by an amount or distribution of rainfall that is often inadequate to meet the needs of all crops in all seasons. During 1980 the season was generally cool and wet. Although some crops were adversely affected and some plant diseases were more prevalent than usual, many crops responded favorably with record or near-record yields. Our research is primarily devoted to solving production problems such as the development of new crop varieties with superior agronomic characteristics; improved insect, disease, and weed control techniques; and improved soil and crop management practices.

This report provides brief summaries of results obtained in 1980. Further information can be obtained by writing to: Research Station, Research Branch, Agriculture Canada, Harrow, Ont. NOR 1G0.

W. I. Findlay
Acting Director

FIELD CROPS

Burley tobacco

Weather fleck. Weather fleck caused by ozone was prevalent on tobacco at the Harrow Research Station. Significant differences in ozone damage occurred among 14 tobacco cultivars. Burley 1, Harwin, and Ky21 × 10 were the most tolerant cultivars of those currently planted.

Corn

Atrazine degradation. Atrazine treatment of cornfields resulted in the formation of the 2-hydroxy metabolite in a clay loam soil. The time and method of atrazine application (preplant incorporated, preemergence, postemergence) and the presence of oil-surfactant additives in the herbicide formulation had no long-term effect on atrazine persistence. Postemergence application and the presence of additives resulted in a slightly greater initial rate of atrazine degradation. Both atrazine, in less than phytotoxic amounts, and hydroxyatrazine persisted into the following growing season and these residues were absorbed, metabolized, and conjugated by oats seeded in the spring.

Breeding. Numerous requests were filled for seed of the Harrow inbred CH663-8. This inbred gave testcrosses that were the best yielding for their maturity with a low amount of root lodging, out of 20 inbreds evaluated in the U.S. north central regional uniform test.

Depth of plowing and soil physical condition. Soil physical measurements, which included air and total pore space and bulk density, indicated that seasonal effects were much more pronounced on soil tilth than plowing at different depths within the 30-cm layer. During seasons when spring rainfall was at or below normal, plowing to 30 cm deep increased the pore space within the 20–30 cm soil depth more than plowing to 10 cm deep. During seasons with above normal spring rainfall, pore space was not increased within any of the three soil depths by plowing at 10, 20, or 30 cm. Results showed that deep plowing was not an effective way of improving soil tilth for plant growth on clay soils of southwestern Ontario.

Diseases. In an early planting, a cultivar whose ears developed more rapidly in the 3 wk after mid-silk had more eventual stalk rot than a cultivar whose ears developed at a more even rate. This probably reflects differences in hormone balance and consequent nutrient distribution between ear and stalk in the plant. Stalk rot in late plantings has been more dependent on cultural conditions.

No head smut was seen in 146 fields surveyed in early August in Essex County.

Insects. Two single-cross grain corn hybrids with resistance to the first generation of a bivoltine strain of the European corn borer were compared with a hybrid that is susceptible to both generations to observe possible differences in the biology of the borer and in levels of borer damage, and to determine if

there could be any advantage in growing hybrids that are resistant to the first generation in an area where the second generation is more important. It was found that there were only small differences between hybrids in the numbers of first-generation eggs laid and in egg mortality. However, the numbers of first-generation larvae that reached the pupal stage and the lengths of borer cavities were higher in the susceptible hybrid than in the two resistant hybrids combined. There was no evidence that the two hybrids with the least amount of damage were more susceptible to attack by the second generation.

Tests with a corn borer pheromone showed that only very small numbers of moths that were marked with a fluorescent powder and released in the vicinity of pheromone traps were recaptured.

Soil applications of carbofuran 10G applied in the spring at a rate of 1.2 kg/ha to control damage of corn rootworm larvae affected populations of nontarget stages of rootworms and other species. There was a threefold increase in number of rootworm eggs per kilogram of soil from treated plots compared with check plots in the fall and spring following treatment. Numbers of arthropods, rootworm adults, and coccinellid adults on yellow sticky traps in treated plots exceeded those in the check plots in July and August by 25%, 19–80%, and 18%, respectively.

Tillage and herbicide persistence. The effectiveness of disc or S-tine cultivation to incorporate herbicides in Brookston clay soil was investigated using chemical and fluorescent techniques. Incorporation of the herbicides by S-tine cultivator resulted in 45% volatile loss of low-vapor pressure type herbicides because of shallow incorporation, whereas only 22% of the herbicides were lost when incorporated by disc. Two incorporations at right angles with the S-tine cultivator reduced volatile losses, but losses were still higher than from disc. S-Tine cultivation deposited 79% of the herbicide nonuniformly in the top 4 cm of soil, whereas 85% of the herbicide was uniformly incorporated in the top 6 cm with the disc. Fluorescent dye verified that vertical distribution was better with disc incorporation and also showed that it gave more uniform horizontal distribution. Herbicide persistence was unaffected by the type of incorporation implement, but because persistence is dependent upon soil moisture content, the lower initial residues from S-tine

incorporation could persist longer because of the lower soil moisture content at the surface.

Weed control. An experiment combining cultivation and reduced levels of chemical gave successful weed control.

Five additional chemical treatments for corn are being recommended by the Expert Committee on Weeds, based in part on the research results obtained from corn herbicide trials at Woodslee.

Weed ecology and physiology. Five pigweed species (*Amaranthus*) differed in their susceptibility to postemergence herbicides in field trials. Prostrate pigweed was the most susceptible species to the herbicides tested. Linuron, atrazine, and INT-28 gave good control of all five species. The growth and development of atrazine-resistant and atrazine-susceptible populations of two pigweed species were examined in greenhouse experiments. Susceptible populations showed marked decreases in leaf number, leaf weight, and stem weight after treatment with atrazine at 0.5 kg/ha, whereas resistant populations tolerated 2 kg/ha. Susceptible populations were considerably more variable in their growth characters than resistant populations, possibly reflecting a narrow genotypic base for the latter population.

In lamb's-quarters populations resistant and susceptible to atrazine, differences in growth characteristics were correlated with differences in geographical location and climate; the northern populations exhibited a greater rate of development, earlier maturation, lower biomass at maturity, and greater reproductive effort compared with the more southerly populations. These growth differences were maintained when plants were grown at their reciprocal location. Although susceptible populations from various geographical locations differed in their growth features, they had the same relative decrease in growth when treated with atrazine. Herbicide-treated individuals of susceptible populations displayed increased variability in growth character measurements.

Soybeans

Bentazon soil residue analysis. A sensitive method for bentazon determination in soil by gas chromatography was developed based on reaction of bentazon under alkaline conditions

with pentafluorobenzyl bromide or *m*-trifluoromethylbenzyl chloride prior to direct analysis by gas chromatography. The pentafluorobenzyl derivative was 14 times more sensitive than the methyl derivative, whereas sensitivity of the *m*-trifluoromethylbenzyl derivatives was intermediate. Chromatograms of soil extracts were relatively free of interference peaks, and 1 g/ha of bentazon could be detected without extract cleanup.

Genetics. A recessive gene, *e_r*, was identified as being involved in early maturing soybeans that can flower and set pods under a 20-h day length.

The reaction of etiolated soybean hypocotyls to inoculation with zoospores of *Phytophthora megasperma* var. *sojae* was shown to vary with race-specific genotype, genetic background of the host, and the aggressiveness of the race.

Physiology of annual weeds. Studies on the intraspecific competition of velvetleaf indicate that a late emerging plant offers increased competition, is a more aggressive plant, and yields more seed than one emerging earlier in the year. Seed production of both early and late emerging velvetleaf plants was noticeably reduced where population density was nine plants per square metre or more.

Later emerging jimsonweed plants, like velvetleaf, appeared to be more aggressive and to yield more seed than an earlier established plant. Unlike velvetleaf, however, seed production per unit area continued to increase with density.

Phytophthora root rot. Based on a survey of Essex County soybean fields, root rot killed 0.43 and 0.66% of plants in fields and headlands, respectively. All survey fields were planted with cultivars with tolerance for phytophthora root rot as recommended for this area. Yield loss from this disease was low in 1980. In certain fields not included in the survey, 25–50% plant loss occurred in low, poorly drained areas. It is recommended that cultivars with race-specific resistance to the disease organism be planted in these problem areas. Under conditions favorable to root rot, resistant cultivars have higher yields than tolerant cultivars. Race-resistant cultivars currently available are not resistant to all known races of the pathogen; therefore a rotation of cultivars will be necessary to limit development of new races. Race 13 of the pathogen was isolated from infected soybeans

in 1980 for the first time in Ontario. Race 9 was isolated most often from diseased plants.

Summary of drainage spacing effects for soybeans. Drainage research showed that drains at 6-m spacing increased average soybean yield by 0.24 t/ha over the conventional 15-m spacing. The 15-m spacing, the one in most general use in southwestern Ontario, produced intermediate soybean yields between those obtained on the closest and farthest spacings. This experiment, carried out on clay soil in Lambton County also compared effect of depth and method of installation of soybean yield. On this basis the laser-controlled plow, which made the trench and installed the drain in a single operation, was as good a method of installation as the conventional wheel trencher. The shallower depth of drain installation at 70 cm was as good as deep installation at 96 cm for yield and was more satisfactory, because it required less energy to install.

Weed control. Where wheat growth was excellent and yields were high, there was no growth of relay planted soybeans. Broad-leaved weed control was accomplished in this crop production sequence, but volunteer wheat was a problem to harvesting matured soybeans.

Based in part on research conducted at Woodslee, four new herbicide treatments are being recommended for weed control in soybeans by the Expert Committee on Weeds.

White beans

Anthraxnose. From the sixth backcross progeny of Fleetwood, Kentwood, and Seafarer, homozygous lines resistant to the delta race of *Colletotrichum lindemuthianum* (Sacc. & Magn.) Briosi & Cav. were selected and forwarded to Idaho for seed increase. All homozygous lines were also screened for resistance to the alpha, beta, and gamma races of *C. lindemuthianum* and to races 1 and 15 of the bean common mosaic (BCM) virus. Similar resistant genes have also been incorporated into Sanilac and Steuben.

Bacterial blight (*Xanthomonas campestris* pv. *phaseoli*). In laboratory assays of seed harvested from blighted plots, using differential media, only about 0.1% of symptomless seeds were contaminated with blight bacteria as compared with 1.2% infection among discolored seeds; among infected pods, 29% had infected seeds. When such seeds were

planted in the field in 32 rows, blight was initially found in only one row, on 5% of the plants. It spread to eight other rows rather late in the season.

The *fuscans* and *nonfuscans* strains of blight bacteria were monitored for blight lesions as well as for leaf surface populations of white bean plants inoculated in the field, using equal proportions of the two. Although a majority of blight lesions contained *nonfuscans*, *fuscans* appeared to increase in leaf surface populations by mid-July. The relative role of the two strains is not understood.

In greenhouse evaluation of breeding material for resistance to blight, 40 out of 265 selections were found to possess moderate to higher degrees of tolerance. In field evaluations, 36 out of 65 selections in preliminary tests and 28 out of 43 selections in advanced tests were found to be tolerant, some combining the attributes of determinate growth habit and early maturity of the commercial cultivars.

Root rot. In greenhouse tests a mycoparasitic fungus, *Gliocladium virens*, reduced *Rhizoctonia* root rot in white beans. Root rot severity decreased with increasing concentration of the mycoparasite in the soil.

Viruses. Bean yellow mosaic virus (BYMV) was identified as a serious and widespread disease in southwestern Ontario, particularly in the Chatham area. It overwinters in volunteer clover, vetch, and alfalfa plants; of samples of these plants with mosaic symptoms collected in early May 1980, 25 of 71 clover, 10 of 64 alfalfa, and 5 of 61 vetch plants harbored BYMV. Aphids transmit it to the bean. Cultivars of beans resistant to BYMV were identified, and the genetics of their resistance is being studied.

White mold. In 1980 white mold infection was first found on 5 August, 10 days after the apothecia were first noted in the field. Initial infection was sporadic and the incidence was low (1.7%). In most cases, apothecia could be found within 45 cm of an infected plant. The initial infections were invariably at or near the first branch about 15 cm above the ground. The disease spread rapidly and exponentially in susceptible varieties by plant-to-plant contact until >75% of plants were affected 3 wk later. The disease spread more rapidly within than across the row. The cv. Ex Rico-23 was tolerant.

Winter wheat

Breeding. Winter wheat strains have been developed that yield well, especially in southwestern Ontario; that are resistant to lodging, to powdery mildew, and to leaf rust; and that have acceptable quality. The most promising line yielded 18% better than Fredrick in southwestern Ontario and yielded more than Fredrick in all six test sites representing the Ontario winter wheat belt.

Diseases. Selections resistant to wheat spindle streak mosaic and having high yield and agronomic acceptability have been developed and entered in the Ontario screening test. Fusarium root rot was reduced where wheat straw of the preceding wheat crop was removed rather than plowed in.

Selections are being made from crosses of commercial cultivars with the wheat spindle streak-resistant cultivar Halytchanka. A number of lines perform well when spindle streak mosaic is severe. Two lines in the Ontario screening tests performed in a manner similar to Yorkstar but not as well as other entries. Spindle streak was not a factor in these trials. A screening test with spindle streak mosaic inoculation will be needed to test these lines fully.

HORTICULTURAL CROPS

Field vegetables

Crucifer crops

Selectivity of insecticides. A field plot study demonstrated that microbial insecticides were selective for leaf-eating pests of cabbage. Higher numbers of predacious arthropods (syrphid larvae, coccinellids, and pentatomids) and higher numbers of cabbage-worms parasitized by *Apanteles glomeratus* were found in plots treated with the bacterium *Bacillus thuringiensis* or with viruses of the cabbage-worm and the cabbage looper than in plots treated with chemical insecticides (permethrin or methomyl).

Weed control. Trifluralin (0.75 kg/ha) incorporated before planting followed by chloramben (2.0 kg/ha) incorporated at layby provided promising weed control and resulted in the production of injury-free cabbage, cauliflower, broccoli, or brussels sprouts. This treatment, evolved on the sandy soil on the

Ridge Farm, has the potential to replace niclofen, which was removed from the market.

Cucumbers

Breeding. Bonus is a new cultivar released from the Harrow pickling cucumber breeding program in March 1980. It is a F₁ hybrid of a gynocious (all-female flowering habit) seed parent and a monoecious pollen parent. Bonus has resistance to scab, angular leaf spot, and cucumber mosaic virus. It is white-spined, strongly gynocious, and very productive and has good shape, a good L:D ratio (2.9:1), and lighter color than commercial cultivars. Bonus is the first of a number of cucumber cultivars being developed at Harrow for the Ontario pickling cucumber industry.

Powdery mildew. Of a number of new fungicides assayed to take the place of benomyl, for which tolerance is widespread, only triforine was effective and not withdrawn from consideration by the manufacturer.

Sphaerotheca fuliginea (Schlecht. ex Fr.) Poll. has hitherto been the only powdery mildew seen on cucurbits in Essex county, but in 1980, *Erysiphe cichoracearum* DC. was found on melons alongside an infestation of *Lamium amplexicaule*. *Cucumis dispaccus* was found to be resistant to *S. fuliginea*.

Scab. Though crop rotation affords the best control of cucumber scab, it was well-controlled by chlorothalonil, and a mixture of chlorothalonil and triforine gave yields 11.4% better than either by itself.

Peppers

Insect control. The green peach aphid was adequately controlled, and European corn borer infestations were kept below 2% with all sprays tested; however, up to 7.8% of fruits were damaged by pepper maggot in treated plots. Carbofuran and acephate were the most effective against all three pests.

Green peach aphid flights. Flights of the green peach aphid have been monitored for 7 yr, using suction traps at Harrow and yellow sticky traps in unsprayed pepper plots at Jordan, Ont. For 6 yr the correlation coefficients between sites were significant ($P \leq 0.02$). In the 7th yr no intercorrelation of sites occurred, and the usual unimodal curve of numbers of aphids flying did not occur. Unusually large flights early in the 7th yr at both sites could be attributed, in part, to warm weather in April and in the previous

November, but differences between the subsequent numbers trapped at Harrow and Jordan could not be explained. These results show that although there has been success at both sites in recent years in forecasting levels of the cucumber mosaic virus, which is transmitted to peppers by the green peach aphid, it is possible that completely different results can be obtained at the two sites in other years.

Potatoes

Flexible spray schedules. In spite of moderately low insect populations on early potatoes, three sprays were required to prevent damage from potato beetles, flea beetles, leafhoppers, and aphids. Excellent control of aphids by methamidophos and decamethrin provided 10% higher yields than plots treated with carbofuran, fenvalerate, and acephate, which allowed aphid numbers to build up.

Sweet corn

Microbial control of the corn borer. Damage by larvae of the corn borer was less and numbers of larvae were fewer in plots treated with the microsporidium *Nosema pyraustae* than in plots treated with fenvalerate, a pyrethroid insecticide, indicating the potential of the pathogen for control of this pest insect. In addition, 80% of corn borer larvae found in plots treated with the microsporidium were infected by the pathogen and would eventually die or the female adults would be infertile, compared with an incidence of 10–20% in other plots. Semiweekly examinations of adult corn borers captured in a light trap indicated a natural infection rate of 17%; this incidence may be sufficient to contribute to suppression of the population of the pest by reducing fecundity.

Varietal resistance to first generation European corn borer. Three years of tests have demonstrated marked resistance in five hybrid cultivars of early sweet corn in terms of larvae per 100 ears at harvest time. Laboratory tests with diets made from corn leaf powder and direct leaf-feeding measurements did not support a hypothesis of antibiosis. The ear infestation ranked very closely with stalk infestation and ranged from 3.57 to 28.41 larvae per 100 ears in 17 cultivars in 1980. Cultivars ranked consistently from year to year.

Tomatoes

Anthracnose and early blight. Mixtures of captafol with mancozeb and maneb with copper sulfate gave good control of these diseases, as did DPX 7331 [DuPont (Canada) Ltd.]. A copper hydroxide formulation depressed yield.

A forecast of early blight is made regularly for the provincial agriphone message for growers.

Charcoal protection from herbicides. Tomatoes (cv. New Yorker) were gel-seeded into sandy loam soil and covered with 75 mL of anticrustant per site containing 0.5 g of activated charcoal. This treatment protected the tomato seedlings from metrazine applied at rates up to 0.50 kg/ha or from metribuzin at 0.375 kg/ha plus chloramben at 1.5 kg/ha, applied in solution or in granular formulations, as shown by visual observations and yields.

Effect of damage to tomato transplants. An automated bare-root transplanter is being developed in conjunction with the Engineering and Statistical Research Institute. In anticipation of mechanical damage to the transplants, the effects of simulated damage on plant establishment and yield were evaluated. Yields were not seriously affected by leaf removal, slitting, or squashing, but were significantly reduced if all the roots of the transplants were removed. Thus, the results from these field experiments suggest that tomato transplants can withstand substantial physical abuse without reductions in yields at harvest.

Ethephon treatment of Georgia-grown transplants. Ethephon (300 ppm) sprayed on tomato transplants 5–10 days before harvest of the transplants is used to abort the initial flower cluster or clusters in order that the plant may become established vegetatively in the field before it has to bear fruit. Ethephon was observed to also have the effect of thickening the transplant stem and causing more root growth than found on the controls. There were differences in this response between cultivars, e.g. the ethephon effect was much more pronounced on the Heinz 2653 line than on the Campbell 37. The thicker stems and heavier root growth suggest that ethephon treatment of transplants may result in plants that establish themselves more readily than do untreated transplants, thus partly explaining the increase in early yields

of thick-stemmed ethephon-treated transplants reported in 1979.

Foot and root rot. Though not a problem disease in field crops in Ontario, *Fusarium oxysporum* f. sp. *radicis-lycopersici* Jarvis & Shoemaker infected all cultivars tested. A granular formulation of dazomet applied as a pretransplant fumigant enhanced the incidence of disease in inoculated plants of cv. Veemore, but because of improved growth and adventitious root production, overall yield was significantly improved in fumigated soil.

Potato aphid populations and flights. The number of embryos present in adult potato aphids was tested as a forecaster of population trends on field tomatoes for 4 yr. In the laboratory the embryo count was correlated with subsequent births ($P = 0.001$), except in young adult wingless aphids. On tomatoes the embryo count was only satisfactory for forecasting population trends in 1 of the 4 yr. This occurred because adults in the field were mainly wingless and because the habits of winged aphids found on the tomatoes differed from year to year; some years they departed without breeding and other years they arrived from outside to breed. Flying populations measured with suction traps were extremely variable from year to year, and in some years, periods of 2 wk without catches occurred in summer. The long-term annual flight pattern was a unimodal curve with a peak in August. Counts of winged aphids arriving on tomato plants were significantly correlated with catches in a suction trap. The first winged adult was trapped on 21 June \pm 5 days and the last on 21 October \pm 5 days in 12 yr of suction trapping.

Water relation and yields. A model that utilizes sunshine and maximum and minimum air temperatures for scheduling irrigation of tomatoes was developed from meteorological data and measurements of evapotranspiration from irrigated tomatoes. Measurements of leaf water potential and stomatal conductance indicated that water status in tomato plants in nonirrigated plots was similar to that of plants in irrigated plots, suggesting that the extensive root system (when fully developed) and high adsorption capacity of the tomato roots may offset effects of periods of drought.

Yield by one cultivar of tomato (H2653) was not affected in 1980 by irrigation treatments, whereas a second cultivar (C28) was

adversely affected. Because of the high rainfall in 1980, this response suggests that cultivars of tomatoes differ in tolerance for excessive moisture in soil. Yields from tomato plants planted at high density (43 054 plants per hectare) surpassed yields from medium-density planting (21 527 plants per hectare) by 34% and from low-density planting (10 765 plants per hectare) by 101%. Planting in double-row beds at high density resulted in higher yields than did single-row planting.

Weed competition. The critical period of weed competition in transplanted tomatoes is influenced by row spacing. Tomatoes (cv. Springset) planted in rows 1 m apart had to be maintained weed-free for only 24 days, as compared with 30–36 days for tomatoes planted in rows 2 m apart. At both spacings, a single weeding at day 24 or day 36, respectively, resulted in yields comparable to those from plots maintained weed-free throughout the season. Yields of tomatoes at the narrower row spacing were 50% greater per unit area than yields at the wider spacing at comparable levels of weed control.

Yellow nut sedge physiology and control. The herbicide glyphosate is translocated to and consequently alters the viability of yellow nut sedge tubers when it is foliarly applied until the latter part of August. With later applications, the herbicide is not translocated to as many of the tubers, presumably because the tuber is more mature and the transportation system is not as functional. In those tubers wherein a lethal dosage level is not attained, severe shoot malformation occurs on sprouting. Under similar circumstances for application, the herbicide bentazon has no adverse activity on the viability or growth of tubers from treated plants.

Shoot and tuber production by yellow nut sedge is highly dependent on the time of field emergence. An advantage of 1 mo in emergence during the first part of the growing season may result in an increase of 1000 tubers and 100 shoots produced from the original plant over that from the later emerging plant.

Studies to determine if the factor causing tuber formation is able to travel from a mother to a daughter plant and vice versa indicated that the translocation is unidirectional, mother to daughter. Mother plants exposed to a short photoperiod cause tuber

initiation in daughter plants growing under a long photoperiod.

Biotypes of yellow nut sedge show a varied response to photoperiod required for tuber formation, a varied tuber production potential, as well as a range in the coldhardiness (overwintering capability) of the tubers.

Greenhouse vegetables

Cucumber

Powdery mildew. As for field cucumbers, only triforine seems a viable alternative to benomyl as a control for powdery mildew, *Sphaerotheca fuliginea* (Schlecht. ex Fr.) Poll.

Several potential biological control agents were identified as parasitizing or antagonizing *S. fuliginea*, in addition to the parasite *Ampelomyces quisqualis* previously reported. A *Tilletiopsis* sp. seems particularly promising.

Tomato

Foot and root rot. In cooperative work with Dr. E. A. Kerr, Ontario Ministry of Agriculture and Food, Simcoe, five lines were identified as resistant to *Fusarium oxysporum* f. sp. *radicis-lycopersici* Jarvis & Shoemaker, from 2500 selections representing 68 lines.

It proved feasible to wedge-graft the highly susceptible cv. MR13 onto the resistant but pomologically poor cv. IRB, without detriment to yield and with complete escape from the disease.

The straw mulch used by the majority of Essex County growers was shown to be a major site for the multiplication of *F. oxysporum* f. sp. *radicislycopersici* in sterilized groundbed soils. Tomato roots left in the soil appear to be a less important site.

The biological control of foot and root rot was considerably enhanced by growing lettuce after sterilizing the soil when an infested tomato crop had been removed, and refraining from sterilizing again before replanting tomatoes. Catch crops of cress, mustard, or spinach had no such effect.

Whitefly control. The synthetic pyrethroid insecticides have proven very toxic to greenhouse whitefly adults. The most toxic was fenpropanate (WL41706, Shell Chemical Co.), followed by permethrin, decamethrin, and cypermethrin. The registered use of

permethrin at 100 ppm was also very effective against vegetable leafminer adults.

Tree fruits

Apple

Fire blight. The fire blight pathogen [*Erwinia amylovora* (Burr.) Winslow et al.] was recovered from 100% of the inoculated leaf scars of both Red Delicious and Idared cultivars in November but from only 90% of the leaf scars of Idared in the following April. Fewer buds had *E. amylovora* than had the leaf scars. It was not detected in either leaf scars or buds of Red Delicious in April. Differences in recovery may be related to the relative fire blight susceptibility of cultivars.

Apricot

Breeding. Two fresh-market cultivars named Hargrand and Harlayne, respectively, tested as HW410 and HW407, and ripening in the mid to late season, were introduced in 1980. Although they were intended for the Ontario fresh market, both cultivars have shown potential for commercial processing as puree for baby food and for home preservation as jam or as canned halves in syrup. In controlled freezing tests, Harlayne has surpassed Hargrand and has equaled the cold-hardiness of Goldcot, the hardy standard, and therefore should be adapted to regions where Goldcot is successfully grown. Both cultivars have good field resistance to brown rot, *Monilinia fructicola* (Wint.) Honey; perennial canker, *Leucostoma* spp.; and bacterial spot, *Xanthomonas pruni* (E.F. Sm.) Dowson. The fruits of both cultivars resist skin cracking in most seasons and do not drop readily even when ripe. They have very firm flesh with good texture and flavor, and the flesh does not adhere to the pit. The fruits of Hargrand are exceptionally large and moderately attractive, and those of Harlayne are of medium size but brighter and more attractive.

Nectarine

Breeding. Five new selections were made. The earliest selection ripened 1 wk before Harko and the latest ripened 10 days after Harko. Four new crosses were made to improve coldhardiness, fruit size, flesh firmness, and quality, from which 752 hybrid seeds were obtained.

Peach

Breeding. Three cold-hardy, double-flowered, ornamental cultivars were introduced and named Harrow Frostipink, Harrow Candifloss, and Harrow Ribirose. Their flower colors are, respectively, light pink, medium pink, and deepest pink to red. Each blossom has three to four whorls of five petals each, instead of a single whorl of five petals, which is typical of peaches. Each introduction is late blooming, about 1 wk later than most peach fruit cultivars. In controlled freezing tests, each introduction was more cold hardy than Redhaven peach. Each introduction also has a good level of field resistance to brown rot (*M. fructicola*), bacterial spot (*X. pruni*), and powdery mildew [*Sphaerotheca pannosa* (Wallr. ex Fr.) Lév.].

Twenty-nine peach crosses were made to improve coldhardiness, disease resistance, productivity, fruit type, and quality. In addition, 28 freestone and two canning clingstone selections were made from previous crosses using a multiple selection index consisting of 15 characters. The earliest selection ripened on 21 July and the latest on 8 September. Each selection will be critically tested for coldhardiness in 1981 before being considered for regional trials.

Crown gall. Biological control of crown gall (*Agrobacterium radiobacter* pv. *tumefaciens*) with Dygall (*A. radiobacter* strain #84) was monitored in a Harrow peach nursery, all on the rootstock Halford. When the nursery stock was dug out, gall incidence was 13% among 2379 check trees as compared with 5% among 3040 treated trees. It appears that biological control continues to be effective in Ontario.

Orchard management. A combined statistical analysis of the first five years of fruit-production data in an experiment of Harken – Siberian C peach using three levels of irrigation (none, 25%, and 50% available soil moisture) and three tree densities (266, 358, and 536 trees per hectare) revealed that: increased tree density was the most important factor favoring increased yield; both total and marketable yields varied between seasons; tree density influenced yield more in some seasons than in others; irrigation did not alter overall yield; in some years, irrigation tended to increase total yield but not marketable yield; and altered tree density did not alter the effect of irrigation on yield. It was considered

that a tree density of 536 trees per hectare was preferable to the traditional density of 266 trees per hectare because yields could be increased by up to 74.6%, even without irrigation. The main advantages of irrigation were the beneficial effect on tree growth and an improved yield in the first three years of production. There was little benefit from irrigation thereafter.

The influence of irrigation and tree density on stomatal conductance, leaf water potential, and available moisture in the soil profile were investigated during the 1978, 1979, and 1980 growing seasons. The results indicated that water status in nonirrigated trees was similar to that of irrigated trees. Measurements of available moisture in the soil profile suggested that the extensive root systems of peach trees were able to withdraw water from subsoil to avoid moisture stress and resultant loss in yield when trees were 6 yr and older.

Pear

Breeding and cultivar testing. Two pear selections, HW602 and HW603, have produced high-quality fruit, remain resistant to fire blight, and are being considered for release. Three fire blight selections, namely HW606, HW607, and HW608, which have fresh fruit and processing quality similar to Bartlett, the main pear cultivar grown in Ontario, have been placed in advance trials. A new cultivar from Purdue, Honeysweet, was determined to be fire blight resistant and has potential as a storage pear for the early winter market.

Psylla resistance was observed in the pear collection and seedling orchard. Twelve cultivars were observed to be resistant. Honeysweet was the only resistant cultivar of *Pyrus communis* derivation that has commercial potential. Psylla resistance was dominant in

progenies of a reputed *P. fauriei* clone crossed with *P. communis* clones. Several selections have been made.

Hardiness tests were conducted on an array of cultivars. *P. ussuriensis* and *P. ussuriensis* × *P. communis* hybrids were considerably more cold resistant than commercial cultivars. One of these clones, Ure, has been used in the breeding program as a source of the coldhardiness for new scion and rootstock cultivars.

It was demonstrated that Bartlett had a unique type of flavor, which was associated with high levels of decadienoate esters. Ten cultivars and selections have been found with a high decadienoate ester level and a flavor similar to Bartlett. These have been placed in cultivar trials and have been used as a source of Bartlett-like flavor in the breeding program.

Three rootstock clones, namely OHF 69, 87, and 51, produced higher early yields than Bartlett seedling and Quince A in trials conducted with the scion cultivars Bartlett and HW602. Efforts are being made to propagate them for extended trial.

MISCELLANEOUS

Grape crown gall

Crown gall (*Agrobacterium radiobacter* pv. *tumefaciens*) strains from 'vinifera' grape cultivars from southwestern Ontario vineyards were determined to belong to biotype 3 according to the currently accepted scheme. Several of them were sensitive to agrocin 84. Contrary to the published reports, evidence was obtained by testing the sap from infected vines that crown gall may not be systemic in 'vinifera' grapes.

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Research Station

Ottawa, Ontario

PROFESSIONAL STAFF

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Cereal Crops

V. D. BURROWS, B.S.A., M.Sc., Ph.D.	Head of Section; Oat breeding
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S. O. FEJER, Ing. Agr., Dr. Sc. Tech.	Barley breeding
R. G. FULCHER, B.Sc., M.Sc., Ph.D.	Morphogenetics and grain quality
D. R. SAMPSON, B.Sc., A.M., Ph.D.	Wheat breeding
W. L. SEAMAN, B.Sc., Ph.D.	Wheat pathology

Cytogenetics

G. FEDAK, B.S.A., M.Sc., Ph.D.	Head of Section; Cereal cytology
K. C. ARMSTRONG, B.S.A., Ph.D.	Brome cytology
I. L. CRAIG, B.S.	Haploidy— <i>Hordeum</i> cytology
B. E. MURRAY, B.S.A., M.Sc., Ph.D.	Haploidy—flax cytology

Entomology

D. G. HARCOURT, B.S.A., Ph.D.	Head of Section; Population dynamics
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T. A. GOCHNAUER, B.S., M.S., Ph.D.	Pathology of bees
J. C. GUPPY, B.S.A., M.S.	Population dynamics
C. C. LOAN, B.A., M.S., Ph.D.	Population dynamics

Forage Crops

L. S. DONOVAN, B.S.A., M.S., Ph.D.	Head of Section; Corn breeding
P. K. BASU, B.Sc., M.Sc., Ph.D.	Plant diseases
L. DESSUREAUX, ¹ B.A., B.Sc., M.S., Ph.D.	Alfalfa genetics
M. A. FARIS, B.Sc., M.Sc., Ph.D.	Legume breeding
W. R. MCELROY, ² B.Sc., M.Sc.	Grass breeding
H. D. VOLDENG, B.S.A., M.Sc., Ph.D.	Soybean breeding
F. S. WARREN, B.S.A., M.Sc., Ph.D.	Agronomy

Genetic Engineering

W. A. KELLER, B.S.A., Ph.D.	Head of Section; Cell genetics
B. L. A. MIKI, B.Sc., Ph.D.	Molecular biology
S. J. MOLNAR, B.Sc., M.Sc., Ph.D.	Cell genetics

Ornamentals

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.	Floriculture
F. J. SVEJDA, Ph.D.	Plant breeding

Experimental Farm, Kapuskasing, Ont.

J. G. PROULX, D.V.M.	Superintendent; Crop management and evaluation
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Experimental Farm, Thunder Bay, Ont.

J. WILSON	Superintendent; Crop management and evaluation
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Departures

T. BURNETT, B.S.A., Ph.D. Retired June 1980	Entomology
W. R. CHILDERS, B.Sc. (Agr.), M.S., Ph.D. Retired December 1980	Head of Section; Grass breeding
W. E. CORDUKES, B.Sc., M.Sc. Retired December 1980	Turfgrass
V. R. WALLEN, B.Sc., M.Sc., Ph.D. Retired July 1980	Head of Section; Aerial photography—methodology

VISITING SCIENTISTS

C. NAKAMURA, B.Sc., M.Sc., Ph.D.
From 1979 to 1981

Cereal tissue culture

A. L. CARPENA, B.S.A., M.S., Ph.D.
From October to November 1980

Plant gene resources

Graduate students

G. DOUGLAS, B.Sc. (Agr.)

Somatic hybridization

S. GLEDDIE, B.Sc.

Somatic hybridization

¹Seconded to Research Branch Headquarters.

²On educational leave, Guelph University, Guelph, Ont., from September 1980 to August 1981.

INTRODUCTION

The Ottawa Research Station (ORS) is the major center for plant breeding in eastern and central Ontario as well as for western Quebec. It is the major center for ornamentals research in the Research Branch. The Canadian Plant Gene Resources is a national program, and a small unit is engaged with studies of behavior and pathology of honey bees. In addition, the Station is charged with numerous service functions and the management of the entire Central Experimental Farm.

The breeding programs are supported by multidisciplinary research, including plant genetics and somatic cell genetics, cytogenetics, plant physiology and pathology, entomology, cytochemistry, and morphogenetics. Agronomy provides important information for improved crop management, and a quality laboratory services all the breeding programs. The scope of landscape architecture includes the beautification of the campus of the Central Experimental Farm, the planning of the annual chrysanthemum show, and landscape planning for Agriculture Canada buildings across the country.

The Experimental Farm at Kapuskasing continues to conduct experiments on crop production and on beef-cattle management for northwestern Quebec and northeastern Ontario. The Experimental Farm at Thunder Bay is engaged in crop production for northwestern Ontario.

One of the more outstanding accomplishments was the licensing and release of the soft, white, pastry-quality winter wheat cultivar, Gordon, and the early maturing timothy cultivar, Salvo. A number of short-season corn hybrids received support for licensing, and a split-temperature management study of greenhouse chrysanthemums was completed, resulting in energy savings. The crop disease loss program was terminated and a genetic engineering program was initiated.

Several professionals retired during the year: Dr. Walter Childers, forage grass breeder and Chief of the Forage Section, after 42 yr; Dr. Vic Wallen, plant pathologist and Chief of the Crop Disease Loss Section, after 35 yr; Dr. Tom Burnett, economic entomologist, after 42 yr; and Mr. Bill Cordukes, turf research scientist, after 35 yr of service.

This report summarizes some of the more important research results from the Station in 1980. Further information can be obtained from the publications listed at the end of this report. Reprints of the research publications and copies of the 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. A high-quality soft white winter wheat for Ontario, line 0-45-4, was licensed in 1980 under the name Gordon, and released through the SeCan Association. Gordon is especially well adapted to central Ontario (Test Area 2), where it outyielded the ORS cultivar Fredrick, the most widely grown cultivar in Ontario, by 7.6% over 4 yr. Gordon has better winter survival than Fredrick but lower hectolitre weight and weaker straw.

Genetics. Kernel hardness and protein content have an important influence on milling yield and baking quality. Ninety-nine F_4 lines from the winter wheat cross Lennox (medium-hard kernels, high protein) \times Stadler (soft kernels, low protein) showed no genetic linkage between the two characteristics ($r = -16$), in spite of a reported correlation of $r = 40$ among commercial cultivars. The latter presumably resulted from selecting either soft types with low protein or hard types with high protein, whereas the soft, high-protein and hard, low-protein types lacked commercial acceptance and were discarded. The Lennox-Stadler cross gave 21

lines that were soft-low, 33 that were hard-high, and 61 lines having the noncommercial combinations.

Pathology. Province-wide surveys showed that winter survival of winter wheat was excellent throughout the growing area in Ontario. Lack of snow cover during much of the winter prevented damage from snow molds, and moderate winter temperatures resulted in little cold injury, despite the lack of insulating snow.

Symptoms of barley yellow dwarf virus (BYDV) appeared in early summer, 1980, in winter wheat plots and fields in the Ottawa Valley. The early appearance of the disease indicated that the plants became infected the previous fall, when aphid populations were unusually high. Fortunately, aphid populations were generally low in 1980, so that there was little further spread of the disease in wheat. These observations suggest that winter wheat most likely provides an overwintering reservoir of BYDV from which the disease could spread to spring-seeded cereal crops.

In mid season unusually high levels of root rot and take-all occurred in central and eastern Ontario. Leaf rust and powdery mildew were locally important.

Wet weather during harvest caused unprecedented levels of sprouting in most areas of Ontario and also favored the development of *Fusarium* spp. on the spikes. In some areas *Fusarium* was accompanied by the production of mycotoxins, particularly vomitoxin.

Barley

Breeding. Two ORS cultivars, Massey and Vanier, continue to be the highest-yielding six-rowed feed barleys in Ontario and they are resistant to smut, mildew, and scald. Two new selections, OB294-1 and OB339-1, show real promise of reaching cultivar status in 1981 and 1982, respectively. Both have outstanding yield performance combined with resistance to lodging. The two-rowed feed barley OB440 performed well again and this strain combines high yield with good protein content. Greater emphasis is being placed on two-row barley breeding, and five new promising selections were promoted to advanced official tests.

Consistent negative correlations were found between mildew resistance and yield under mildew-free conditions in barley. In a reciprocal winter \times spring barley hybridization program, no heterosis was found in the F_6 , but

valuable selections were made; earlier selections from similar programs reached the final stages of testing. Competition tests between three early and three late cultivars grown under two-row spacings showed some high interaction effects, with some mixture superiority from closer row spacing.

Oats

Breeding. The ORS oats breeding program is directed toward improving oats as both a feed and food grain. ORS cultivars Sentinel and Scott continued to outperform recommended cultivars in many areas of Eastern Canada. A new day-length insensitive cultivar, OA366, continues to perform well in official tests and it may be licensed in 1981-1982. It shows promise as a milling oat for the food industry and as a feed oat to be grown in pure stand or in mixtures with barley. Major advances have been made in the breeding of lodging resistant dwarf-type oats that combine high yield and good seed size. Several advanced semidwarf lines (PGR 9887 to 9920) have been made available to oats breeders. The superior large-seeded hull-less oats referred to in the *Research Branch Report 1979* continue to perform well in Ontario, and whole groats of some of these lines have been evaluated in the preparation of human food (rice substitute) by the Kemptville College of Agricultural Technology (P. Johnston). An awned hull-less strain has been bred, and the awn makes it easy to separate unthreshed kernels from naked kernels. A prototype dormant cultivar (OA499) has been produced and is being evaluated on a farm scale in eastern Ontario as part of a technology transfer project.

Pathology. The oats crop in eastern Ontario and western Quebec suffered severe damage from crown rust (*Puccinia coronata* Cda. f. sp. *avenae* Eriks.) in 1980. Field tolerance and disease-loss tests employing maneb fungicide to control leaf diseases showed that losses from natural infection by crown rust amounted to 40% in seed yield and 20% in kernel weight. The tolerance test compared 45 cultivars and further showed that inoculation with septoria (*Septoria avenae* Frank f. sp. *avenae*) caused little additional loss in yield, and mean kernel weight was increased over natural infection because of the supplemental irrigation provided to induce septoria development. Tolerance for

the two diseases was identified in four cultivars using both yields and kernel weights. A third field experiment showed that Laurent was tolerant of crown rust and that it produced higher seed yield, kernel weight, and percent of protein than did Fidler and Hudson, both of which have major genes for resistance.

Barley and oats mixture tests continued to show in yield and kernel weight that leaf disease development was lower in most mixtures (eight cultivar combinations) compared with solid stands of each component.

Physiology and morphogenesis

A new fluorescent marker was isolated, purified, and adapted for routine microscopic detection of major cereal lipid reserves. The marker is capable of differentiating neutral lipids from other significant lipid residues in situ, with a sensitivity approaching 10^{-15} g. Using this and a range of fluorescent markers for other important seed reserves, comprehensive analyses of wheat and oats grain morphology have been completed. Similar technology has been developed for rapid detection of leaf-borne fungal pathogens, industrial grain fractions, and cereal fibers.

CYTOGENETICS

Wide crosses in cereals

Barley-wheat hybrids were produced by crossing the wheat cultivars Koga and Chinese Spring onto barley cultivars Emir, Bonus, and Betzes. Chiasma frequencies in the hybrids ranged from 0.60 in the Emir \times Chinese Spring combination to 3.60 in Bonus \times Koga, indicating that the background genotype has a profound effect on chromosome pairing in the hybrids. Chromosomal location of genes in Chinese Spring promoting crossability with Betzes barley was determined by crossing the entire series of 21 Chinese Spring - Hope substitution lines (where chromosomes of the noncrossable variety Hope were substituted for chromosomes of Chinese Spring) onto Betzes barley. By this means, the major genes for crossability were located on Chinese Spring chromosomes 5A, 5B, and 5D. Only those varieties of wheat carrying these three genes are crossable with barley. Chinese Spring wheat carrying the *Ph* mutant when crossed onto Betzes barley raised the chiasma frequency in the hybrids from 1.8 to 8.5, indicating that this

will be an effective way in which to achieve recombination and hence gene transfer between chromosomes of wheat and barley.

In an effort to produce addition lines of rye in barley, the wild rye species *Secale vavilovii* L. was crossed onto tetraploid Betzes to give a hybrid with 21 chromosomes, 14 from barley, and seven from rye. Selfing the hybrid or repeated backcrossing to barley should produce progeny with the entire complement of 14 barley chromosomes with additions of single rye chromosomes.

Hordeum gene pool. During a 1980 expedition, approximately 550 accessions of wild and cultivated barley were collected from the Canary Islands, Morocco, Portugal, and Spain. During this expedition the maximal variability in cultivated barley was observed in Morocco in the Anti Atlas Mountains at elevations of 3218 km and in river valleys of the Sub Sahara, where apparent land races are still being grown. The *Hordeum* gene pool at ORS now consists of 26 wild species in addition to approximately 650 accessions of cultivated barley. Studies on the 360 accessions of *H. bulbosum* L. collected in Turkey, Iran, and Greece showed that all are tetraploid with considerable variation in morphology, whereas the 50 accessions from Spain have the diploid chromosome number. Studies on previously undescribed wild species from Argentina and Chile indicate that they are all diploids.

Chromosome banding

A modified C-banding technique was developed that produces bands on the B-genome and on chromosomes 4 and 7 of the A genome of *Triticum aestivum* L. cv. Chinese Spring, following a normal Feulgen preparation. C-Banding on the meiotic chromosomes of the trigeneric hybrids of barley \times wheat \times rye revealed that rye chromosomes paired less often with barley and wheat chromosomes (0.27 per cell) than with nonhomologous rye chromosomes (0.073). The majority of pairing configurations (1.91 per cell) probably involved wheat homologues.

Brassica cytogenetics

The maximum pairing in haploids of *B. campestris* L. was $3^I + 2^{II} + 1^{III}$, which suggests that the species is hexasomic for one and tetrasomic for two other chromosomes. Haploids of *B. oleracea* L. formed $4^I + 1^{II} +$

1^{III}, which suggests that the species is hexasomic for one and tetrasomic for one chromosome.

Bromus cytogenetics

The karyotypes from species and interspecific hybrids of the section *Pnigma* suggests that the section can be divided into two groups differing in chromosome size. The group with the largest chromosomes (almost entirely New World species) consists of short-lived perennial to annual species that are highly self-fertile and are mainly diploids. The group with the smaller chromosomes (almost entirely Old World species) consists of long-lived perennials that are generally cross-fertile and are mainly polyploids.

Flax. Results from haploid × diploid crosses in flax indicated potential for selecting genetic stocks by combining the twinning, meiotic pattern and the haploid-producing traits from Rocket 4 with the fiber trait of Natasja and the rust resistance of Dufferin among F₂ haploid-diploid twins from haploid (Rocket 4) × diploid (Natasja) and from haploid (Rocket 4) × diploid (Dufferin) crosses. In the haploid (Rocket 4) × diploid (Natasja) cross, the hybrid haploids had a distinctive meiotic pattern that resembled an anaphase II disjunction of the haploid chromosome complement, resulting in the development on nonviable spores and low seed set from intracrossed twins. This contrasted with the Rocket haploid-meiotic pattern in which equal anaphase disjunction of sister chromatids resulted in viable spores and the potential to produce seeds in haploid × diploid crosses. Crosses with Dufferin as the pollen donor produced a response in the haploids and the F₁s similar to that of Natasja. Segregation ratios in the F₂ indicated simple inheritance for the regulation of the meiotic pattern in haploids and complex inheritance for the twinning trait. Selection is in progress for rust-resistant fiber-type lines, with the twinning trait for utilization as genetic stocks in plant breeding.

ENTOMOLOGY

Population dynamics and pest management

Alfalfa weevil. Studies aimed at developing a province-wide management strategy for the alfalfa weevil, *Hypera postica* (Gyll.), were

expanded to document survival between generations. Ecological life tables showed that a new parasitoid of the adult stage, the wasp *Microctonus colesi* Drea, has spread into Ontario to impose further stability to population oscillations in the weevil. Pooled data for five locations showed that the spring brood of *M. aethioides* Loan attacked and sterilized a sufficient number of overwintered adults to reduce oviposition by 30%. Disease destroyed 75% of the feeding larvae, but mortality of cocooned stages from the combined effects of disease and parasites was only 29%. Nearly one-third of the emerging adults contained larvae of *M. colesi*, and 27% of the remainder were attacked by the summer brood of *M. aethioides* during the 'feed up' period. Generation survival to the onset of hibernation averaged 8%. This points to lower populations for 1981.

A thermal summation model was developed for predicting seasonal development of alfalfa in the Quinte area. Analysis of weather and growth patterns for 6 yr showed that the first crop reaches the bud stage following the accumulation of 320 degree-days above 5°C (DD₅) from 1 April, and should be harvested between 360 and 510 DD₅ for maximum yield of protein. The following equation accounts for 98% of the variation in growth: height (in centimetres) = 0.215x - 4.754, where x is the number of heat units > 5°C.

Alfalfa blotch leafminer. In an attempt to describe the factors and processes that govern population trends in the alfalfa blotch leafminer, *Agromyza frontella* (Rond.), statistically reliable sampling procedures were developed for two life-history stages. For prepupae, population estimates are based on counts of mature larvae that drop from the alfalfa canopy into 22 × 22-cm pans containing ethylene glycol. For puparia, estimates are based on the contents of quadrats of soil 16 × 16 cm in area and 5 cm deep. Analysis of sampling variability showed that 40 pans and 50 quadrats per field, respectively, give adequate precision for numerical estimates of intensive population studies. The pattern of counts for both stages is overdispersed but conforms to the negative binomial distribution.

Life-table data from two plots at Ottawa showed that survival rates, egg to adult, varied from 0.5 to 4.8%, decreasing in each of the three generations. Critical mortalities

occurred during the larval and prepupal stages.

Honey bees

Behavior and physiology. Honey bees in a swarm distinguish and prefer their own queen over a foreign one. They attack, but rarely kill, the foreign queen. However, continuous feeding of artificially scented syrup to worker bees over a few days gradually diminishes their ability to discriminate between queens. Moreover, when artificial Nassenoff pheromone is released from a capillary dispenser near a foreign queen, she is preferred even to a familiar queen.

Several volatile fatty acids, including hexanoic, octanoic, and oct-2-enoic acids, occur in the mandibular glands of worker bees. These acids contribute to the antibiotic activity of royal jelly.

Disease. Honey bee larvae killed by American foulbrood disease emit an odor composed of one or more volatile sulfides and volatile fatty acids, including the valeric acid series. Cultures of the causative agent, *Bacillus larvae* White, emit odors of similar composition. The cultures produce hydrogen sulfide from cysteine and from sodium thiosulfate, but not from cystine, methionine, or glutathione.

Larvae killed by *Ascosphaera apis* (Maassen ex Claussen) Olive and Spiltoir, the organism causing chalkbrood disease, are very rapidly disinfected by exposure to ethylene oxide vapor. Colonies were infected by a minimum of 10^8 – 10^9 spores fed in a pollen-sucrose cake; evaporation of citral vapors in the hive suppressed such infection but did not control a preexisting infection.

FORAGE CROPS

Grasses

Timothy. There continues to be a high priority on improved cultivars with a wide range of maturity, high forage and seed yields, and an increasing percentage of digestibility and protein content. Salvo, an extremely early high-yielding cultivar, was licensed in 1980. There was 1450 kg of breeder and foundation seed available for seeding in the spring of 1980. Salvo is headed out by 8–10 June, which makes it extremely valuable in mixtures for alfalfa-timothy

haylage management. In the Atlantic provinces, Salvo will be used for early hay. A new synthetic (O-C high digestibility) of Champ origin outyielded its parent by 30 kg/ha in a four-station Ontario provincial trial. Labelle 23, a climax maturity broad-leaved strain, was the highest yielder of the Labelle strain in tests in Ontario and the Maritimes. A new high-digestibility five-clone synthetic was established in 1980.

Orchardgrass. A new synthetic of Rideau orchardgrass with higher yield and greater winterhardiness outyielded the check cultivar Kay by approximately 100 kg/ha in a two-station Ontario provincial test.

Alfalfa

The main objectives in alfalfa breeding have centered on yield, *Phytophthora* root rot (Prr) resistance, and selection for better nitrogen fixation.

Four synthetics were formed and tested for yield and Prr resistance. Synthetics 1 and 2 equaled the check Angus in total dry-matter yield but were twice as resistant as Apollo to Prr. Seed of these two synthetics was increased, and they will be entered in regional trials for possible release as new cultivars.

In another study, performance of some Prr-resistant and Prr-susceptible cultivars was determined under artificially inoculated field conditions. Yields of both resistant and susceptible cultivars were reduced after inoculation; however, the resistant cultivars outyielded the susceptible ones. The resistant cultivars exhibited less winterkill due to fewer plants infected by *Phytophthora megasperma* Drechsler. A total of 400 clones from different genetic backgrounds were selected as possibly possessing Prr resistance, which might contribute to new cultivar development.

Dry-matter production, plant height, protein content, and in vitro digestibility (IVD) were measured in 1st- and 2nd-yr plantings of six cultivars grown under potato leafhopper infestation with or without methoxychlor treatment for control of the pest. All treated plots yielded more dry matter than did the untreated plots. Plant height and protein content were higher and IVD was lower in the treated plots. All cultivars were susceptible to leafhopper infestation; however, Angus was the least affected. Leafhopper injury was season specific and damage carry-over from one season to another occurred, but the extent was less than that from one cut to the next.

Corn

Breeding. Eight new hybrids qualified for licensing in provincial trials: OX599, OX643, and OX646 in Manitoba and OX647, OX651, OX652, OX661, OX673 in Ontario. Applications from companies have been received for seed production and marketing rights for all of them. Those qualifying in Manitoba tests represent significant progress in developing still earlier maturing hybrids for short-season areas.

A release list of 26 inbreds was established. Eighteen of these, Plant Gene Resources (PGR) Nos. 8390–8407, are for general breeding use. They range in maturity from 2600 to 3500 corn heat units. The remaining eight, PGR Nos. 8863–8870, have shown some resistance to corn borer, and their use will likely be limited to breeding programs concerned with this character.

Modifications to improve efficiency were made to equipment that was developed to measure root strength in corn. Further testing of six inbred lines showed that all differed significantly in the force required to pull them vertically out of the ground.

Agronomy. Plant population or density is known to affect yield of corn silage. At Ottawa, maximum yields of dry matter were obtained, generally, with populations of about 51 000 plants per hectare. Information on yield of digestible dry matter (DDM) was obtained over a 3-yr period by growing three representative corn hybrids at seven population densities. Green yield, moisture content, dry yields, and digestibility were measured to permit the calculation of DDM yield. The three hybrids, early, medium, and late maturing, responded similarly. The pattern of performance is consistent each year, though actual yield levels were variable. Dry-matter yield peaked at about 51 000 plants per hectare and then decreased between 58 000 and 65 000 as ear development was inhibited, before rising again as plant numbers increased to 72 000, producing more vegetative material. Yield of digestible dry matter tended to follow the same pattern within a narrower range, so that there was only a small variation in populations above 44 000 plants per hectare. With these hybrids, populations higher than 44 000 were not effective in producing higher yields of digestible dry matter. The cost advantage of requiring less seed for such a plant density is an important consideration.

Soybeans

Breeding. The intermediate maturity line AU313 (OT80-1) has been evaluated for 4 yr in short-season areas throughout Canada. It matures 5 days before Portage, yields 10% more, and has higher seed oil and protein levels. Seed supplies have been increased for licensing and release in 1981. High-podded, pure line selections from the crossing program were evaluated for yield and for other agronomic characteristics. Six selections produced yields equal to standard cultivars of comparable maturity and carried the lowest pods 5 cm higher off the ground. The study was completed of the photoperiodic response of 14 cultivars and lines at day lengths from 12 to 24 h.

Flowering and pod formation of Maple Presto was delayed only 5–6 days even under a 24-h photoperiod. Other lines showed marked delay in flowering normally associated with soybeans. Studies indicated that the flowering of certain lines may not be delayed by long photoperiods, but pod set and maturity may be affected.

Agronomy. The herbicide metribuzin is widely used in soybean production in Ontario. Some evidence indicated that soybean cultivars varied greatly in tolerance for metribuzin, with early maturing cultivars often suffering severe injury. In a 2-yr study, six cultivars and several breeding strains were sprayed preemergence with metribuzin at five rates in a split-plot arrangement. Approximately 4 wk after spraying, the cultivar Vansoy showed severe phytotoxicity ratings; Maple Presto and some strains had moderate ratings; and Maple Arrow, McCall, Evans, and Beechwood showed little evidence of damage even at rates up to 0.56 kg/ha. All entries other than Vansoy exhibited considerable recovery in ratings made 4 wk later, and for these entries yield was not significantly reduced by any of the rates of metribuzin used. The study indicated the importance of determining the herbicide tolerance of strains early in the breeding program, particularly where early maturity is essential.

Pathology

Effects of cold exposure and of inoculation with *Phytophthora megasperma* Drechsler f. sp. *medicaginis* Kuan & Erwin on young alfalfa plants were studied under controlled conditions. Symptomatically, the effects

of these two factors could be readily distinguished. Freezing alone killed plants but did not produce blackish lesions, which were typical of root rot caused by pathogen. Disease development was not specifically enhanced by cold exposure applied (-5°C for 48 h). A definite relationship between freezing injury and *Phytophthora* root rot was not evident in terms of alfalfa yield (shoot number or top weight). Superficial brown spots on roots or internal streaks could be ignored when assessing cold injury or root rot yield.

Ten soybean cultivars and lines (Altona, AU313, BD 22115-13, Evans, K 357-1, Maple Arrow, Maple Presto, McCall, Portage, and PI 153-293) were tested to characterize resistance or susceptibility to bacterial blight (*Pseudomonas glycinea* Coerper) under field conditions. Of these, Evans was the most resistant and PI 153-293 the most susceptible, and the remaining cultivars were in the intermediate range (closer to Evans). The method of inoculation should be less drastic than the conventional use of airbrush; otherwise many promising strains for the short season areas may be classified as susceptible and may be neglected. It is highly probable that the pathogen survives in the field over the winter months and initiates infection in the following spring.

GENETIC ENGINEERING

Experimental haploidy

Brassica spp. A number of factors influencing microspore embryogenesis in anther cultures of *B. oleracea* L. (broccoli) cv. Green Mountain were identified. Short-term high-temperature pretreatments (45°C , 1 h + 40°C , 3 h) of the buds prior to anther culture increased embryo yield. Elevated levels of auxin in the anther culture medium also stimulated embryogenesis. Several hundred plants were regenerated directly through embryo culture or through shoot induction in hypocotyl explants. Approximately 50% of the regenerates were haploids.

The potential for haploid production in four winter *B. napus* L. cultivars (Herkules, Jet Neuf, Ligiora, Rapora) was evaluated. Maximal embryo yields were obtained when anthers were initially cultured at 35°C for 2 days, followed by incubation at 25°C . In Herkules, more than 1000 embryos were obtained per 1000 anthers.

A tissue-culture method was developed for maintaining and propagating anther-derived lines of *B. campestris* L. in a vegetative condition. The procedure involved axial bud culture on hormone-free media in 8-h photoperiods at 15°C . The technique was applied to *B. napus* and *B. oleracea* as a method of maintaining and cloning haploid lines.

Interspecific hybridization

Somatic hybridization. Chloroplast protein analysis of 14 *Nicotiana rustica* L. + *N. tabacum* L. somatic hybrids was performed via isoelectric focusing. Plastid segregation occurred in all lines with 11 plants carrying *N. rustica* chloroplasts and three carrying *N. tabacum* chloroplasts. Most somatic hybrid lines yielded viable seed when backcrossed with either of the parental species. Alkaloid analysis revealed that the hybrids were highly variable, having a range of alkaloid levels that was greater than that identified for the parental species.

Plants were regenerated from stem and leaf explants and from calluses of several *N. rustica* + *N. tabacum* somatic hybrid lines. In certain lines cytological stability was evident, but in others chromosome elimination occurred during regeneration.

Sexual hybridization. Postpollination placental culture resulted in the recovery of viable embryos and plantlets from the crosses *N. rustica* \times *N. tabacum*, *N. rustica* \times *N. glutinosa* L., and *N. rustica* \times *N. sylvestris* L. Maximal plantlet yields were obtained by culturing placentas 3 days postpollination on a hormone-free medium containing 4% sucrose. Cytological evaluation revealed a stable amphiploid chromosome number in all regenerates. Additional evidence for hybridization was obtained from morphological and isozyme analysis.

In vitro morphogenesis

Cereals. Factors influencing callus induction and plant regeneration from immature embryos of three triticale cultivars (Rosner, Beagle, Welsh) were identified. Genotype, embryo age, and culture-medium composition, including auxin type and concentration, influenced both callus growth and morphogenesis. Cytological abnormalities, including aneuploidy as well as chromosome structural changes, were identified in approximately 10% of the regenerates.

Plants were regenerated in callus cultures derived from immature inflorescences of triticale, *Triticum crassum* (Boiss.) Aitch. & Hensl., and from *T. crassum* × *Hordeum vulgare* L. cv. Bomi intergeneric hybrids. All *T. crassum* regenerates had 35 chromosomes rather than the expected number of 42. Several aneuploids were identified among the triticale regenerates, whereas the *T. crassum* × *H. vulgare* regenerates usually had the amphiploid chromosome number ($2n = 28$). Colchicine treatment of amphiploid calluses prior to induction of morphogenesis resulted in the identification of some mixoploid regenerates with the amphidiploid chromosome number.

Eggplant. Leaf explants of *Solanum melongena* L. (eggplant) cultured on medium with high auxin levels (10 mg/L 1-naphthaleneacetic acid) underwent callus proliferation, followed by the development of somatic embryos. Frequency of embryogenesis was influenced by auxin type and concentration, and by the nitrogen source in the medium. Transfer to hormone-free media resulted in plant regeneration in 25% of the embryos.

ORNAMENTALS

Floriculture

Propagation, growth, and yield of roses grown from cuttings in rock-wool propagation blocks were investigated. The yield of blooms was considerably larger than that obtained by the conventional growing methods, but the quality was lower. The method may permit increase in yields of flowers, planning of production peaks to coincide with peak demand times, and more efficient usage of greenhouse space.

Comparative growth and growth-parameter analysis of chrysanthemums grown at warm or low split night temperatures showed no detrimental effects of those parameters.

Dwarf Pinocchio asters and *Chrysanthemum pacificum* L. were evaluated as potential pot plants.

Impatiens hybridus L. cv. Starburst is one of the economically important New Guinea cultivars, but the environmental control of flowering in these plants is poorly understood. When grown at 25°C, a quantitative short-day response was demonstrated. Flowers in an 8-h photoperiod were initiated 2 wk earlier than those in 18-h photoperiods. When grown

at 15°C, the photoperiodic control was lost and a day-neutral response was demonstrated. An earlier and stronger flowering response was associated with this loss of photoperiodic control at a low temperature.

Streptocarpus nobilis C.B. Clarke could be induced to flower in response to one inductive short day. Explants from photoinduced leaves produced flower buds when cultured in noninductive photoperiods. This indicates that floral-determining factors are stable for some time within the leaf. When explants were cultured in inductive photoperiods, the flowering response was amplified. The in vitro induction of the floral stimulus was demonstrated when explants taken from noninduced leaves produced flower buds in inductive photoperiods. The system is being used to investigate both the induction of the floral stimulus and the factors that affect its action.

Pathology

Experiments showed that when greenhouse rose cultivars Samantha and Promise Me were grown on their own roots in soil inoculated with *Pythium aphanidermatum* (Edson) Fitzp. and *Rhizoctonia solani* Kühn, reduction in growth of 20% and reduction in flower yield of 20–30% resulted. None of the plants died or showed symptoms other than limited stunting. In a survey in Ontario these two fungi were isolated from roses grown on different rootstocks in five out of eight greenhouses.

It was established that *P. aphanidermatum* is highly pathogenic on carnations, but that there is resistance to it in several cultivars of chrysanthemums.

A strain of *R. solani*, isolated from poinsettia plants at Ottawa, did not produce visible symptoms when inoculated onto the roots of poinsettia. Cuttings taken from these plants 6 wk after inoculation failed to root and were found to be infected with the fungus. The fungus was isolated from the inoculated mother plants 10 wk after inoculation, at which time they were still symptomless.

A clone of *Poa annua* L. obtained from Manitoba proved to be immune to anthracnose caused by *Colletotrichum graminicola* (Ces.) Wils. in several tests under controlled conditions. A clone from Ontario also exhibited a high degree of resistance to the disease.

Plant breeding

Rosa. A new winter-hardy, repeatedly flowering rose with attractive double red flowers and excellent shrub, named John Franklin, was released for commercial production. Two seedlings of *Rosa rugosa* Thunb., obtained from seeds collected near Abashiri, Japan, showed resistance to the twospotted spider mite when compared with the floribunda cultivar Arthur Bell.

The rose selections U04, an everblooming bedding rose, and L15 and L72, hardy climbers, were propagated and grown for trial plantings. Selection indexes were established from points assigned for winter survival, length of flowering, flower production, resistance to diseases, and general ornamental features.

Seedlings of *R. rugosa* obtained from Bar Harbor, Maine, showed great genetic diversity; the inheritance of the flower color and fertility are being investigated.

Weigela. The aim of the breeding program is the development of winter-hardy shrubs with purple foliage. Parent plants have been obtained from crosses of the winter-hardy cultivar Dropmore Pink with the purple foliage cultivar *W. rosea purpurea*. These parents produced seedlings with improved winterhardiness and intensely purple colored foliage. The observed segregation ratios suggested that purple foliage is controlled by one pair of genes. Three chimeras with variegated foliage were found.

Selection of winter-hardy, floriferous, and disease-resistant *Forsythia* cultivars is continuing, and seven new selections have been obtained. The *Philadelphus* breeding program is being phased out, concluding the selection of winter-hardy, low-growing, purple-center flowering plants.

Turf

A red fescue strain, Saltol, which is tolerant of road salt (NaCl), was selected. This strain will find application in roadside and similar locations exposed to salt applications in winter.

Eighteen cultivars of *Poa pratensis* L. were grown in different day-length and temperature environments, relating these conditions to stem shading and cultivar selection. Day length and temperatures affected the growth; cultivars that produced long stems had many nodes and a short upper leaf blade, whereas short-stemmed cultivars had few buds and a

long upper leaf blade. These growth traits may find use in cultivar selection.

Evaluation of a large number of cultivars for turf quality was continued.

Arboretum and plant evaluation

More than 100 cultivars of geranium, *Pelargonium* × *hortorum* L.H. Bailey, were raised from seed and evaluated. Cultivars Red Express and Encounter Salmon received the top ratings. Among the evaluated dahlia cultivars, Coltness hybrids, Verdi Mix, Mignon Ideal Bedding Mix, Redskin, and Rigolletto were the best.

In the arboretum, a start was made on propagating all the *Philadelphus*, *Deutzia*, and *Forsythia*, with a view to renewing the existing collections and including several new cultivars. New selections of *Ginkgo*, *Malus*, and *Populus* were planted in the early winter.

PLANT GENE RESOURCES

Plant gene information

Genetic-resources inventories of Canadian barley, tomato, and wheat were published in 1980. These are computer-produced lists of cultivars and genetic stocks classified under various traits specific to each crop. Descriptions for over 3700 stocks of barley, tomato, alfalfa, wheat, and oats have been obtained to date, with close to 1350 of these in 1980. Another 2225 stocks of barley, oats, corn, sunflower, and tobacco were listed by plant breeders under the trait-inventory program initiated last year.

Conservation

Under Canada's participation in the program of the International Board for Plant Genetic Resources for the preservation of international collections of millet and oats, collections of pear millet, *Pennisetum americanum* (L.) Leeke, from Somalia, Cameroon, and the Sudan were received for long-term conservation at the Plant Gene Resources Office. A duplicate of the U.S. Department of Agriculture's World Oats Collection was also obtained. Seed of almost 59 000 stocks of various plant species is preserved at present in the seed stores that include 54 m³ at 4°C and 20% relative humidity and 64 m³ at -20°C with no humidity control.

Exchanges

Activities of the Plant Gene Resources Office in connection with exchanges of genetic stocks and cultivars in 1980 involved 275 such exchanges with individuals in 39 countries, for a total of 9500 accessions. Over 4800 genetic stocks and cultivars were introduced from 16 countries.

EXPERIMENTAL FARM KAPUSKASING, ONT.

Cereal management

A small trial was started in the spring of 1979 and repeated in 1980 to compare two sources of nitrogen, ammonium nitrate and urea, at four levels of concentration (25, 50, 75, 100 kg/ha). Grain yields for both years were not significantly different as a result of the two sources of nitrogen. In 1980, a N level of 50 kg/ha was sufficient to obtain the best grain yield, whereas in 1979, a N level of 75–100 kg/ha was required.

A study was initiated in the spring of 1979 and repeated in 1980 to examine four rates of urea nitrogen (at 25, 50, 75, 100 kg/ha) on spring-sown Keystone barley. These rates were applied in four different methods: broadcast over the soil immediately after seeding; broadcast over the soil immediately after seeding, and harrowed lightly; banded in with the seed at seeding; and banded to the side of the seed (5 cm laterally and 2.5 cm deep). In both years, the grain yields increased with N applications of up to 50 kg/ha. Increasing the nitrogen level from 25 to 50 kg/ha resulted in 1015 kg/ha more grain in 1979 and 660 kg/ha more grain in 1980.

In 1979, the grain yields from applications of N at 75 kg/ha and 100 kg/ha were 4277 kg/ha and 4222 kg/ha, respectively. In 1980, the grain production with applications of N at 75 and 100 kg/ha was 6392 kg/ha and 6776 kg/ha, respectively. In both years, there was a significant grain-yield advantage when the urea was side banded, when compared with the other three methods. In 1979, side-banding urea resulted in a grain-yield increase of 338 kg/ha over the average of the three methods of application. In 1980, a similar application method resulted in a grain-yield increase of 494 kg/ha. The highest grain yields of the test in both years were obtained by the side-banding application

method; with N applied at 75 kg/ha in 1979 the yield was 4852 kg/ha and in 1980 the yield was 7160 kg/ha. Both plant height and lodging were increased when the nitrogen rate was increased from 25 kg/ha to 50 kg/ha. Applications of N at 75 and 100 kg/ha did not significantly increase lodging and plant height over those obtained from applications of N at 50 kg/ha. In both 1979 and 1980, barley maturity was hastened by a few days with the addition of N at 50 and 75 kg/ha. The method of applying urea did not affect any of the agronomic characteristics except the total grain production per hectare.

EXPERIMENTAL FARM THUNDER BAY, ONT.

Crop management

Winter survival of red clover varieties in northern Ontario. Five cultivars of red clover (Lakeland, Ottawa, Florex, Redland, Prosper-1) were seeded on 7 May 1977 and were established well enough by the fall of 1977 to harvest one crop in that year. The stand went into winter in excellent condition, but severe icing conditions in January 1978 killed most legumes. The cultivars Florex, Prosper-1, and Ottawa managed to survive, producing good yields that year. For 1977–1979, the total mean yields of the three cultivars was 7295 kg/ha. After the winter of 1979–1980, only two of the cultivars revealed significant persistence and resistance to winter injury. In their 4th yr of cropping, only Florex and Prosper-1 remained with stands of 75%. The combined yields of Florex and Prosper-1 for the only cut taken in 1980 was 6013 kg/ha, mainly because of poor precipitation in May and June. Now in their 4th yr, the cultivars Florex and Prosper-1 continue to show persistence to winter injury and to retain a better stand than Lakeland, Ottawa, and Redland.

The effect of fall applications of nitrogen applied to brome grass, orchard grass, and timothy. Significant differences were noted in yields when N was applied at 15-day intervals, from 1 August to 30 September. The highest response to N when applied to brome grass and orchard grass occurred when it was applied on 15 August. The most favorable time for application of N to timothy was 30 September. The dry-matter yields for timothy

when applied on 15 August was 3943 kg/ha, compared with 5203 kg/ha when applied on

30 September. The rate of N application for each test was 120 kg/ha.

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INTRODUCTION

Integrated pest management (IPM) programs for apple, peach, and carrot crops were again used extensively by Ontario growers. The spotted tentiform leafminer continued to be a serious problem in apple orchards. Although leafminers can be readily controlled with synthetic pyrethroids, these compounds decimate the predacious mite populations. Without predators in the orchards, miticides are required to avoid mite damage to the trees. There is evidence also that the European red mite is developing tolerance for the available miticide cyhexatin, which will further aggravate the mite problem.

The seventh meeting of the International Council for the Study of Viruses and Virus Diseases of the Grapevine was successfully staged at Niagara Falls and managed by local staff. Unfortunately, Dr. H. F. Dias, who had done the early planning and organizing, died 5 wk before the conference. He was a world renowned grapevine virologist and had served this Station for 16 yr.

Evidence has been accumulated that tobacco mosaic virus is spread on plants in greenhouses by splashing of contaminated soil particles during watering. This phenomenon explains the appearance of virus symptoms on test plants, where none should exist.

Although none of the 21 peach rootstocks tested proved resistant to nematodes, two introductions from China appear to be likely sources of tolerance.

Objective measurement with specific instruments on juices and purees prepared from several tomato lines generally agreed with the subjective ratings of the human senses.

This report presents in capsule form some of the significant research results obtained in 1980. For more information on these or other research projects, or for reprints of published papers, please write: Director, Research Station, Research Branch, Agriculture Canada, Vineland Station, Ont. L0R 2E0.

A. J. McGinnis
Director

PESTICIDES

Application

Evaluation of spray coverage. The effect of spraying water on residues of phosmet in peach trees was evaluated by both bioassay and residue analysis. Phosmet at 1.12 kg/ha failed to provide adequate control of first instar oriental fruit moth (OFM), *Grapholitha molesta* (Busck), within 3–5 days after the water treatment; at higher rates (2.24 and 4.20 kg/ha) control was achieved for longer periods after the water treatment. At the 1.12 kg/ha rate, water application on the day of pesticide application significantly reduced the phosmet residues, but had little effect if applied when the phosmet residues were either 3 or 6 days old.

The relationship between first instar mortality of OFM and visual coverage ratings was established for pesticide to fluorescent dye (P:D) ratios of 5, 8, and 11, with phosmet at 4000 ppm. The deposit ratings were underestimated at mortalities $\geq 70\%$ for the P:D ratio of 11, but not for ratios of 8 and 5.

When the phosmet concentration was varied but the P:D ratio was kept constant, low mortalities due to sparse deposits could be avoided by increasing the phosmet concentration.

Phytotoxicity of captan–phosmet mixtures to peach foliage occurred under many combinations of temperature and humidity. Dried deposits became phytotoxic when placed in a higher temperature, high-humidity environment.

Fate of oxamyl. It has been the general view that oxamyl does not move in soil. To test this concept, bare peach seeds were coated with oxamyl and planted in sterilized soil in clay pots (5 cm diam). After 1 wk oxamyl was found in the soil surrounding the seed and also in the clay pots after pulverization. Intact oxamyl constituted 96% and 52% of the total residue (oxamyl + oxime) in the soil and pots, respectively. There was still no evidence of oxamyl degradation on the seed 3 wk after planting.

Carbaryl spray deposits. A rapid colorimetric method was developed to measure deposits of the insecticide carbaryl on foliage of fruit trees. Analyses take less than 3 min per sample when 50 or more samples are processed together. A 5-cm² disc punched from a leaf constitutes the sample. Carbaryl is extracted and hydrolyzed by methanolic NaOH, then coupled with *p*-nitrobenzenediazonium tetrafluoroborate, which produces a spectrum of colors ranging from red to blue. Within a range of 0.5–10 µg/cm² of leaf surface or 0.25–5.0 µg/mL of alkaline solution, the absorbance obeys the Beer-Lambert law at 580 nm. This method meets the demand of field entomologists who need an unsophisticated method that can be used by the nonchemist. Such analyses can be used to judge whether another spray application is required after a heavy rainfall or to check the distribution of spray deposits on the target. In addition, semiquantitative determinations can be made anywhere simply by using a series of color standards.

INSECTS AND MITES

Integrated pest management

Pest management in apple orchards. Azinphos-methyl failed to control the spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabricius) in some apple-growing areas of southern Ontario in 1980. Leafminer populations from these areas proved to be resistant to the insecticide and showed cross resistance to phosmet with partial cross resistance to diazinon. Irrespective of resistance to azinphos-methyl, all leafminer populations were highly susceptible to the synthetic pyrethroids permethrin, fenvalerate, and cypermethrin, and to methomyl. Endosulfan was less toxic than the latter insecticides, whereas phosalone was not toxic to either resistant or susceptible populations. Good leafminer control was obtained by applying either permethrin when eggs were first detected on the foliage or methomyl when 50% egg hatch had occurred.

Pest management in peach orchards. A series of fact sheets, *Pest management program for peach insects*, was prepared and released for use by growers and extension workers. Effective control strategies for most insect pests of peach are outlined. Pest control was generally excellent in 1980; few peaches

were damaged by OFM and plant bugs were not a serious problem. Results of the studies with several synthetic pyrethroid insecticides during the last several years indicate that they give excellent control of pest insects, but they adversely affect predacious mites. Hence outbreaks of European red mite (ERM), *Panonychus ulmi* (Koch), can be expected if pyrethroid compounds are used extensively.

Pest management in carrot fields. A simple method for monitoring the carrot weevil early in the season before the carrot crop is susceptible to attack would enable growers to determine whether an insecticide is needed for its control. Hence a potential monitoring procedure was tested. In late May, before the new crop of carrots had emerged, 10-cm sections of mature carrot root were partly buried in soil in commercial carrot fields, at or near sites where carrot weevil injury had been reported the previous year. Overwintered adult weevils oviposited in the root sections. The carrot sections were examined every 3 or 4 days, and oviposition punctures were readily identified with a hand lens. In heavy infestations, all root sections contained up to five oviposition punctures per day. Based on the number of punctures, growers were advised to spray at five of the six sites monitored; excellent control of carrot weevil was obtained at all sites.

Ecology

Establishment of beneficial mites in apple orchards. The predacious phytoseiid mite, *Amblyseius fallacis* Garman, was released in apple orchards in 1979 to determine its capacity to control ERM. In 1979, either 10 or 50 *A. fallacis* mites were released per apple tree (cv. Red Delicious) in early July when ERM averaged 0.04 active stages per leaf. A satisfactory predator-prey ratio of 1:5.5 was not reached until the end of August, at which time foliage injury was rated moderate to severe on most of the release trees. During the 1980 season, *A. fallacis* was detected in release trees as early as 5 May and as late as 24 September. The predators reached their maximum population level of 0.3 per leaf between 6 and 14 August, but again there were too few to control ERM.

In 1980, either 25 or 50 *A. fallacis* mites were released per apple tree (cv. McIntosh) on 15 July. The number of *A. fallacis* found at weekly intervals during the season was directly proportional to the number released.

In this experiment, as in the one commenced in 1979, predator-prey ratios adequate for control did not occur until late in the season, and propargite sprays were necessary as early as 6 August to protect the trees. In both seasons, either difolatan or captan was applied for scab control, and three applications of either phosmet or azinphos-methyl were needed to control codling moth and apple maggot. These pesticides caused minimal harm to the *A. fallacis* mites. In contrast, in both years the pyrethroid permethrin, applied prebloom to control spotted tentiform leafminer, caused high mortality in the predator population and contributed to the failure of the predator to provide adequate mite control.

Chemical control

Mites developing resistance to cyhexatin. In 1980, ERM was exceptionally troublesome in Ontario apple orchards, and numerous instances of control failure with cyhexatin, an important acaricide, were reported. Tests showed that a mite population from an apple orchard in the Ruthven region of southwestern Ontario had a low level of resistance (threefold) to cyhexatin when compared with a standard laboratory strain. General resistance to the organotin acaricides will constitute a serious problem for Ontario fruitgrowers.

Evaluation of acaricides and insecticides for integrated pest management. The pyrethroids permethrin, cypermethrin, fenvalerate, and AC 222705 (Cyanamid Canada Inc.) were more toxic to the predator *A. fallacis* than to its prey, ERM. Populations of ERM were higher in plots treated with either permethrin or cypermethrin in both apple and peach orchards than in comparable plots treated with azinphos-methyl, phosmet, or phosalone. The herbicide paraquat used in IPM programs was moderately toxic to *A. fallacis*.

Control of the spotted tentiform leafminer. Methomyl, a systemically active material recommended for control of larvae of the spotted tentiform leafminer proved to be an effective ovicide. No hatch occurred when the spotted tentiform leafminer eggs were treated 1, 3, or 5 days after deposition. Effective control was also obtained with any of six synthetic pyrethroid compounds when application coincided with first egg deposition for both first and second generations. All treatments, however, caused populations of the

two-spotted mite, *Tetranychus telarius*, and the ERM to rise.

Control of the carrot weevil. In 1980, phosmet was registered for control of the carrot weevil on carrots, where previously no effective insecticide had been available for use. A trial at the Holland Marsh in 1978 demonstrated the efficacy of two applications of phosmet with active ingredients at 1.1 kg/ha. In 1980 efficacy of phosmet under commercial conditions was confirmed. When the insecticide was used on five farms infested with carrot weevil, the carrots were harvested with negligible damage.

NEMATODES

Ecology

Winter survival of root-knot nematodes in southern Ontario. In a peach orchard, the southern root-knot nematode, *Meloidogyne incognita*, overwintered successfully in a moderate winter, but failed to survive a subsequent severe winter. This species failed to survive below the frost line in a moderate winter under alfalfa (a poor host), but some survived a severe winter under red clover (a good perennial host), and tomato (a good annual host). By comparison, during both winters the northern root-knot nematode, *Meloidogyne hapla*, survived well under alfalfa, red clover, and tomato at soil depths of 0–90 cm.

Anhydrobiosis in Pratylenchus penetrans. Anhydrobiosis, the phenomenon of survival through the loss of body water in a dehydrating environment, was observed in *P. penetrans* when either Vineland silt or Fox sandy loam was dried. The anhydrobiotes form tightly coiled spirals. The anhydrobiotes developed as the soil was air dried. The numbers increased logarithmically from 15/50 g of soil on day 0 to 500/50 g on day 18; soil moisture declined exponentially from 10–12% to 2% during the same period. The number of anhydrobiotes remaining alive declined over this period. The passage of *P. penetrans* to the anhydrobiotic state was similar in the two soils. Anhydrobiosis was more rapid, however, in fast-dried soils but fewer anhydrobiotes survived.

Host-parasite relationships

Reaction of peach rootstocks to root-lesion nematode, Pratylenchus penetrans. With 21 peach rootstocks (including four commercially available cultivars) tested in the greenhouse, differences were demonstrated in rate of nematode increase, total number of nematodes per plant at termination of the study, and number of nematodes in the soil and roots. With an initial inoculum of 2800 nematodes per kilogram of soil, final soil populations ranged from 6400 to 18 300 per kilogram and total populations ranged from 11 200 to 32 800 per year-old tree. Nematode infection reduced growth, total fresh and dry shoot weights, and fresh root weight. None of the currently available rootstocks appears to be resistant, but two Chinese introductions, Chui Lum Tao and Tzim Pee Tao, are promising sources of nematode tolerance.

Paratylenchus projectus on forage legumes. The pin nematode, *Paratylenchus projectus*, reduced forage yields of alfalfa, birdsfoot trefoil, red clover, and white clover by reducing seedling stands; with birdsfoot trefoil and red clover there was also a decrease in weight per surviving plant. Birdsfoot trefoil, however, was the only crop that showed an inverse relationship between forage yield and nematode inoculum density. Over a 2.5-yr period, nematode numbers decreased consistently under alfalfa, increased consistently under clover, and remained static or declined after the first year's increase under red clover and birdsfoot trefoil. In contrast to other nematode species in northern climates, the numbers of the pin nematode did not decline during the winter under favorable hosts.

Control

Control of dagger nematodes in grape soils with a systemic nematicide. The dagger nematode, *Xiphinema americanum*, is a vector of tomato ringspot virus in vineyards. The systemic nematicide, oxamyl, which translocates basipetally from foliar application, was tested as a control chemical on virus-susceptible grapes. After four foliar sprays of oxamyl with active ingredients at 1.12 kg/ha in 450 L water per season for two seasons, no dagger nematodes were found in soil samples from around individual vines after the second season; about 75 nematodes per litre of soil were present in the unsprayed checks. Trace infestations (five or less per litre) were found

around some sprayed vines 2 yr after spraying ceased, whereas around adjacent unsprayed vines there were 50–100 nematodes per litre. One year later most of the sprayed vines were infested, although the numbers of nematodes were generally similar to those of the previous year.

PLANT DISEASES

Fruit crops

Botrytis bunch rot of grapes. Benomyl-resistant *Botrytis cinerea* Persoon was identified in five of nine vineyards examined in 1979. In 1980, a combination of the two fungicides benomyl and captan was applied five times to three of the vineyards possessing low levels of resistance and it gave substantial protection. Of the infections that developed, however, most were benomyl-resistant, indicating rapid development of resistance and the failure of the benomyl–captan combination to prevent it.

Iprodione and vinclozolin were superior to captan, benomyl + captan, and chlorothalonil for the prevention of bunch rot. Results from a series of spray programs show that the critical period for protection of Gamay Beaujolais and Chardonnay was between post-bloom and early bunch closure. Fungicides applied after July have little if any effect on severity of the disease at harvest in early October.

Dissemination of tobacco mosaic virus from infested soil. Contamination of greenhouse-grown plants used for virus indexing of fruit trees with tobacco mosaic virus (TMV) was associated with infested potted soil. It was shown that virus dissemination occurred by splashing during watering. Aerial movement of the virus over distances of at least 160 cm was demonstrated. The virus was adsorbed to leaves from rolling water droplets. Soil to which virus particles were adsorbed also adhered to leaves and induced infection if the leaves were rubbed. TMV was reversibly adsorbed to soil at low concentrations of Ca^{++} and Mg^{++} relative to those of K^{+} and Na^{+} and was desorbed at high ionic concentrations. It appears, therefore, that colloid-cation–virus binding is largely responsible for adsorption. Optimum virus recovery from soil occurred near pH 6, and binding to soil increased as the pH was either raised or lowered. Rapid inactivation of TMV in soil

occurred under drying conditions and was associated with virus particle disruption. The virucidal effects of soil dewatering were more closely related to evaporation per se than to moisture levels.

Vegetable crops

Synergism between cucumber mosaic virus and soil fungi relative to sudden wilt of greenhouse cucumbers. Synergism between soil fungi, particularly *Pythium* spp., and cucumber mosaic virus (CMV) in the sudden wilt disease of greenhouse cucumbers in Ontario was demonstrated. At both 10° and 20°C cucumber plants simultaneously inoculated with *Pythium* and CMV suffered greater mortality than did those inoculated with either the fungus or virus alone. At 30°C no death occurred. Although CMV-*Rhizoctonia* and CMV-*Fusarium* combinations caused mortality in greenhouse cucumbers at 10°C, it was much less extensive than that caused by the CMV-*Pythium* combination.

Allium viruses in Ontario. Elongated flexuous virus particles about 725 nm long and stiff rod-shaped particles about 30 nm in length with a noticeable central core were detected in leaf dips of diseased garlic and onions, respectively, from southern Ontario. Infected garlic seedlings were severely stunted with noticeable chlorotic striping of the leaves; affected onions were not stunted, but showed mild chlorotic leaf striping. The symptoms induced by the onion virus on a limited host range and its particle size indicate a similarity to TMV. The garlic virus remains unidentified, but it has been transmitted mechanically to onion and certain *Chenopodium* species. Neither virus has been reported before from these plants in Canada.

Antagonists of the pea root rot pathogens. Ten species of microorganism antagonistic to pea root rot pathogens *Fusarium solani* (Mart.) App. & Wr. f. sp. *pisi* (F.R. Jones) Snyder & Hansen, *Rhizoctonia solani* Kühn, and *Pythium ultimum* Trow were cultivated on agar at 22°C. Three of them proved inhibitory to growth of all three pathogens. Four others were inhibitory to two pathogens, either *F. solani* and *R. solani* or *R. solani* and *P. ultimum*, but not the other combination. Three organisms proved antagonistic to the growth of only one pathogen, either *F. solani*, *R. solani*, or *P. ultimum*.

Interaction between pea root rot pathogens.

When the three pathogens were introduced singly into the soil before planting peas (cv. Little Marvel), *P. ultimum* was the most destructive to peas and *R. solani* was the least damaging. When *F. solani* and *P. ultimum* were introduced into the soil together, root rot more severe than that caused by either organism alone resulted. Likewise *F. solani* and *R. solani* in the soil together resulted in root rot more severe than that caused by either fungus alone. When three pathogens were present together in the soil, however, severity of root rot was no greater than that caused by the combination of *F. solani* and *P. ultimum*.

CONTRACT RESEARCH

Mechanization

Electrostatic orchard sprayer. An electrostatic orchard sprayer, modified and evaluated under contract, was shown to improve deposition in the top canopy of 3-m-high apple trees (cv. McIntosh) by 85% over a conventional sprayer, with no improvement in the bottom canopy. The ratio of top-to-bottom canopy deposition was 0.97 with the electrostatic unit and 0.51 when sprayed conventionally.

Sprayboom height control—design criteria. Four boom suspension systems, comprising a range of designs currently used commercially, were evaluated both over a test track and over a variety of crops in southern Ontario. Dynamic stability was monitored using ultrasonic sensors with the spray tank both full and empty, and with three types of tires.

Energy conservation

Product drying. Sodium bentonite, in intimate mixtures with corn, oats, wheat, and peanuts, was assessed as a desiccant suitable for an on-farm low-energy drying system. Corn was dried from 25% to 16% moisture content (wet bulb) in 44 h with no apparent rise in temperature. After drying, the bentonite was easily separated from the product with a fan mill.

Zeolite heat storage for solar grain drying. A mathematical model of a zeolite bed was developed and refined to evaluate the bed's performance as a heat-storage medium to be used for grain drying. A cylindrical parabolic

collector was simulated and used as a heat source for drying the bed. The system design was optimized on the basis of air mass flow rate and peak temperatures.

EXPERIMENTAL FARM, SMITHFIELD, ONT.

Vegetables

Evaluation of tomatoes for concentrated strained product. Juice made from six cultivars covered the entire range in consistency from very thick to very thin. Consistency and solids, two properties of the juice, were usually indicative of these properties in the puree. However, viscosity and insoluble solids are involved in a major way in determining the consistency of both juice and concentrate. There was some indication that the concentration process affects cultivars differently.

Instrumental evaluation of tomato products. Instruments used to measure differences in consistency of juice or puree included the Bostwick Consistometer, Ottawa texture measuring system with back extrusion cell, Brookfield viscometer, Efflux tube, and Cannon-Fenske viscometer. With minor variations, depending on the instrument, these objective methods picked out variety and harvest differences that corresponded well with subjective ratings.

The Ottawa texture measuring system with back extrusion cell and modular signal conditioning system effectively measured the graininess of tomato juice samples. The method has potential applications in both research and industrial quality control.

Fruits

Propagation of apple rootstocks by tissue culture. A series of rootstocks from Poland, Ottawa, Russia, Michigan, and Vineland have been collected and placed in a nursery to establish stool beds. To obtain sufficient

material for field evaluation, propagation employing aseptic tissue culture techniques has been attempted. At present, meristem cultures of MAC 9, MAC 1, M 26, 0-3, and P 22 have been successfully sterilized and the cultures have undergone shoot multiplication.

Techniques for sterilization, multiplication, rooting, and transfer to the greenhouse potting soil have been developed for three rootstocks—MAC 9, M 26, and P 22.

Mechanical pruning of McIntosh apple trees. McIntosh (VC-309) apple trees on MM 106, *M. robusta* 5, and OH 3 rootstocks were planted in 1971 at a 5 × 3 m spacing. Trees were trained to a central leader system until 1975 after which the only annual pruning carried out was with a sickle bar mower in early June to form a pyramid-shaped hedgerow.

The accumulated production from the mechanically pruned trees was increased by 16 to 40%, depending upon the rootstock vigor, and fruit color was reduced in the central portion of the rows relative to those pruned in the traditional manner. A system was tested whereby the well-colored fruit from the outer and upper part of the canopy was harvested for the fresh market and the fruit in the central portion of the row was shaken and marketed for juice.

Growing apples for juice. A mature orchard containing McIntosh, Delicious, and Red Spy apple trees has been managed as a juice block for seven seasons. Because of the minimum spraying and pruning programs, total production has decreased with time. Problems have been encountered with spotted tentiform leafminers, mulllein thrips, spring-feeding caterpillars, and apple maggots that required corrective action. Loss of major limbs due to the heavy cropping has reduced the fruiting area of these standard trees. A review of the production and management costs shows that the orchard would have returned a profit to the grower most seasons; 1980 was an exception.

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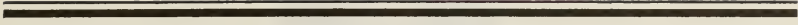
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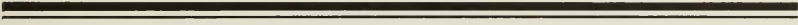
Miscellaneous

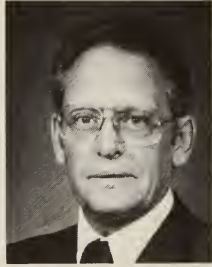
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 WESTERN REGION 
RÉGION DE L'OUEST





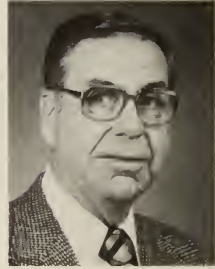
Dr. A. A. Guitard



Dr. W. N.
MacNaughton



Dr. D. M. Bowden



Mr. H. C. Korven



Mr. P. B. Griffith



Mr. J. J. McConnell

EXECUTIVE OF THE WESTERN REGION
L'EXÉCUTIF DE LA RÉGION DE L'OUEST

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Directeur général

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Assistant Director General
Directeur général adjoint

W. N. MACNAUGHTON, B.Sc., M.Sc., Ph.D.

Program Specialist
Spécialiste en programmes

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Chief, Finance and Administration
Chef, finances et administration

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Manager, Information Services
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J. J. McCONNELL, B.S.A., M.A.
Seconded from Information Services, Ottawa
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PREFACE

The Western Region, with headquarters in Saskatoon, consists of 15 research stations, four experimental farms, and eight substations. These research establishments serve the agricultural community throughout the Prairie Provinces and British Columbia. In 1980 the Region managed a budget of \$44 million and employed approximately 350 professionals and 885 subprofessionals in carrying out its research programs designed to solve a broad range of agricultural problems.

Long-term studies showed that restoration of the productivity of eroded soil with legume crops and fertilizers was only partly successful and that zero tillage was helpful in reducing erosion, conserving soil moisture, and reducing energy requirements for crop production.

Perhaps most significant in forage crop breeding was the licensing of Norgold, the world's first low-coumarin, yellow sweetclover. Also licensed were Heinrichs alfalfa, Clarke intermediate wheatgrass, Nova sainfoin, Elbee Northern wheatgrass, and Peace alfalfa. The alfalfa breeding program at Lethbridge was redirected in response to the survey findings that the disease verticillium wilt is spreading in Western Canada. Two strains of *Rhizobium meliloti* were released to legume-inoculant manufacturers.

The cereal breeding programs in the Western Region continue to have a significant impact on the industry. Five cultivars of hard red spring wheat that were developed at the Winnipeg Research Station since 1965 were sown on 73% of the total area planted with wheat on the prairies in 1980. Breeding programs in 1980 produced Columbus hard red spring wheat, Norbert two-row barley, Johnson six-row barley, Fidler oats, Musketeer winter rye, and Manor buckwheat.

Ochre, the first public cultivar of condiment yellow mustard, was licensed by the Saskatoon Research Station. Significant progress was made in research on control of diseases, insects, and weeds in oilseed crops. Research showed that canola meal can economically substitute for soybean meal in broiler chicken and turkey diets when it costs less than 63% of soybean meal. Canola meal was also found to be a satisfactory replacement for soybean meal in swine growing-finishing diets at levels up to 15% of the diet.

Further definition of the response of F_1 beef cows to various environments was obtained. The influence of differences in summer grazing conditions on relative productivity of various types of crossbred cows was demonstrated. Recommendations were formulated for use of rangelands in British Columbia, to aid both beef cattle producers and wildlife managers. The finding that rate of initial digestion is an important factor in the bloat-causing tendencies of forage legumes will aid in developing bloat-safe alfalfa cultivars.

Common cattle grubs were controlled on a large ranch with systemic insecticides and sterile male warble fly releases. A computer simulation model was developed that can estimate losses in productivity of cattle infested with horn flies.

A new tissue culture medium that is selective for dwarf growth habit in apple trees will aid in breeding new apples.

Food quality and processing research resulted in a better definition of factors influencing quality of fruit leathers, as well as the development of a stem-jacketed extruder for fruit snack bars and an improved drum drier for fruit purees.

Electrical stimulation of beef carcasses showed potential for improving tenderness when storage conditions were properly controlled.

Contracting out of research is increasing and becoming more closely related to in-house research programs. During 1980-1981, 13 research stations were involved in 62 contracts for a total expenditure of \$1 350 000. Major contract research areas were irrigation, drainage, and desalination; energy utilization and conservation; beef; supportive research and development; protection; and processing technology.

The Western Region is strengthening research in new energy sources and energy conservation by recruiting two energy engineers to develop an in-house research program and to assist in administration of energy contracts on crop residues for fuel and feed, heat exchangers for drying grain and heating livestock buildings, use of solar collectors and waste heat in greenhouses, alternate fuels, and energy conservation in meat processing plants and restaurants.

Staff changes within the Region in 1980 included the appointment of new directors to the research stations at Brandon (Dr. B. H. Sonntag), Kamloops (Dr. J. D. McElgunn), Lacombe (Dr. D. E. Waldern), Morden (Dr. D. K. McBeath), Saskatoon (Dr. J. R. Hay), and Winnipeg (Dr. D. G. Dorrell). At Lethbridge Research Station, Dr. T. G. Atkinson was appointed Assistant Director. At Western Region Headquarters, Dr. W. N. MacNaughton transferred from the Brandon Research Station to become Assistant Director General. Upon the transfer of Dr. D. E. Waldern to the Lacombe Research Station, Dr. D. M. Bowden took up the position of Program Specialist. Dr. B. H. Sonntag left the position of Economist to become Director at the Brandon Research Station.

Further information about our programs may be obtained by writing to the research establishments concerned or by addressing inquiries to Western Region Headquarters, Research Branch, Agriculture Canada, Room 600 Federal Building, 101-22nd Street East, P.O. Box 9241, Saskatoon, Sask. S7K 3X5.

A. A. Guitard

PRÉFACE

La région de l'Ouest, dont l'Administration centrale est située à Saskatoon, compte 15 stations de recherche, 4 fermes expérimentales et 8 sous-stations qui desservent les collectivités agricoles des provinces des Prairies et de la Colombie-Britannique. En 1980, son budget était de \$44 millions et son personnel comptait environ 350 professionnels et 885 techniciens travaillant à la solution d'une large gamme de problèmes agricoles.

Des études à long terme ont montré que la remise en valeur des sols érodés par la culture des légumineuses et par la fumure n'a pas eu tout le succès espéré et que la pratique de la culture sans labour aide à diminuer l'érosion, à conserver l'humidité du sol et à réduire les besoins d'énergie des cultures.

L'homologation de Norgold, la première variété de mélilot à fleurs jaunes et à faible teneur en coumarine, est un des faits saillants de l'année. On a aussi homologué la luzerne Heinrichs, l'agropyre intermédiaire Clarke, le sainfoin Nova, l'agropyre Elbee Northern et la luzerne Peace. Le programme de sélection de la luzerne de la station de Lethbridge a été réorienté par suite de la progression de la fétrissure verticillienne dans l'ouest du Canada. Deux lignées de *Rhizobium meliloti* ont été mises à la disposition des fabricants d'inoculum pour légumineuses.

Les programmes d'amélioration des céréales ont toujours une incidence significative sur l'industrie. Cinq cultivars de blé roux vitreux du printemps, créés à la station de Winnipeg depuis 1965, occupaient 73% des emblavures totales des Prairies en 1980. Les programmes d'amélioration de 1980 ont produit le blé roux vitreux du printemps Columbus, l'orge à deux rangs Norbert, l'orge à six rangs Johnson, l'avoine Fidler, le seigle d'hiver Musketeer et le sarrasin Manor.

Ochre, le premier cultivar de moutarde jaune du secteur public, a été homologué par la station de recherche de Saskatoon. On a démontré qu'il est économiquement avantageux de remplacer le tourteau de soja par le tourteau de canola (colza) dans le régime du poulet à griller et des dindes, lorsque ce dernier coûte moins de 63% du prix du tourteau de soja. Le tourteau de canola peut aussi, jusqu'à concurrence de 15%, remplacer l'autre dans les régimes de croissance-finition du porc.

On a pu préciser la réaction des vaches de boucherie F_1 à diverses conditions ambiantales. On a démontré les effets des différences dans les conditions de paissance d'été sur la productivité de divers types de vaches croisées. On a formulé des recommandations touchant l'utilisation des parcours en Colombie-Britannique pour la production du boeuf et la gestion de la faune. La découverte du rôle important que joue le taux initial de digestion dans l'effet météorisant des légumineuses fourragères devrait faciliter la sélection de cultivars de luzerne non météorisants.

On a lutté contre les hypodermes dans un grand élevage, à l'aide d'insecticides systémiques et de

lâchers d'hypodermes mâles stérilisés. On a élaboré un modèle de simulation pour réduire les pertes de productivité occasionnées par l'infestation du bétail par la mouche des cornes.

Un nouveau milieu de culture de tissus sélectif pour le nanisme chez les pommiers sera un outil utile pour la création de nouvelles variétés.

Des études sur la qualité et la transformation des aliments ont permis de mieux définir les facteurs qui influent sur la qualité des pulpes de fruits déshydratés et de perfectionner un extrudeur à vapeur pour les comprimés de fruits et un séchoir à tambour pour les purées de fruits. On a démontré la possibilité d'améliorer la tendreté du boeuf par stimulation électrique des carcasses dans des conditions de conservation réglées.

Les études effectuées par contrat deviennent plus nombreuses et plus étroitement liées à la recherche effectuée à l'intérieur de nos établissements. En 1980-1981, 13 stations ont administré 62 contrats de recherche totalisant \$1 350 000. Les principaux domaines concernés étaient l'irrigation, le drainage et l'assainissement des sols salins; l'utilisation et la conservation de l'énergie; le boeuf; la recherche et le développement de soutien; la protection et les techniques de transformation.

La région de l'Ouest intensifie ses efforts sur la recherche de nouvelles sources d'énergie et sa conservation, en embauchant deux ingénieurs spécialistes chargés d'élaborer un programme de recherches interne et d'administrer les contrats portant sur l'utilisation des déchets de culture comme combustibles et aliments, l'utilisation des échangeurs de chaleur pour le séchage du grain et le chauffage des bâtiments du bétail, l'utilisation des capteurs solaires et de la chaleur excédentaire pour le chauffage des serres, les nouveaux combustibles, et la conservation de l'énergie dans les installations de traitement des viandes et les restaurants.

Parmi les changements apportés au personnel de la région, en 1980, mentionnons la nomination de nouveaux directeurs aux stations de recherche de Brandon (B.H. Sonntag), de Kamloops (J.D. McElgunn), de Lacombe (D.E. Waldern), de Morden (D.K. McBeath), de Saskatoon (J.R. Hay) et de Winnipeg (D.G. Dorrell). M. T.G. Atkinson a été nommé directeur adjoint de la station de recherche de Lethbridge. Chez l'Administration centrale, M. W.N. MacNaughton anciennement de Brandon devient directeur général adjoint. Par suite de la mutation de M. D.E. Waldern à Lacombe, M. D.M. Bowden est devenu spécialiste en programmes. M. B.H. Sonntag a quitté son poste d'économiste pour devenir directeur à Brandon.

Pour de plus amples renseignements sur nos programmes, prière d'écrire aux établissements de recherche concernés ou de s'adresser à l'Administration centrale de la région de l'Ouest, Direction générale de la recherche, Agriculture Canada, pièce 600, édifice fédéral, 101, 22^e rue est, C.P.9241, Saskatoon (Saskatchewan) S7K 3X5.

A.A. Guitard

Research Station

Brandon, Manitoba

PROFESSIONAL STAFF

B. H. SONNTAG,¹ B.S.A., M.Sc., Ph.D.

A. J. DAGENAIS

VACANT

Director

Administrative Officer

Information Officer

Animal Science

J. H. STRAIN, B.S.A., M.Sc., Ph.D.

Head of Section; Animal breeding
and management

A. G. CASTELL,¹ B.Sc., M.S., Ph.D.

Swine nutrition

R. L. CLIPLEF, B.Sc., M.Sc., Ph.D.

Meats physiology

G. W. DYCK,² 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

G. W. RAHNEFELD, B.Sc., M.Sc., Ph.D.

Beef cattle genetics

Plant Science

L. D. BAILEY, B.S.A., M.Sc., Ph.D.

Head of Section; Soil-plant
relationships

K. W. CAMPBELL, B.Sc., Ph.D.

Barley breeding

P. N. P. CHOW,⁴ B.S.A., M.A., Ph.D.

Weed physiology

R. D. DRYDEN,⁵ B.S.A., M.Sc.

Crop culture

R. I. HAMILTON, B.Sc., M.S.A., Ph.D.

Corn physiology

E. D. SPRATT, B.S.A., M.Sc., Ph.D.

Plant nutrition

R. I. WOLFE, B.S.A., B.D., Ph.D.

Barley breeding

Departures

W. N. MACNAUGHTON, B.Sc., M.Sc., Ph.D.
Assistant Director General Western Region,
Saskatoon, April 1980

Director

A. P. PILOSKI, B.S.A.
Retired September 1980

Information Officer

¹Appointed October 1980.

²On postdoctoral transfer of work to University of Nottingham.

³Transferred from Melfort Research Station, September 1980.

⁴Returned September from postdoctoral transfer of work to Weed Research Organization, Oxford, England.

⁵Returned August 1980 from Canada - Sri Lanka rainfed agriculture project.

INTRODUCTION

The research program at Brandon encompasses beef cattle breeding; swine nutrition, physiology, breeding, and management; barley breeding; physiology and management of corn, soybean, and sorghum; and soil fertility, agronomy, plant nutrition, and weed control in cereal, oilseed, and forage crops.

Several important changes occurred in the professional staff in 1980. Dr. W. N. MacNaughton, Director, resigned to accept an appointment as Assistant Director General, Research Branch, Western Region. Dr. A. G. Castell, swine nutritionist, transferred to Brandon from the Melfort Research Station. Mr. A. P. Piloski, information officer, retired after 31 years of faithful service. Dr. R. Simons, forage agronomist, was appointed in 1980 and will join our staff early in 1981.

A highlight in 1980 was the licensing of Johnston feed barley with improved yield and disease tolerance and adaptability over a wide area in the prairies. This variety is named after Dr. W. Johnston, a long-time barley breeder at Brandon.

Low zinc levels were identified as the main constraint to responses of flax to fertilizer P in Manitoba. Research at Brandon was instrumental in obtaining approval for registration in Canada of a new herbicide (BAS 9052) for control of weeds and volunteer cereal in oilseed crops.

The Brandon Research Station continued participation in the long-term three-station foreign cattle breed evaluation project. The swine program continued with emphasis on nutritional and hormonal aspects of reproductive performance, production efficiency, and meat quality.

The Brandon Research Station continued involvement in international research and development. This included secondment of Mr. R. D. Dryden to the Sri Lanka - Canada dry zone project and short-term consultative missions to Pakistan, Brazil, and Ethiopia by Drs. E. D. Spratt, R. I. Wolfe, and K. W. Campbell, respectively.

This report summarizes the major results obtained in 1980. More detailed results can be obtained from our annual *Review of Results*, reprints of published papers, or by direct contact with research personnel at: Research Station, Research Branch, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

B. H. Sonntag
Director

ANIMAL SCIENCE

Beef cattle

Performance of first-cross cows in two environments. A population of 1150 first-cross females from Hereford × Angus (HA control) and nine crosses produced by bulls from Charolais (C), Limousin (L), and Simmental (S) mated to Angus (A), Hereford (H), and Shorthorn (N) cows provided the base population for a cooperative study at Brandon, Lacombe, and Lethbridge research stations. These females were born in 1970, 1971, and 1972 and maintained in an extensive range-management system on short-grass prairie at Manyberries, Alta., or in a semi-intensive farm-management system at Brandon, Man. As yearlings, these females were bred to

either Red Angus or Beefmaster bulls. Thereafter they were mated to a third breed from one of Charolais, Chianina, Limousin, or Simmental.

Results with 2-yr cows and their calves showed that the HA heifers were the lightest at 18, 24 (HA, LH, and LA did not differ), and 30 mo and had the shortest gestation period. The HA, LN, and LA crosses produced calves with lowest birth weight. The progeny of all breed crosses surpassed those of the HA control in weaning weight, but only the SA, SH, SN, and LN exceeded them in weaning weight ratio, i.e. weaning weight of calf (av. 205 days)/weight of cow at weaning^{0.75}. Progeny of CN and SN were heaviest at birth and those of SN had the highest weaning weight and weaning weight ratio. The Charolais-cross cows tended to be heaviest particu-

larly at 30 mo. Crosses from Hereford dams or Simmental sires had the longest gestation period. Cows at Brandon were lighter at 18 mo but heavier at 24 and 30 mo than those at Manyberries; the cows at Brandon produced calves 7.3% heavier at weaning than did those at Manyberries. Beefmaster-sired calves were carried 3.2 days longer, were heavier at birth (9.4%) and weaning (5.7%), had 10.4% more assisted births, and more deaths at calving (7.6% versus 3.4%) than calves sired by Red Angus.

Lifetime reproduction efficiency studies showed that extensive range environment gave greater cow losses, lower conception and weaning rates, and less weight of calf weaned than under semi-intensive pasture. Barren cows comprised the largest proportion of losses with sire breed ranking $C < S < L$ and dams ranking $A < H < N$ for the exotic crosses at both locations. The C sire breed ranked lowest for total attrition and highest for percentage conception and calves weaned per mating opportunity at both locations. At Manyberries these elements combined to give C-sired dams a slight advantage in weight of calf weaned per mating opportunity (143 versus 139 kg for S) but this ranking was reversed at Brandon (176 versus 181 kg for S cross). First-cross dams out of A cows ranked above N cross cows in weight of calf weaned (139 versus 135 kg) at Manyberries but the reverse was true at Brandon (172 versus 176 kg). All 'exotic' crosses ranked above the HA control for weight of calf weaned per mating opportunity. However, for this measure of productivity all L cross versus HA differences at Manyberries were negligible.

Growth patterns were determined from weights of cows taken each year to 1979 at calving, breeding, and weaning. Average weights of the two herds at the initial breeding (15 mo) and final calving differed by less than 3% but growth patterns differed between the locations. Females at Brandon gained weight during gestation and usually lost weight during nursing but at Manyberries, females had substantial losses during gestation in 3 yr but gained weight during nursing all years. Nursing status influenced weight changes with large compensatory gains occurring during barren years. The ranking of females by their sire breed was $C > S = L > HA$ for annual breeding and weight at weaning at both locations ($P < 0.05$). Average ranking by breed of dam was $N > H > A > HA$ at Brandon and $H > N > A > HA$ at

Manyberries. However, the only consistent differences were between the HA control and the other crosses. Breed rankings were not affected by nursing status.

Swine

Metabolic changes during feed restriction. Feed restriction by intermittent fasting compared with full feeding did not affect the blood glucose (BG) levels but decreased urea nitrogen (BUN) and free fatty acids (FFA) in both Lacombe and Yorkshires during winter but not in summer. Analysis of blood samples collected after full-feeding, fasting (24 h), and refeeding revealed that BUN and FFA were significantly ($P < 0.05$) elevated after fasting and returned to near normal after refeeding with little or no fluctuation in BG for the 3 days reflecting the phenomena of active tissue (protein and fat) catabolism and gluconeogenesis. This metabolic response to fasting appeared to be different between Lacombe and Yorkshires.

Choline supplementation for sows. Choline supplementation (500 mg/kg) of a barley-wheat-soybean meal ration for gestation and lactation did not improve the reproductive performance in both Lacombe and Yorkshire sows. A positive response was observed only in Lacombe gilts during winter with more live pigs born (9.64 versus 7.90) and weaned (7.50 versus 6.73) after choline feeding. The incidence of spraddle leg syndrome was low (2.5%) in both breeds and was not influenced by choline supplementation.

Estrus cycle regulation. Progesterone implants at 0, 100, and 500 mg for 48 h in 41 first-parity Lacombe sows did not have a consistent effect on initiating early return to estrus after weaning.

Embryonic mortality. Para 1 and para 2 Yorkshire sows bred to either Yorkshire (Y) or Lacombe (L) boars treated with implants were slaughtered at 90 days pregnancy. Both parities of Y sows bred to Y boars and treated with estrone early in pregnancy had an increased number of live fetuses. The estrone had no effect on para 1 Y sows and decreased the number of live fetuses in para 2 sows when bred to L boars. Fetal survival to 90 days was similar for the YY and LY groups. When allowed to go to term the Y sows bred to Y boars and treated with estrone tended to deliver larger litters.

Boar taint physiology. Active immunization against 5α -androstenone (boar taint) and implantation with testosterone was tested on growing boars as a potential method to control secretion of boar taint in market hogs. Under optimal conditions both methods reduced serum levels of 5α -androstenone in boars below those of either barrows or gilts.

PLANT SCIENCE

Wheat

Weed control in wheat. SSH 0860 gave good control of wild oats and better control of green foxtail and broad-leaved weeds than triallate or triallate-trifluralin mixtures. This resulted in wheat yield increases of 10–20% over triallate on average in 1979 and 1980.

The interaction of DPX 4189 at 5–50 g/ha in mixtures with each of four herbicides for control of wild oats has been studied. Antagonistic effects were negligible with difenzoquat, light with barban and flamprop-methyl, and high with diclofop-methyl. The antagonistic effect of 2,4-D on barban for wild oat control was associated with reduced absorption and translocation of ^{14}C -barban in the leaves and to meristematic sections of the growing point. Furthermore, 2,4-D increased the incorporation of ^3H -thymidine into DNA overcoming the effect of barban in meristematic tissues.

Other cereals

Barley breeding and genetics. A new feed barley cultivar, Johnston, was licensed in 1980 and given to SeCan for increase and distribution. It outyielded the top check, Klondike, by 5% in the Black and Brown soil zones of the Western Cooperative barley tests. In the Black and Gray Luvisol soil zones of Alberta it yielded 14% higher than the top checks, Bonanza and Klondike. In addition to resistance to stem rust, it carries resistance to scald, making it superior to many licensed cultivars in this respect. The variety is named in honor of Dr. W. H. Johnston, barley breeder at the Agriculture Canada Research Station, Brandon, Man., from 1936 to 1971. During this period he developed eight barley varieties, two of which, Conquest and Bonanza, are still major malting barleys on the Canadian prairies.

Two breeding lines from the feed program are in final stages of testing and may be considered for licensing in 1981. The most promising malting barley line (BT 343) with

blue aleurone has passed initial malting and brewing tests and shows improvements in agronomic performance over Bonanza. A yellow aleurone line with similar performance will be advanced to licensing trials in 1981. The two-row phase of the malting and feed programs continues to increase in importance.

Barley production and management. In the 3rd yr of a barley-legume rotation, significant increases in grain protein were obtained when barley was grown after soybeans, fababeans, and sweetclover when compared with barley grown on summerfallow and on barley stubble. Barley grown on fallow without added nitrogen yielded 3230–3425 kg/ha, with 10–12% protein. No yield response was obtained with fertilizer N at 30, 60, and 120 kg/ha, but at the higher rates of nitrogen, grain protein increased to 14–16%. To obtain similar yields, N at 30–60 kg/ha was required after soybeans and fababeans (14–16% protein), 30 kg/ha after sweetclover (14–16% protein), and 120 kg/ha after barley (12–14% N).

Corn and sorghum physiology and management. Corn trials were successful despite record abnormal weather. Low and high precipitation records of 0 mm in April and 200 mm in August were established. Rainfall of 11 mm in May and no significant amount of rain until 27 June produced difficult establishment problems. Some seeds of corn germinated on 1 and 2 May from April plantings, and were then frozen six times between 6 and 15 May. However, 95% of the seedlings recovered and yielded an average of 5 t/ha. Highest yields of individual selections were 6.5 t/ha.

Further assessment of sorghum genotypes indicated that this species has sufficient adaptability for this environment. Two 0.4-ha increase plots of the most advanced populations (begun in 1976–1977) resulted in satisfactory performance and further improvement. Direct combine yields were 2.2 t/ha.

Weed control in corn. Under drought conditions in the spring of 1980, M-3972, dicamba, and dicamba in mixtures with metolachlor or alachlor gave only partial control of lamb's-quarters and green foxtail in corn. However, dicamba and dicamba with metolachlor or alachlor resulted in significant increases in yields of corn of over 50%.

Oilseed crops

Fertilizer placement for rapeseed, flax, and soybeans. Root morphological studies show that banding of fertilizer P, 2.5 cm directly below or 2.5 cm below and 2.5 cm to the side of the seed, produced a greater proliferation of roots and a greater uptake of P by the crops than when the phosphorus was placed directly with the seed.

Soybean physiology and management. Soybean trials yielded highest at Dauphin, 51.5°N lat., followed by Brandon, 50°N, and Lyleton, 49°N, with 2000, 1400, and 1200 kg/ha, respectively. The Ottawa line AU-3-1-3 to be recommended for licensing in 1981 showed a decided advantage in yield and maturity over the standard Portage; it was stable in percentage protein and oil across all three locations.

Weed control in flax, rapeseed, and soybeans. BAS 9052 at 0.25–0.4 kg/ha in mixtures with Atplus surfactant gave excellent control of wild oats, green foxtail, and volunteer barley, and doubled yields in all three crops. TF 1169 demonstrated a similar pattern for weed control in oilseed crops. Mixtures of BAS 9052 with MCPA and bromoxynil/MCPA broadened the spectrum of weed control in flax.

Soil fertility factors affecting flax production. During 3 yr (1977–1979) 404 flax plots (25 trials) with various fertilizer treatments were analyzed for a complete spectrum of nutrients in both soil and plant samples. Mean values for quantity of various nutrients were quite adequate for flax growth but deficiency levels of some nutrients were well within the

standard deviation, e.g. Zn in plants, 22 ± 8.9 ppm; N in plants, $2.2 \pm 0.6\%$; and P in surface soil, 12.9 ± 11.1 ppm. The overall mean yield of grain was 1560 ± 611 kg/ha; the average response to fertilizer P was 218 kg/ha. In 19 out of the 25 trials zinc deficiency was identified as the main constraint for responses of flax to fertilizer P. When levels of Zn in the check plants were marginal (20 ppm), fertilizer P often depressed the Zn to deficiency levels (10 ppm). Flowering and seed set were affected and the harvest index (grain to straw ratio) often approached 20%. The mean extractable Zn level of surface soil was equal to Cu (1.5 ppm) and the subsoil zinc level approached zero, whereas Cu levels increased with depth (to 1.9 ppm). Occasionally (10 out of 25 trials) significant amounts of subsoil P (5 kg/ha per 15 cm depth) increased check yields and decreased the response of fertilizer P.

Forage crops

Alfalfa production and management. To assess the residual value of fertilizer P on the yield and chemical composition of alfalfa forage, single large applications of P_2O_5 fertilizer (100, 200, and 400 kg/ha) were compared with annual applications of P_2O_5 at 25, 50, and 75 kg/ha. Although yield increases and increased uptake of P were obtained from the single applications, annual applications of 50 and 75 kg/ha produced the largest yields and highest concentrations of P in the forage. Further, when the annual rates of P_2O_5 were superimposed on the single application plots, significant yield increases were obtained on the 100 and 200 kg/ha treated plots after 2 and 3 yr of cropping.

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Research Station

Morden, Manitoba

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¹Seconded to the Canadian International Development Agency Indo-Canadian research project for Dryland Agriculture.

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, flax, sunflowers, potatoes, herbaceous and woody ornamentals, and new crops. This report summarizes some of the results of research conducted during 1980.

Breeding programs resulted in the licensing of Manor buckwheat and the release of three early corn inbreds. Evaluations were continued on promising cultivars of other crops. Refinements were developed for several management practices that may lead to increased productivity. Additional understanding was obtained on several diseases affecting crops. Information was generated on several new herbicides, which may lead to registration of these products for 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: Research Station, Research Branch, Agriculture Canada, P.O. Box 3001, Morden, Man. R0G 1J0.

D. K. McBeath
Director

FIELD CROPS

Buckwheat

Breeding. Manor, a large-seeded buckwheat cultivar, was licensed in 1980 and pedigreed seed was released to growers through SeCan. This cultivar outyielded Mancan by 9.2% in 4 yr of cooperative testing. It reaches full flowering 1 day earlier than Mancan but is up to 1 wk earlier in reaching a given percentage of ripe seeds in the fall. It is expected to replace a large portion of Mancan, which accounted for 90% of the commercial production in Manitoba in 1980.

Management. A study of several growth and flowering parameters on lines with both normal and semidwarf habits has shown that there is large variability in number of branches, number of side flower clusters, number of terminal flower clusters, and total number of flowers per plant. The percentage seed set over a 2 yr period varied from 4 to 30%, depending on plant type.

Disease. Downy mildew was found in 15 of 17 fields examined in a province-wide survey. The leaf area affected averaged around 10%, except in one field where 50% was diseased. This low level of infection was probably due to the low rainfall prior to the surveys. Resistance to this disease was again confirmed this year in several breeding lines and appears heritable. Under plot conditions, an application of the fungicide Ridomil to the foliage

significantly reduced severity of the disease and provided a corresponding increase in yield.

Weeds. Satisfactory tolerance was found with postemergence treatments of TCA, BAS 9052, and TF 1169 and with preplant-incorporated treatments of metribuzin, alachlor, metachlor, and triallate. Initial crop injury resulted from postemergence treatments of difenzoquat, dicolofop, and metribuzin.

Field corn

Three early maturing inbreds with high combining ability, CM 145, CM 108, and CM 122, were released to the seed trade. Morden hybrid 1125 yielded 15% better than the mean of standards and was equal in maturity to the earliest standard, Pioneer 3995.

Several new, early maturing inbreds with a high degree of resistance to stalk rot were developed from populations obtained from European breeders. These inbreds yielded very well in top-cross trials.

The program to convert superior 'corn belt' inbreds to earlier maturing inbreds for Manitoba conditions has made progress. Selections from the backcrossing programs with H99 from Indiana, Mo17 from Missouri, and A619 from Minnesota have been crossed with Morden inbreds CMW9 and CM 174. The derivatives from H99 appear most promising, particularly when crossed with CMW9.

A similar backcross breeding program has commenced with the inbred B73 from Iowa.

Field peas

Breeding. The breeder seed of Triumph, a green-seeded cultivar, was released to growers through SeCan after a 4-yr program of virus elimination and genetic purification. A semileafless (*afaf/StSt*) line, MP 919, selected from a backcrossing program with Century, was equal in yield to the cultivar Century in cooperative tests. High yielding, semileafless lines with Trapper background have also been selected and will be evaluated in cooperative tests. Two green-seeded lines that are resistant to bleaching, MP 841 and MP 843, are under final evaluation.

Management. Preharvest spraying of green field peas with diquat containing active ingredient at 0.28 and 0.56 kg/ha resulted in good desiccation of late green growth and permitted earlier harvesting. The peas that were harvested earliest escaped weathering and had the best color. Chemical desiccation had its greatest advantage in years when maturation proceeded slowly and when regrowth was most prevalent.

Diseases. Of 1494 breeding lines evaluated for presence of pea seed-borne mosaic virus (PSbMV), 18 were infected. PSbMV detection is an integral part of the research program, necessary for the production of virus-free cultivars for licensing. The sensitivity of the assay plant *Chenopodium amaranticolor* for the detection of PSbMV was enhanced by providing it with low light intensity or high light intensity for growth, followed by a period of darkness prior to inoculation. Two of 35 advanced breeding lines showed some resistance to *Mycosphaerella pinodes*, and six lines as well as the cultivar Tara were highly resistant to powdery mildew.

PULSE CROPS

Evaluation. Eight pulse crops were evaluated. The lentil cultivar Eston continued to yield higher than Laird in Manitoba. Lines of adzuki beans selected at Morden outyielded introductions from Japan and the United States. Two chick-pea lines resistant to *Ascochyta* blight were identified. Black bean lines earlier in maturity and higher yielding than commercial cultivars have been selected.

High-yielding lathyrus lines that are resistant to drought have been identified.

Management. *Lathyrus* was found to give excellent germination and growth under severe drought conditions, with yields above 3500 kg/ha.

Quality. A screening technique for *N*-oxalyl-diaminopropionic acid was developed under contract by the University of Manitoba. Ninety-three Morden accessions of *Lathyrus* were screened for this compound and wide variation was found in the amounts of this lathyrogenic compound occurring both within and between species.

OILSEED CROPS

Flax

Breeding. Two lines, the late maturing FP 692 and the mid-early FP 698, continue to be superior in yield to the widely grown cultivars Linott and Dufferin. FP 692 also has better lodging resistance than Dufferin.

Utilizing recurrent selection, lines have been developed that are up to three percentage points higher in oil content than Dufferin and have good yield potential.

Sunflowers

Breeding. A sunflower hybrid, Morden 15, performed well in the 1980 cooperative test and will be proposed for licensing in 1981. Morden 15 yields 3.5% more than CMH 101, matures 1 day earlier, and has better resistance to downy mildew. Branching and non-branching restorer lines with identical genetic background did not differ in combining ability. The contribution of the hull content and oil content of the kernel (hull-less achene) to the oil content of the whole seed in commercial hybrids was found to be 56.5% and 43.5%, respectively. The contribution of the oil content of the kernel is higher than previously reported.

Management. Yields were reduced by about 70% when planting was delayed from 2 June to 19 June, due mostly to considerable lodging, which occurred in the late planted crop. Premature harvesting resulted in a much greater oil reduction in late maturing hybrids than in early maturing hybrids.

Diseases. Tan, a new strain of *Sclerotinia sclerotiorum*, was discovered in a sunflower field near Portage la Prairie. Unlike the

normal strain of *S. sclerotiorum*, which produces black sclerotia and brown apothecia, this new strain produces tan sclerotia and white apothecia. Sclerotia of the tan strain lack dormancy and are capable of attacking sunflower plants in soil shortly after inoculation.

In 2 yr of testing for resistance to sclerotinia wilt (*S. sclerotiorum*), inbreds CM 526 and CM 497 have shown wilt resistance superior to CM 400 and RHA 273, the inbreds currently used widely in the commercial production of hybrids.

Premature ripening, a disease of undetermined etiology, was widespread in sunflower fields in Manitoba and was particularly severe in early sown fields. Sclerotinia diseases generally were of unusually restricted incidence and mildness. Rust was more prominent and severe than usual, and verticillium wilt was conspicuous in fields of hybrids known to be moderately susceptible.

Weed control. Results in 1980 confirmed those from 1979 showing BAS 9052 to be selective in sunflowers at rates effective for control of wild oats, green foxtail, and volunteer barley. Band application of BAS 9052 or flamprop-methyl followed by cultivation between rows was as effective for control of wild oats and green foxtail as overall application in sunflowers sown at 75-cm row spacing. When wild oats emerged early relative to crop emergence, treatment with barban was not as effective as treatment with flamprop-methyl or BAS 9052, which could be applied at later stages of wild oat and sunflower growth. In a study of wild oat competition, a weed population of 70 plants per square metre between rows contributed substantially to the yield loss. Full-season competition by a 20-cm band of wild oats centered on the row resulted in a yield loss of 23%, whereas on unweeded plots the yield loss was 44%.

HORTICULTURAL CROPS

Ornamental crops

Breeding. Heritability of mildew resistance in roses was found compatible with an interpretation based on multigenic additive inheritance. The newly derived tetraploid RSMK1 hybrid germ plasm transmitted resistance at a level of 81% in seven progenies; its performance indicates its value as a disease-resistant parent. A dwarf honeysuckle and a hardy

weeping willow were increased for release in 1981 through the Canadian Ornamental Plant Foundation. These selections possess reliable hardiness for the prairie region. In lilies, two tetraploids derived by colchicine treatment from nearly sterile diploid hybrids of *Lilium aurelianese* × *L. longiflorum* proved fertile and cross compatible; these results indicate the value of tetraploid derivation for fertility restoration. This is the first known successful culture of second-generation embryos in this wide interspecific cross.

Arboretum and evaluation. Arboretum evaluations were continued with the addition of 140 new accessions in 1980. A preliminary evaluation of birch for tolerance or resistance to borers showed that *Betula davurica*, *B. albo sinensis septentrionalis* from Asia, and the native *B. occidentalis* offered particular value for direct use or for further breeding. Other promising accessions include *Cornus rugosa*, roundleaf dogwood; *Fraxinus americana*, white ash; *Populus grandidentata*, large-toothed aspen; *Populus* CAG hybrid, white poplar; *Quercus bicolor*, white oak; *Rhus glabra*, smooth sumac; and a *Sorbus aucuparia* hybrid. These plants are being increased for final assessment and recommendation to nursery growers.

Propagation. Morden Cardinette rose was propagated from leaf-bud cuttings using a range of concentrations of indolbutyric acid (IBA) and 7000 ppm was found to be optimum. A positive correlation existed between root formation and seasonal growth. Cuttings taken in early summer gave better rooting, growth, and overwintering than late-summer cuttings. A pilot project was developed to transfer this technology to commercial growers.

Nursery management. Herbicides were evaluated for efficacy and crop tolerance on a range of woody nursery crops. Data are being used to support registrations of oxadiazon in nursery stock kept in containers and of oxyfluorfen in established spruce, and to broaden information on herbicide performance in woody nursery crops.

Potatoes

Breeding and evaluation. Seventeen advanced seedlings or newly named cultivars were evaluated in commercial field trials. Atlantic (B6987-56) and Oneida have achieved some support from the chipping

industry and require field-scale production before final acceptance. Wisc 726 appears about equal to Norchip and Dakchip. Crystal and M69S06-69 are unacceptable for chipping. The red table stock cultivars, Botache and Wisc 729R, have gained some acceptance from the industry and have higher dry matter than Pontiac and Norland. Lemhi Russet (A68678-1) and Shepody (F69016) have some potential for french fry production.

Quality. Chipping potatoes were monitored for sucrose content (SR rating) beginning 4 wk prior to harvest and throughout the entire storage period. Preharvest SR rating was found to be useful in assessing tuber maturity as it relates to vine killing and harvesting, and for predicting long-term storage potential. Monitoring sucrose content in storage permitted the identification of stress conditions, such as poor air circulation, and the breaking of tuber dormancy.

Herbicides. Herbicide treatments of EPTC (Eptam) alone gave good control of lamb's-quarters and were as effective as EPTC plus extender or as a tank mix with napropamide. Variable cultivar tolerance for metribuzin was evident, ranging from only minimal injury (Norchip, Nipigon, F72117) to severe injury (Alaska Red). Some treatments that showed visible injury still produced good yields.

Diseases. A survey of Russet Burbank potato fields in 2-yr rotations revealed a very high incidence of rhizoctonia disease. The least amount of rhizoctonia disease was found in the potato-wheat rotation, with levels increasing in the potato-barley, potato-onion,

and potato-corn rotations. Both stems and stolons were affected; up to 100% of stems and 80% of stolons bore cankers, and 57% of stems and 46% of stolons were girdled.

NEW CROPS

Essential oil and spice crops

Evaluation. Extremely droughty and hot conditions at seeding time imposed difficulties in seedling emergence. These conditions resulted in very poor plant stands. However, cumin and fenugreek were identified as having agronomic potential for the southern prairies.

Management and quality. Dill oil quality has been adversely affected by the presence of phoma blight, which destroys the fern, and by volatile compounds obtained from certain weed species. Control of phoma blight was achieved by timely spraying with chlorothalonil (Bravo) at 1.7–2.2 kg/ha. Effective control of broad-leaved weeds was obtained with ethalfluralin, trifluralin, and chloramben.

Because the geraniol-rich monarda seedling is a triploid, it can only be propagated asexually. The most effective and rapid method was found to be through mist propagation of stem cuttings dipped in 1000 ppm of IBA and placed in sand in a misting chamber. Cuttings taken from mid-May to mid-June rooted best, producing root initials in 1 wk; these cuttings were ready for transplanting in 14–16 days. As the mother plants advanced in growth, the stems became more fibrous and their ability to produce roots decreased rapidly.

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Winnipeg, Manitoba

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³On transfer of work to the Royal Veterinary and Agriculture University, Copenhagen, Denmark, October 1980 – September 1981.

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. Three cultivars were licensed in 1980 as a result of their combined efforts. The hard red spring wheat cultivar, Columbus, is the first Canadian cultivar with a high degree of harvest-time sprouting resistance. The two-row barley cultivar, Norbert, is the first cultivar to combine resistance to stem rust and net blotch with tolerance for barley yellow dwarf mosaic virus. The spring oat cultivar, Fidler, is the first cultivar with effective multigenic resistance to stem and crown rust and good yield. Cereal cultivars developed by the Winnipeg Research Station are currently grown on more than 9.5 million ha in Western Canada.

Research on the preservation of grain and oilseeds and their products is national in scope and requires close cooperation with Plant Products and Quarantine Division of Agriculture Canada, the Canadian Grain Commission, and the grain industry. Factors that cause the development of toxins in stored grain are being investigated as part of a strong mycotoxin program. Low-cost ventilation systems have been developed that permit safe storage and maintenance of quality in damp rapeseed.

Research on the control of field crop insects, particularly those that attack rapeseed, includes the evaluation of new insecticides, an assessment of economic damage, and the development of management systems. A highly successful integrated control program for the strawberry cutworm was developed that includes chemical and cultural methods.

Dr. W. C. McDonald, Director of the Winnipeg Research Station since 1971, retired at the end of 1979 after a distinguished 29-yr career with the Research Branch. He is noted for his contribution to genetic control of barley leaf diseases. Drs. R. Rohringer and F. L. Watters subsequently shared the responsibilities of Acting Director for 8 mo in 1980.

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

Barley

The two-row barley line T.R. 206 was licensed as the cultivar Norbert. This cultivar is well adapted to the eastern prairie region because it possesses improved yield and straw strength and is the first cultivar with resistance to stem rust and net blotch and with tolerance for barley yellow dwarf virus. Although its status as a malting barley has not been established, it has good malting quality.

Barley-quality studies revealed that high lysine lines from the breeding program did not appear suitable for malting purposes. Their

high β -amylase activity appeared to be associated with lower levels of other enzymes essential for malting. Similarly, in initial malting tests it was found that lines with a very low polyphenol content showed a decrease in essential enzyme activity. More evidence was obtained to indicate that the level of hordein protein in barley affects amount of fermentable material that can be extracted from malt. Preliminary results indicate that hordein content can be easily screened for in the breeding program.

Common wheat

The hard red spring wheat line, B.W. 37, was licensed as the cultivar Columbus. This is the first Canadian cultivar with a high degree of resistance to harvest-time sprouting and it establishes a new standard of quality. This

characteristic means that the crop has a lower level of α -amylase activity in wet harvest seasons and meets the stringent requirements of the Japanese market. Columbus is slightly later maturing and higher yielding than the popular cultivar, Neepawa. It has good resistance to leaf rust and bunt, and moderate resistance to stem rust and smut. The overall quality is good.

Progress was evident for the incorporation of sprouting resistance, and additional leaf and stem rust resistance, into the breeding populations.

The genetics of rust resistance was determined in several cultivars. Glenlea was shown to carry *Sr5*, *Sr6*, *Sr7a*, and one or two type 2 genes for stem rust resistance. It has at least three genes for leaf rust resistance: *Lr1* for seedling resistance and two genes for adult plant resistance. Sinton has *Lr10* for seedling resistance plus *Lr13* and one of the Glenlea genes for adult plant leaf rust resistance. Hork "S," a cultivar from the International Maize and Wheat Improvement Center, has *Lr10* for seedling resistance and *Lr13* and *Lr12* for adult plant resistance. The seedling leaf rust resistance of Columbus is due to *Lr16*. Lines with stem rust resistance derived from *Agropyron* (*Sr26*), *Aegilops ventricosa* Tausch and *Triticum persicum* var. (VPM), and *T. longissimum* (Scheinf. & Muschli in Muschli) Bowden appear to have satisfactory quality.

An increase in protein content, achieved by nitrogen fertilizer application, was shown to increase the water absorption capacity of flour and to decrease the mixograph development time in five Canadian cultivars. The effect of protein content on extensigraph areas differed among cultivars. Remix and blend-loaf volumes increased with increasing protein content for each cultivar. Quality evaluation of Rescue-Cadet chromosome substitution lines showed reciprocal chromosome effects in the direction of the donor parent for mixograph development time with chromosome 1A, farinograph absorption with 2A and 6B, and grinding time with 1A, 1B, and 6D. Cadet chromosomes of the homologous groups 4 and 7 had a major effect on Rescue quality.

Durum wheat

Two lines from the breeding program were advanced in the cooperative test. After further evaluation the most promising appears to be DT 433, which yielded 108% of Coulter in

the Black soil zone and was equal to the best check cultivar in the Brown soil zone after 2 yr of testing.

A preliminary study established that a link existed between factors controlling glume color and electrophoretic banding patterns of gliadin proteins, specifically bands 42 and 45. These bands were earlier shown to be associated with gluten strength. It is now suggested that gluten strength is controlled by a factor associated with glume color and bands 42/45, and one or more factors segregating independently.

The sodium dodecyl sulfate (SDS) sedimentation test to measure protein quality was further modified to speed processing of samples. This modified test is being utilized in the quality screening program.

Oats

The oats line O.T. 210 was licensed as the cultivar Fidler. This cultivar is adapted to the eastern prairie region because it possesses highly effective multigenic resistance to stem rust and crown rust, and resistance to smut. It has shorter and stronger straw and good yield characteristics.

Promising lines entered in the final testing stage combine rust and smut resistance from *Avena sterilis*, large seed size from Harmon and Kent (an Australian cultivar), and tolerance for barley yellow dwarf virus from Kent.

CEREAL RUSTS

Rust surveys

Stem rust of wheat. Wheat stem rust was scarce in Canada in 1979 because little airborne inoculum was introduced from the south; hot dry weather during July and August was unfavorable for rust development; and rust-resistant cultivars were planted in the rust-prone areas. Twenty-one races were identified in Canada in 1979, three of which were new. Race C25, first identified in 1965, was potentially the most dangerous. It has been isolated with increasing frequency in recent years, although it has not been found in farm fields and does not appear to threaten resistant commercial cultivars. Nevertheless, it has shown some virulence on these cultivars in greenhouse trials.

For many years most wheat stem rust collections in Western Canada were made from the wild grass, *Hordeum jubatum* L. In 1978, however, a sudden change occurred and

the preponderance of rust found on this grass shifted from wheat stem rust to rye stem rust. This situation persisted in 1979, and because rust has not been found in farm fields of resistant varieties for many years, nearly all the wheat stem rust collections identified in the race survey were from three plots of the susceptible cultivar Klein Titan planted at Morden, Portage, and Brandon, Man. Similar plots sown at six locations in Saskatchewan produced only three pustules. There is always a concern that the limited number of samples identified may not be representative of the wheat stem rust population. Nevertheless, we feel that no important new race went undetected.

Leaf rust of wheat. Rust surveys carried out in Manitoba and Saskatchewan indicated that wheat leaf rust occurred at very low levels of infection in 1980 and did not cause any damage to the wheat crop. Preliminary identifications of races indicated that only a few races of leaf rust were present in Manitoba in 1980 and these could not attack any of the recommended resistant cultivars.

The identification of races from leaf rust survey samples was carried out in 1979 with 19 backcross differential lines of wheat. Lines with resistance genes *Lr16*, *Lr19*, *Lr21*, and T⁴ × PI 58548 were resistant to all isolates of leaf rust, and *Lr11* was attacked by only a few isolates from Ontario. Thirty virulence combinations on 14 genes for resistance were identified.

Oat crown rust. Avirulence–virulence combinations in crown rust were identified using 19 single-gene lines in 1979. Thirty-three combinations collected from across Canada were identified, but there were no important changes in the populations that could affect advanced breeder lines or the sources of resistance being used in the Winnipeg breeding program.

In 1980 crown rust occurred throughout most of Manitoba and eastern Saskatchewan, but infections were the lightest in many years, with almost no crop damage, even in late maturing fields.

Oat stem rust. Avirulence–virulence combinations of oat stem rust were identified using nine backcross single-gene differential lines in 1980. Twelve combinations were identified from across Canada but there were no changes in the rust population that could threaten advanced breeders lines or the new

rust-resistant cultivar, Fidler, in Western Canada. The resistance conferred by gene *Pg-16* remains effective against all isolates identified in Canada, and the resistances conferred by gene *Pg-13* and the *Pg-a* complex were highly effective against more than 99% of the isolates identified in 1979. In 1980, stem rust occurred throughout Manitoba and eastern Saskatchewan, but infections were light and there was very little crop damage. The 1980 physiologic race survey in Eastern Canada was expanded to include a 'trap nursery,' and two new avirulence–virulence combinations were identified.

Resistance to the rusts

A number of accessions from the World Wheat Collection were tested in the seedling and adult plant stages with eight races of leaf rust. A number of potentially useful sources of resistance were identified. Genes *Lr3* and *Lr10* occurred in a number of these accessions. The incorporation of additional genes for resistance to leaf rust into the cultivar Benito was continued. Genes *Lr3ka* and *Lr21* are being backcrossed into this cultivar.

A botanical expedition to the Canary Islands, northwest Africa, and the Iberian Peninsula in quest of new genetic resources produced 3850 accessions of *Avena*, *Hordeum*, *Triticum* and *Aegilops*.

Three hundred and sixty new accessions from Turkey and Iran were tested for stem rust and crown rust resistance. Although new resistance was identified, it is at the tetraploid level, making it difficult to utilize.

Molecular biology and ultrastructure of the cereal rusts

Lectin-coated gold particles were used as histochemical markers to detect lectin receptors in ultrathin sections of stem rust uredosporelings and rust-infected wheat leaves.

Con A receptors, presumably consisting of glucan or mannan, or both, were found in spore walls but not in germ tube walls. No receptors for soybean lectin (galactose-specific) or *Lotus tetragonolobus* lectin (fucose-specific) were detected, although gas chromatography indicated that galactose and fucose may be present in macromolecular constituents of germ tube walls.

Wheat germ lectin-coated gold (specific for *N*-acetylglucosamine) showed anomalous behavior in the presence of chitin hydrolysate. The latter inhibited binding of the lectin to

lectin-specific receptor sites on germ tube walls, confirming the presence of chitin. On spore walls, however, it not only failed to inhibit binding, but greatly promoted it. Further work is necessary to determine the nature of wheat germ lectin receptors in spore walls.

The ultrastructural and histochemical analysis of tissue infected with wheat stem rust indicated that the neck wall and body wall of haustoria contains Con A receptors. Wheat germ lectin receptors were found in hyphal walls and in the body wall of old haustoria but not in those of young haustoria or in haustorial neck walls. The extrahaustorial matrix contained Con A receptors and probably cellulose as well, but no wheat germ lectin receptors. The possible presence of cellulose may indicate that this structure is of host origin.

A histochemical study was conducted to identify the major components of the structures at the host-parasite interface in oat leaves infected with crown rust, including the haustorium mother cell wall, the septum and septal protrusions, the adhesive substance attaching the haustorial mother cell to the host wall, the haustorial neck and body walls, the haustorial neck ring, and the interacting regions of the host cytoplasm. Comparisons were made between dikaryotic haustoria in oats and monokaryotic haustoria of this fungus in buckthorn. Information was obtained to aid in defining monokaryotic haustoria.

Germ tube walls of wheat stem rust uredosporelings were extracted using five different methods to solubilize macromolecular wall constituents. The extracts contained various amounts of protein and bound sugars (mannose, glucose, galactose, fucose, and *N*-acetylglucosamine), depending on the method of extraction. The macromolecular components were further characterized by passage through columns of Sepharose-bound Con A, revealing the presence of glucose or mannose, or both, in terminal positions.

Protein was extracted from resistant and susceptible near-isogenic lines of wheat and compared by slab gel electrophoresis and isoelectric focusing to detect the product of the gene for resistance. This comparison was hindered by the presence of the major leaf protein, chloroplast fraction I protein. Therefore, leaf proteins were prefractionated to obtain a membrane-enriched fraction relatively free of fraction I protein. Similar

membrane-enriched fractions were prepared from ditelosomic lines of wheat missing either 2D α or 6D β chromosome arms. Evidence was obtained that the susceptible line has one additional protein not found in the resistant line or in the ditelosomic lines.

OTHER CEREAL DISEASES

Smuts

Smut was found in 73% and 64% of the barley fields examined in the Prairie Provinces in 1979 and 1980, respectively. The levels of *Ustilago nuda* (Jens.) Rostr. and *U. nigra* Tapke were lower in 1980 than in 1979, whereas *U. hordei* (Pers.) Lagerh. was found at the unusually high level of 20–25% in three fields in Saskatchewan.

Different strains of *U. nigra* and *U. nuda* were used to demonstrate that these two barley loose smuts are more difficult to differentiate than commonly assumed. Laboratory germination is required for positive identification.

Bromus was shown to be a new host for *U. avenae* (Pers.) Rostr. and *U. kollerii* Wille.

The smut *Ustilago aegilopsidis* Picbauer, collected on *Aegilops caudata* L. in Turkey and on *A. cylindrica* Host in Azerbaïdzhân, was hybridized with false loose smut of barley collected in Canada, Turkey, and Azerbaïdzhân. Behavior of the progeny suggests that the two smuts, pathogenic on species of *Aegilops* or *Hordeum*, are conspecific and could be a link between ancestral species and the present species that are specialized on either wheat or barley.

Foliage diseases

Breeding lines and entries in the cooperative barley test were tested for resistance to leaf stripe, net blotch, and scald. Good resistance against scald was identified in the recently licensed barley cultivar Johnston.

A genetic study with net blotch indicated that the gene for resistance found in CI 9214 is different from that found in CI 5791. The presence of modifying factors, however, may preclude effective use of CI 9214 as a resistant donor. Field inoculation of cultivars Klages and Norbert barley with *P. teres* was repeated successfully by using a mechanical air pump to apply inoculum. The use of plastic bags on inoculated plants to stimulate the development of the disease was found to have a detrimental effect on grain yield.

The major components of the microflora of seed of four malting barley cultivars grown at six Canadian locations in 1979 were determined. Differences between locations and cultivars were noted. The cultivar Bonanza had the cleanest seed and should be used as a standard in future testing.

Viruses

Some of the properties of the protein and ribonucleic acid (RNA) of oats necrotic mottle virus (ONMV) were determined. The molecular weights of ONMV protein and nucleic acid were determined by polyacrylamide gel electrophoresis. Two bands were consistently found on gels for the protein with mean molecular weights of 39 800 and 29 400. It is suggested that the slow component represents the true viral protein and that the fast component is a breakdown product. Glycoproteins were not detected in the virus. When ONMV nucleic acid was run on the gels, only one band was found with a mean molecular weight of 2.6×10^6 . Enzyme treatments indicated that the virus contained single-stranded RNA.

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: 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

The keeping quality of soybean seed, cultivar Amsoy 71, was determined by monitoring biotic and abiotic variables in seed lots of 13.1% and 17.3% moisture content stored at 10° and 30°C under aerobic and anaerobic conditions for 22 wk. Seeds of both moisture contents stored at 10°C had negligible quality loss after 22 wk. At 30°C under anaerobic conditions, however, fat acidity values (FAV) increased sharply, seed viability was drastically reduced, and microorganisms developed

rapidly, thereby substantially reducing quality. The relative ratio of triglycerides did not change during the 22-wk period. The major postharvest microflora that developed on the soybeans were: *Penicillium* spp., *Aspergillus flavus*, ascomycetes, and bacteria, particularly *Erwinia herbicola*. The mites *Acarus farris* (Oud.) and *Tyrophagus putrescentiae* (Schrank) did not survive on the soybeans; in contrast, the red flour beetle multiplied on seeds at 30°C under aerobic conditions.

Principal component analysis was used to determine the relative importance of changes in wheat stored at 15.5% moisture content and artificially infested with lesser grain borer, rice weevil, red flour beetle, rusty grain beetle, and sawtoothed grain beetle. Tri-weekly and cumulative 60-wk analyses showed that high bacterial counts were associated with high FAV. The mite *Tarsonemus granarius* Lindquist, which was present initially in the grain, was positively correlated with the storage fungi of the *Aspergillus glaucus* group and *Aspergillus candidus* Link. The field fungi *Alternaria* spp. and seed germination were negatively related to FAV, bacteria, and grain damage. The number of insects was related to the presence of *Aspergillus* and negatively related to the presence of bacteria. The combined action of the lesser grain borer and *Aspergillus* spp. increased seed damage and moisture content, thus promoting bacterial growth, which in turn inhibited growth of insects and molds.

In rapeseed stored at 25°C and 12.4% moisture content, *Penicillium* spp. were most frequent after 30 days and *Aspergillus versicolor* after 147 days; at 9.7% moisture content, however, species of the *Aspergillus glaucus* group were most frequent after 50 days. Guidelines for maximum safe storage periods for farm-stored rapeseed at various temperature and moisture levels, derived from laboratory data, were validated with rapeseed data collected from farm bins in Manitoba.

Small-scale field experiments were conducted with rapeseed at 10.9–15.0% moisture content to determine changes in quality. Respiration of rapeseed during the first 7 wk was high, and quality declined progressively during the 65-wk storage as indicated by decreased seed germination, increased leakage of seed electrolytes, and increased free fatty acid levels. There was also an increase in the levels of postharvest molds, *Aspergillus*

candidus, *A. glaucus* group species, *A. versicolor*, *Penicillium verrucosum* var. *cyelopium*, and *Wallema sebi*. The results suggested that moist rapeseed should be dried immediately after combining, because loss in seed quality occurs within 24 h as a result of seed enzymatic action and *Penicillium* activity.

Experiments conducted to simulate the effect of water leakage in a grain bin of wheat on the dynamics of the rusty grain beetle revealed that the most beetles were obtained after 8 wk at 27.5°C when 20 g of water was added to 50 g of wheat. There was no difference between adding 20 g of water initially or adding 5 g per week for 4 wk.

Mycotoxins

Fusarium trichothecene toxins at levels of approximately 6 ppm were discovered in a sample of *Fusarium*-infected wheat from Ontario, submitted by the Grain Inspection Division of the Canadian Grain Commission. Subsequent mass spectrometry analysis of other samples in Agriculture Canada's Ottawa facilities confirmed the presence of vomitoxin and resulted in a temporary embargo of this crop.

Laboratory studies were conducted to examine the natural formation of ochratoxin A, a potent nephrotoxin, in 1-kg parcels of wheat at 20.5% moisture content, at various temperatures. After 10 wk of storage, 8 ppb was formed at 15°C and more than 24 ppb at 22°C. Strains of *Penicillium verrucosum* var. *cyelopium* were associated with the production of this toxin.

Biology

An energy budget was determined for the sawtoothed grain beetle reared singly on rolled oats at $30 \pm 1^\circ\text{C}$ and $80 \pm 2\%$ relative humidity. The mean energy content of a rolled oat is 310 J. It was estimated that 311 J/individual were ingested during an 80-day life-span. The highest rate of oxygen consumption ($1.38 \mu\text{L}/\text{individual per day}$) occurred on the eighth day of the life cycle. It was estimated that a female adult consumes 273 J in 60 days and expends 107 J in egg production, 135 J in respiration, and 12 J as feces.

Studies with the larger grain borer showed that although this species is capable of developing into a serious pest of stored corn in mild climatic regions of Canada, it is unable to reproduce on stored wheat seeds, cultivar

Neepawa. Oviposition occurred on ground wheat or corn at 18–32°C at 70% relative humidity. Maximum lifetime production of 200 eggs per female occurred at 27 and 30°C. The lowest temperature at which adults developed normally over a period of 85 days was 20°C. The shortest mean developmental period was 25.4 ± 0.2 days at 32°C, 70% relative humidity.

Adult rusty grain beetles were found to exhibit a powerful geotactic response resulting in downward movement in wheat-filled containers. When beetles were introduced at the top of a 250-cm column of wheat, significantly more beetles were found in the bottom 25 cm after 3 days than anywhere else in the column. When moisture was added to a 10-cm layer midway down the column, 91% of the beetles congregated after 7 days in either the moist wheat or in the 5-cm layer immediately below. Knowledge of these behavioral responses is helpful in locating insects in grain bins.

A survey of more than 1000 residences was conducted in Winnipeg in 1980 to determine the incidence, distribution, and economic importance of the merchant grain beetle as an urban household pest. About 13.5% of single-family residences and 19.3% of multiple dwellings were, or had been, infested with this species. The percentage of infested apartments increased by 1.3% since 1971.

Control

Field experiments with rapeseed cultivar Tower, stored in a farm granary in which bromophos with active ingredient (ai) at 0.5 g/m² had been applied to the floor and walls prior to storage, showed that after 16 wk bromophos residues ranged from 0.1 ppm in rapeseed samples taken from the center of the bulk to 2.6 ppm in floor samples. After a further 36 wk of storage, bromophos residues in floor samples contained 3.5 ppm. Laboratory studies showed that uptake of bromophos by wheat or rapeseed was higher from wood surfaces than from concrete ($P < 0.01$); uptake of bromophos was higher in rapeseed than in wheat; and both wheat and rapeseed had higher affinities for bromophos than for malathion. The persistence of these chemicals on plywood surfaces was influenced by the type of abrasion applied after treatment. Persistence of malathion emulsified concentrate (EC) and wettable powder (WP) was significantly extended by the abrasive action

of a broom over the surface, whereas the persistence of malathion EC and WP, bromophos EC and WP, and iodofenphos EC was significantly reduced by abrasion with wheat kernels.

Wheat was treated with malathion EC to provide a deposit of 8 ppm prior to storage at seven temperatures from -35 to 27°C. Malathion degraded by <3% during 72 wk of storage at -20 or -35°C, but the degradation process increased progressively as the temperature was increased with losses of 26, 61, 74, 95, and 96% from initial deposits in wheat stored at -5, 5, 10, 20, and 27°C, respectively, after 72 wk.

The effectiveness of carbon dioxide, produced from Dry Ice, for the control of the hairy mite, *Lepidoglyphus destructor* (Schrank), was determined in a column of wheat 179 cm high and 30 cm in diameter. When carbon dioxide concentrations of 1300-1800 mg/L were maintained for 9 days, all adult and nymphal stages of the mite were killed at all depths except near the surface. However, a number of hypopi formed during fumigation emerged as adults after they were removed from the wheat and exposed to normal atmosphere. Thus it appears that CO₂ would be ineffective as a fumigant.

CROP PROTECTION

Research on insect pests of oilseed and field crops emphasizes the development and implementation of better methods of pest management to avoid or reduce damage. The program includes field testing insecticides, developing and testing techniques for monitoring and predicting pest abundance and crop damage, and investigating methods of improving nonchemical control of pests. 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.

Sunflower beetle

Phorate and cloethocarb were effective as in-furrow granular treatments for the control of sunflower beetles on sunflowers. This confirms the results of previous tests with phorate and emphasizes the critical importance of correct placement of granular insecticides in attaining effective control. The

synthetic pyrethroids, decamethrin, cypermethrin, and fenvalerate, were effective as postemergence foliar sprays in the control of adults of the sunflower beetle.

Pea aphid

In cooperation with scientists from the Morden Research Station, preliminary studies were conducted on the role of pea aphid as a vector of seed-borne mosaic virus. A survey of commercial pea fields showed that although aphid populations were very low in the early part of the summer, the aphid populations in more than half the fields exceeded the accepted economic threshold. Both sweep net and foliage samples gave satisfactory estimates of aphid density.

Cutworms

An integrated control program against the strawberry cutworm was developed for and implemented by strawberry growers in Manitoba. Registration was obtained for the use of Lorsban 4C on strawberries, and its use gave 90% control of the cutworm larvae. The early application of spray permitted the development of a natural parasite complex, which destroyed 20% of the remaining larval population; delaying fall tilling until after moth flights in September destroyed 78% of the eggs laid by surviving moths. A second insecticide, Supracide 25EC, gave good control but was less effective than Lorsban 4C.

Experimental manipulation of photoperiod and temperature failed to induce diapause in any stage of the armyworm. It was concluded that the armyworm could not overwinter in Manitoba, because at no stage of development was this pest found to survive exposure of more than 2 wk at 0°C.

Sex attractant trapping has shown that the clover cutworm is normally present and quite abundant in Manitoba, despite the difficulty of locating larvae. In 1980, the first recorded outbreaks of this species were reported on various broad-leaved crops in southern Manitoba. Insecticidal spraying was required, and some fields were destroyed by the feeding of the larvae. Catch data from sex attractant traps were highly variable, indicating that the usefulness of traps may be restricted to predicting larval abundance within fields adjacent to them.

Red turnip beetle

A study of the effect of overwintering temperature on survival of red turnip beetle eggs showed that after 200 days of exposure, all eggs survived at -5 and -10°C , none survived at -20°C , and 58.5% and 73.4% survived at 0°C and -15°C , respectively. The data suggest that the eggs are able to withstand cold temperatures for long periods and that overwintering mortality caused by cold temperatures normally is not an important factor in the population dynamics of the beetle.

Flea beetles

The extremely hot dry weather in the spring and early summer of 1980 caused delayed and sporadic germination of rape and increased the movement of flea beetles, followed by their concentration on patches of suitable food. A sticky-trap warning system to anticipate invasion levels of flea beetles in rapeseed was tested at five locations in Manitoba. Although the drought and very high beetle densities throughout the province interfered with the test, the data obtained revealed that the method is not sufficiently precise to apply to commercial operations.

Exposing caged rape seedlings to very high flea beetle densities (up to 3500/m²) for up to 4 days did not cause a reduction in their subsequent yield, either from adults feeding on foliage or from larvae feeding on roots. Protecting the germinating rape and the young seedlings from adult flea beetle attack for different times and at different periods of growth indicated that damage by adults continued for 15–20 days, most of it inflicted between 5 and 10 days after germination. Because most damage results from the killing of plants at the cotyledon stage, an adequate crop can be produced if at least 45 late germinating seedlings per square metre are protected from beetle attack, and survive. This occurs because there is little correlation between plant densities above 45 and seed yield, when yield per plant decreases as plant density increases.

Despite the low soil-moisture conditions early in the summer, the use of in-furrow granular insecticides resulted in better plant development and higher yields of rapeseed than other insecticides tested. New granular formulations of aldicarb and clothocarb compared well with carbofuran and warrant further testing. Seed dressings lacked the

persistence to provide protection much beyond the period of seedling emergence and allowed flea beetles to cause severe plant damage and retarded development. No outstanding new seed dressings were identified, but some entries will be retested in a year of less extreme weather. Postemergence foliar sprays were generally ineffective, except for decamethrin, a new entry among the synthetic pyrethroids. This failure was a result of damage having occurred before spraying and the short residual effect of these sprays.

It has been established that rapeseed yields in Manitoba average about 15% higher when carbofuran is used as an in-furrow granular treatment than when lindane is used as a seed treatment or postemergence foliar sprays are applied. In addition, yields are usually not significantly enhanced by seed treatments or sprays when compared with nontreated controls.

A further 653 adults of *Microctonus bicolor*, a European parasite of flea beetles, were released in the attempt to increase parasitism. Over 5000 adults of the flea beetle *Phyllotreta striolata* (F.) and smaller numbers of *Phyllotreta cruciferae* (Goeze) and *Psylliodes punctulata* Melsh. were collected and reared, but there was no evidence that the European parasite, released in small numbers in 1978 and 1979, had become established.

Medium- and small-plot systems were tested as a means of screening genetic lines of crucifers for seedling resistance to flea beetle damage. A single-row system with sequential seeding of groups of replicates revealed moderate to high levels of resistance to seedling damage in some lines.

Survival of overwintering flea beetles in riverbank forest litter was found to be very high: nearly 100% for *P. striolata* and about 80% for *P. cruciferae*.

Continuous culture of flea beetles under laboratory conditions is extremely difficult. Egg production was measured for flea beetles collected in the field in late summer and conditioned for storage at 2°C by maintaining an 8:16 h light-to-dark cycle and by decreasing the rearing temperatures. Viable eggs were produced at a rate of 1.2 per female per day for a 2-wk period from groups of 200 adults caged over rapeseed seedlings. Egg productivity was not affected by storing females at 2°C for up to 30 wk.

Bertha armyworm

The techniques previously developed to detect and predict the location and severity of bertha armyworm infestations were tested and gave excellent results. Sex attractant traps were placed at 13 locations in Manitoba. Those locations with less than 25 moths per trap did not develop damaging larval infestations. Early larval surveys taken at the locations producing higher catches confirmed the abundance of larvae and enabled an early warning to be issued to growers. Subsequently, spraying was restricted to about 3200 ha of rape in the areas where damaging infestations were predicted.

Collections made during the late larval stages showed a 33% mortality from parasites and diseases, and 50% survival to healthy pupae. This indicates a high potential for increased populations in 1981. The overwintering survival of pupae can be estimated from the duration of their exposure to low soil temperatures. Equations have been developed and are currently being tested for predicting soil temperatures in rape fields from air temperature and snow cover.

The effect of different levels of bertha armyworm infestations was determined in farm fields by estimating larval density in the field and then protecting part of the field from aerial spraying. Spraying did not significantly increase yields in fields with initial larval densities of 10–30/m² because of high variability in the yield of the small sample plots. In fields with larval densities of 63–150/m², the differences in yield were significant, and the average loss per larva was 0.319 g, similar to the 0.325 g/larva estimated in previous cage trials.

A dose-effect test of Dipel, an insecticide based on *Bacillus thuringiensis* formulation, was run on fifth and sixth instar larvae of the bertha armyworm. Feeding inhibition was observed, but there was little kill except at very high doses. Thus, it was predicted and confirmed that applications of 0.45 kg/ha would not reduce damage sufficiently to increase seed yield.

Neurophysiology

Octopamine has been identified as a major neurotransmitter in the central nervous system of insects, opening the way for research

and development of new insecticides that block or interfere with the octopaminergic system.

Taurine, a putative inhibitory neurotransmitter, was studied in detail in the brain, blood, and whole body of the bertha armyworm during larval growth, and diapause and postdiapause development. The study revealed a close correlation between taurine and certain developmental events that occur during metamorphosis. No correlation, however, was evident between the induction of diapause and levels of taurine occurring in the larval brain during diapause induction. Feeding taurine to the larvae did not reverse the induction of diapause, and it was therefore concluded that manipulation of taurine in the larval stage is not likely to affect the diapause-triggering mechanism.

Grasshoppers

In 1980, approximately 30 350 ha were sprayed to control grasshoppers, a fourfold increase from 1979. The adult survey, conducted in the fall of 1980, showed that the infested area had increased slightly from the previous year. Nevertheless, population densities are expected to be lower in 1981. The largest area of infestation was in the south central part of Manitoba, extending south from Neepawa and Gladstone. Infestations were light except for two small areas of moderate infestation. The second largest area infested was east of the Red River and covered most of the municipalities of De Salaberry and Franklin. Infestations ranged from light to moderate. A smaller, light-to-moderate infestation was present in the area extending from Brandon, south and east to Rathwell between the Assiniboine River and Highway 2. Three areas of light infestation were located in the Red River Valley west of the Red River.

Infestations in the Red River Valley were mainly along roadsides, where the dominant species was the two-striped grasshopper, *Melanoplus bivittatus* (Say). In the south central area, pastures, hay land, and some roadsides were infested, and the clearwinged grasshopper, *Camnula pellucida* (Scudder), was dominant.

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Research Station

Melfort, Saskatchewan

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J. WADDINGTON, B.Sc., M.Sc., Ph.D.	Forage ecology and weed control

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W. F. NUTTALL, B.S.A., M.Sc., Ph.D.	Soil fertility

Departures

A. G. CASTELL, B.Sc., M.Sc., Ph.D. Transferred to Brandon Research Station, August 1980	Crop utilization, swine nutrition
L. H. GUTEK, B.Sc., M.Sc., Ph.D. Resigned December 1980	Crop evaluation and agronomy
S. O. THORLACIUS, B.Sc., M.Sc., Ph.D. Died April 1980	Ruminant nutrition

INTRODUCTION

Scientists at the Melfort Station are involved in the development of forage production and utilization systems designed to provide beef cattle producers with an alternative to expensive feed grains and to encourage greater use of forage crops in rotations, in the interest of better land management; the improvement of the long-term production efficiency of cereal, oilseed, and special crops; and the development of efficient cow-calf management systems in the northern park belt.

The transfer of Dr. Castell and the swine nutrition (crop utilization) program to the Brandon Station and the sudden passing of Dr. S. O. Thorlacius, our ruminant nutritionist, adversely affected the Station's research program. Dr. Thorlacius was carrying on an excellent program on utilizing forages and crop residues and preserving high-moisture hay. He is sadly missed by his colleagues.

Brief summaries of some of our work are presented here. For more details, readers may refer to the publications listed at the end of this report or may obtain a copy of our *Research Highlights* by writing to the Research Station, Research Branch, Agriculture Canada, P.O. Box 1240, Melfort, Sask. S0E 1A0, or by telephoning (306) 752-2776.

S. E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Effects of companion crops and fertilizer on forage yields

Bromegrass (*Bromus inermis* Leyss.) seeded in pure stands on summerfallow in six experiments produced a 4-yr total of dry matter (including seedling year) of 17 t/ha from one annual harvest at the flowering stage. Use of wheat (*Triticum aestivum* L.) or Argentine rapeseed (*Brassica napus* L.) as companion crops reduced the yield of bromegrass by 24% and 30%, respectively.

Similarly, alfalfa (*Medicago media* Pers.) produced 14 t/ha over a 4-yr period, with yield reduced by 28% when either wheat or Argentine rapeseed was used as a companion crop. Bromegrass outyielded alfalfa, probably because of the high levels of N in the summerfallowed land.

In the first year after seeding on stubble, alfalfa yielded 6000 kg/ha when seeded without wheat and only marginally lower when seeded with wheat. However, alfalfa established with wheat fertilized with N at 50 kg/ha produced 25% less. Phosphorus or additional N applied at time of seeding had little effect on subsequent yield.

Effect of fall cutting date on yield and bud development of alfalfa

Fall cutting dates ranging from 15 August to 15 October affected yield and elongation of crown buds of cultivars Beaver, Rambler, and Anchor in the first harvest year. Harvest taken 1 September was 9–32% higher than on other dates. Highest numbers of elongated crown buds (4–5.5 per plant) were found on plants of Anchor and Beaver harvested on 15 September and of Rambler harvested on 30 September. Number of rudimentary crown buds (3–4 per plant) was unaffected by fall cutting date, whereas number of branch buds doubled (2 per plant) when cutting was delayed to 15 October.

Evaluation of forage cultivars

Sweetclover, *Melilotus officinalis* L. 'Madrid', yielded 24% more forage (7212 kg/ha) and 55% more seed (1044 kg/ha) than the recommended cultivar Yukon, which is more winter-hardy. A low-coumarin selection from Saskatoon Research Station (L.C. Syn.) produced as much forage and seed as Yukon and 49% more forage and 30% more seed than *Melilotus alba* L. 'Polara'.

Meadow bromegrass, *Bromus biebersteini* Roem and Schutt 'Regar', yielded 18% less forage than smooth bromegrass, *B. inermis* 'Carlton'. A new selection, S-7414, from the

Saskatoon Station nearly equaled smooth brome in the first 2 yr of production.

Response of forage species in a community pasture to N and P fertilizers

Nitrogen fertilizer applied at 45 and 90 kg/ha in combination with P fertilizer at 20 kg/ha on forage species in a community pasture located on a Gray Luvisolic soil over a 5-yr period increased herbage yield from 933 kg/ha (control) to 2021 kg/ha (N at 90 kg/ha and P at 20 kg/ha). A single application of N at 180 kg/ha and P at 78 kg/ha every 4 yr produced an average yield of 1738 kg/ha of herbage per year, which was equivalent in yield (1721 kg/ha) to N applied at 45 kg/ha and P at 20 kg/ha applied every year.

Cow-calf management systems

A severe drought reduced length of grazing season in 1980. Cow-days per hectare ranged from 67.4 to 83.8 on pastures fertilized with N and P and 53 on nonfertilized pastures. Cow-calf gain per hectare was 113.2 kg for fertilized rotationally grazed fields compared with 71.9 kg for continuously grazed nonfertilized fields.

Actual weaning weight for the early born calves (January-February) was 48.5 kg higher than for late born calves (March-April). During the winter, early calving cows consumed 11% more dry matter than those calving late. A severe outbreak of calf scours occurred; 45% of early calves and 53% of late calves had to be treated for Rotavirus.

Remote sensing

A contract research project was conducted by Intera Environmental Consultants of Calgary to develop a method for estimating the total biomass of a parkland-seeded community pasture. The hue, value, and chroma of false-color infrared photographs obtained by aircraft and Landsat satellite were described according to the InterSociety Color Council - National Bureau of Standards method for designating color. These values were related to the dry-matter data obtained at specific sites on the pasture. Using interpreted characteristics of texture and color from 1:8000 scale false-color infrared photography, productivity levels of 50 g/m² could be identified and levels of about 100 g/m² from enlargements of Landsat imagery could be obtained.

Annual versus perennial pastures for sheep

In a 7-yr grazing experiment, in which annual cereals (oats, barley) were compared with perennial grass-legume mixtures (brome-alfalfa, brome-sainfoin) as pastures for sheep, gain per hectare was highest for oats and brome-grass-alfalfa, both yielding 330 kg/ha. Oats provided an additional season of grazing during the establishment year for the perennial forages, but annual input costs were higher.

Ammonia as a preservative for high-moisture hay

Application of 1 or 2% (w/w) anhydrous ammonia to high-moisture baled bromegrass hay (31% dry matter) prevented heating and excessive spoilage of the hay. Forage quality did not deteriorate following removal of the polyethylene cover 1 mo after treatment. Crude protein content was increased from 12% (untreated control) to 18% and 21% for the hays treated with 1% and 2% ammonia, respectively. Application of ammonia at either level significantly increased ($P > 0.01$) digestibility of organic matter, protein, and energy. An increase in voluntary intake of treated hays by sheep approached significance at the 5% level.

Effects of wild oats herbicides on seed production of bromegrass and crested wheatgrass

Applications of diclofop (2-[4-(2,4-dichlorophenoxy)phenoxy]propanoic acid) with active ingredient (ai) at 0.7 and 1.4 kg/ha on established bromegrass in spring resulted in lodging of the mature crop in 1979 and in reduced yields of seed in 1980. Barban (4-chloro-2-butynyl-*m*-chlorocarbaniolate) applied at 0.5 kg ai/ha and flamprop (*N*-benzoyl-*N*-[3-chloro-4-fluorophenyl]-DL-alanine) applied at 1.0 kg ai/ha also reduced seed yields in 1980, but had no effect in 1979. None of the herbicides had any effect on crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) in 1979, but flamprop reduced seed yields in 1980.

The dry spring in 1980 reduced seed yields to only 20% of the yields obtained in 1979 and probably contributed to the enhanced effects of the herbicides in 1980.

Acidulated fatty acids (AFA) for growing and finishing steers

Adding 3% AFA (a by-product in the manufacture of canola oil) to a ground crested wheatgrass (78%) and rolled wheat (20%) ration increased rate of gain (1.35 versus 1.18 kg/day) and improved the feed:gain ratio (6.02 versus 6.81). Also, gains in steers were worth \$20 more per head at the end of the 84-day test.

A similar test indicated that although implanting with Ralgro and adding 3% AFA to the ration increased both rate of gain and feed efficiency, the combination of treatments gave the best results, increasing the rate of gain from 1.29 to 1.43 kg/day and improving feed:gain ratio from 7.10 to 6.55.

In a steer-finishing trial, adding 0, 3, 4, and 5% AFA to the ground-hay ration produced rates of gain of 1.38, 1.45, 1.53, and 1.52 kg/day, respectively, and feed:gain ratios of 10.2, 9.4, 8.8, and 8.9. Return per head averaged \$18 loss, \$9 gain, \$3 loss, and \$4 gain per head, respectively, indicating that the optimum level under current price situations is not over 3%. In the same test, adding monensin (Rumensin) or Avoparcin to the ground hay + 3% AFA ration reduced rate of gain, feed efficiency, dressing percentage, and carcass grades, thereby reducing returns per head by \$22 and \$16, respectively.

Effect of growth-promoting implants administered to steers fed a ration with and without monensin

On an 80-day test, growing steer calves receiving no monensin in a ground hay (78%) ration gained 0.72, 0.97, and 1.20 kg/day when receiving no implant, 36 mg of Ralgro, and 220 mg Synovex S, respectively. Comparable rate of gains were 0.88, 0.85, and 1.10 kg/day when the ration was supplemented with 11 g of monensin per tonne of dry matter.

Development of Schwarting hay tower system

A special thrust bearing was made and installed on the bung in the Schwarting hay tower. This arrangement prevented the bung from rotating with the central shaft and made it possible to lower the bung below the hay surface. This considerably reduced air leakage around the bung and thus improved drying efficiency.

PRODUCTION AND UTILIZATION OF CEREALS AND SPECIAL CROPS

Cultivar testing

Columbus, a new hard red spring wheat, outyielded Neepawa by 12% over the past 3 yr. It is 3 days later in maturity but has improved resistance to weathering in the swath. Benito, a new cultivar, yielded slightly less but is 1 day earlier than Neepawa.

Klondike and Johnson, six-rowed feed barley cultivars, outyielded Bonanza, a commonly grown six-rowed malting cultivar, by 5 and 20%, respectively. Johnson, released recently, has poor lodging resistance and is late in maturity. Klages, Elrose, Summit, and Norbert, two-rowed barley cultivars, yielded 4755, 4423, 3861, and 4479 kg/ha, respectively, in comparison to Betzes, the standard at 4300 kg/ha over the past 2 yr at three testing sites in the area. Norbert, the newest cultivar, has quality equal to Klages and has better disease resistance, stronger straw, and good kernel and test weight, and it is 2–3 days earlier.

Altex rape was 7% lower yielding but 3–4 days earlier than Regent, the commonly grown 0-0 *B. napus* rape cultivar. A selection approved for licensing in 1980, 75G-2180, yielded 7% higher than Altex at Melfort in 1980.

Management studies

The use of zero-till drills that leave the stubble standing to hold snow produced 25% higher yields than did discer seeding of winter wheat on stubble over the past 2 yr. An application of N at 112 kg/ha produced a yield increase (over check) of 62% when using the zero-till drill. In spring wheat, direct seeding with the discer with a heavy packer produced 18% more grain than hoe press-drill seeding into a prepared seedbed on stubble over the past 2 yr. A broadcast application of N at 56 and 112 kg/ha increased the yield with the discer by 57 and 65%, respectively.

Summerfallow studies over 15 yr have shown that herbicides are valuable for replacing tillage for weed control, reducing the hazards of soil erosion, conserving energy, and increasing production. Chemical summerfallow was the highest yielding treatment (3542 kg/ha) and normally tilled fallow the lowest (3471 kg/ha). There was no significant difference in the moisture or nutrient status of

the soil between treatments applied to the same plots in a fallow-wheat rotation for the past 15 yr.

Effect of spring- versus fall-applied N fertilizer on cultivar yields

Nitrogen was broadcast on wheat stubble at 45, 67, and 90 kg/ha in the spring and in the fall with P applied at 20 kg/ha. Barley, rapeseed (*Brassica campestris*), rapeseed (*Brassica napus*), spring wheat, and flax were included in the test.

Number of years tested, control yield, and yields resulting from nitrogen applied in the spring and fall were as follows: barley, 11 yr, 2712, 3596, and 3506 kg/ha; rapeseed (*B. campestris*), 11 yr, 937, 1408, and 1311 kg/ha; rapeseed (*B. napus*), 6 yr, 988, 1522, and 1428 kg/ha; wheat, 6 yr, 1884, 2677, and 2213 kg/ha; and flax, 3 yr, 1118, 1269, and 1282 kg/ha.

Cereals for growing-finishing pigs

Bonanza barley (1.78% N), Neepawa spring (2.50% N), and Norstar winter wheats (2.11% N) with soybean meal (SBM) (7.62% N) or canola meal (CM) (5.70% N) were used in six diets (Bonanza barley + 15% SBM; Bonanza barley + 22% CM; Neepawa Spring + 5% CM; Norstar winter wheat + 15% CM; Neepawa spring wheat + 15%

CM; and Norstar winter wheat + 5% CM) fed ad libitum from 25 to 91 kg liveweight. Among pigs fed the first four (16% crude protein) diets, growth rates ranged from 802 g/day (Bonanza barley diets) to 732 g/day (Neepawa spring wheat diet, $P < 0.05$). Feed-to-gain ratio was best with the Bonanza barley + CM diet (3.48:1), and pigs fed Bonanza barley had the leanest carcasses. For pigs fed the four wheat diets, differences because of cultivar were minor at the same level of dietary CM. Apparent digestibilities of energy (77 versus 89%) and N (69 versus 86%) were lower ($P < 0.05$) for barley than for wheat diets but palatability studies revealed a preference for SBM over CM and Neepawa spring wheat over Norstar winter wheat.

Canola meal in market pig diets

Four diets (15.1, 15.6, 16.2, and 16.5% crude protein) containing barley (1.98% N) and CM (5.81% N) with percentage compositions of 84.7 + 12.5, 82.2 + 15.0, 79.7 + 17.5, and 77.2 + 20.0, respectively, were fed ad libitum to pigs from 29 to 91 kg liveweight. Live performance and carcass measurements were not significantly ($P < 0.05$) affected by dietary level of CM but apparent digestibility of energy was reduced ($P < 0.05$) in the 20% CM diet, and CM levels exceeding 15% adversely affected diet palatability.

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Research Station

Regina, Saskatchewan

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INTRODUCTION

This report outlines the work done in 1980 at the Experimental Farm at Indian Head and the Research Station at Regina.

The Indian Head establishment is operated as a substation. The program evaluates new cultivars of cereal, forage, oilseed, and pulse crops for adaptability to conditions in southeastern Saskatchewan. Management research designed to increase efficiency of production of those crops is also conducted, as well as long-term rotation experiments.

The Regina Research Station is the center for weed control research in Canada. Four programs, biological control, weed physiology, weed ecology, and herbicide behavior in the environment, are under way. In 1980, Dr. Jim Hay left the Station to take up the position of the Director at the Research Station, Saskatoon. Miss Betty Guild, the Information Officer, also left to join the noon-hour agricultural program on CBC Radio. Dr. Knud Mortensen, a plant pathologist, has joined the staff to investigate the possibility of using host-specific diseases of weeds as a means of biological control.

The facilities at Regina and Indian Head are also used to increase and distribute breeder seed and seed of new cultivars of cereal, forage, oilseed, and pulse crops developed by the Branch.

Only a portion of the results are reported here. More can be obtained from the scientists at the following address: Research Station, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask. S4P 3A2.

R. Grover
Acting Director

BIOLOGICAL CONTROL

Leafy spurge

A small release of a leafy spurge root-boring beetle, *Oberea erythrocephala* Schrank, made by transplanting infested plants in Saskatchewan in October 1979, produced some survivors in 1980. Larger releases using adult beetles were made in the summer of 1980 in Saskatchewan and Alberta. At one site, larvae became established in only 4% of the stems with oviposition punctures, 16% at another, and 59% at the third site.

Feeding tests on the spurge moth, *Clepsis strigana* Hb., showed that it would feed indiscriminately on a diverse range of plants and hence it is not suitable for introduction as a biocontrol agent. Tests are currently under way on two other spurge moths, *Minoa murinata* (Scop.) and *Lobesia occidentis* Falk.

Knapweed

The colony of the root-boring beetle *Sphenoptera jugoslavica* continued to increase on diffuse knapweed in British Columbia.

Stenodes straminea (Haw.), a moth that attacks both the roots and seed heads of

spotted knapweed, also developed on safflower and globe artichoke in feeding tests and so it is unsuitable for introduction as a biocontrol agent.

Canada thistle

The stem-mining weevil, *Ceutorhynchus litura* (F.), has been established on Canada thistle in a range of climates across Canada, but the loss of eggs and larvae from spring cultivation prevents the establishment of dense populations on cultivated land. In an Ontario pasture, the weevils mined 77–91% of the stems during the past 5 yr; but even this level of attack did not stress the thistle enough to reduce density below the original six to eight stems per square metre.

The stem gall fly, *Urophora cardui* L., spread to over 1000 ha from a release site in New Brunswick, but galls were found on only 6% of the stems.

St. John's-wort

The aphid *Aphis chloris* Koch was released on St. John's-wort in August 1979 near Cranbrook, B.C., but the colony disappeared shortly afterward. Further releases were made in May 1980, and a strong breeding colony was established.

The moth *Anaitis plagiata* was released in the summer of 1980 near Cranbrook, B.C., and two adults were caught in September about 3 km away from the release point.

Field bindweed

Three beetles, *Chirida guttata* Oliv., *Metricona purpurata* Boh., and *Chelymophra cassidae* Fab., collected in Saskatchewan, were released near Medicine Hat, Alta., but none were recovered in 1980.

Absinth

A survey of the abundance and distribution of absinth in Saskatchewan showed that the weed was spreading from several centers, all associated with settlement from central Europe. It was concluded that the present abundance of the weed did not warrant biological control.

WEED ECOLOGY

Weed surveys and crop losses

The analysis of questionnaire data from the 1979 Manitoba provincial survey indicated that 89% of the surveyed area had received a herbicide treatment for the control of broad-leaved weeds and 64% had been treated for the control of grassy weeds. Only 10% of the surveyed area did not receive a herbicide treatment. The herbicide 2,4-D, either alone or as part of a mixture, was applied to 32% of the surveyed area. About 70% of the 2,4-D applied was the amine 80 formulation. Producers indicated in the questionnaire that they considered wild oats, green foxtail, wild mustard, Canada thistle, and wild buckwheat to be their worst weed problems.

A survey of crop losses from weeds in 18 wheat fields was conducted in two soil types near Regina. A comparison of hand-weeded and unweeded plots indicated yield losses (15.5%) on loam soil were higher than the losses (4.5%) on heavy clay soil. Out of the 18 fields examined, 10 had no detectable crop loss.

A survey of weeds of field peas in northeastern Saskatchewan indicated that stinkweed, wild oats, volunteer rapeseed, lamb's-quarters, shepherd's-purse, Canada thistle, and perennial sow-thistle were the most abundant weeds remaining in the fields in August. Plots

established in 22 fields revealed that competition from weeds resulted in an average yield reduction of 15% (range 0–49%).

Rangeland ecology

The lack of available moisture during 1980 prevented the successful establishment of alfalfa when it was seeded directly into herbicide-treated sod. Alfalfa seeds failed to germinate and glyphosate failed to control the resident vegetation. However, when adequate moisture became available during August, a uniform stand of alfalfa was established. This may have occurred because of modifications made to the direct-seeding drill. Packer wheels placed behind the disc openers pressed the sod close to the alfalfa seeds.

In moist years, the yield of brome grass is reduced by the rate of tebuthiuron required to control brush. However, during the dry 1980 season, the yield of brome grass on tebuthiuron-treated plots was either higher or similar to the control.

When 2,4-D was applied once in 1978, three times in 1979, and three times in 1980 to control leafy spurge, it reduced the shoot weight of leafy spurge 62% and increased the yield of forage threefold. Thus, continued use of one to three applications per year of 2,4-D is required to maintain high forage yields and reduce leafy spurge biomass.

Population biology of weeds

Bluebur plants that have not been vernalized rarely become reproductive. When vegetative rosettes were transferred in late November from the field to the growth chamber, they all produced viable seed. A controlled-environment experiment indicated that moist seed was the most responsive stage to the vernalization treatment. A minimum of 4 wk at 2°C is required for a distinct response. Seed was buried in a cultivated field in late November and retrieved at regular intervals until spring. Only a few of the plants (<17%) that were grown from the seed retrieved during the first 18 wk flowered under controlled conditions. During the next 2 wk the seed sprouted in the field. When these germinated seeds were retrieved and grown, 96% of the plants flowered.

WEED PHYSIOLOGY

Seed dormancy in prickly lettuce

Prickly lettuce seeds germinated 34% in the dark at 18°C. Gibberellic acid (GA) was effective in inducing maximum germination. Red light (R) and far-red light (FR) induced 65% and 13% germination, respectively. Repeated reversibility of response by R and FR is clear evidence of control by phytochrome. After 14 days of dark moist storage, the promotive effect of GA, R, and R + GA had decreased dramatically. Thus, dark moist storage treatment interferes not only with the phytochrome-independent germination process, but it may also decrease the effectiveness of endogenous gibberellins. It is concluded that actions of GA require residual active form of phytochrome for initiation of germination, and vice versa, and that both exogenous GA and R or fluorescent light are required for germination when both endogenous hormones and active form of phytochrome in prickly lettuce seeds are below threshold levels.

HERBICIDE BEHAVIOR IN THE ENVIRONMENT

Air monitoring studies

Polyurethane foam plugs were used to collect airborne residues of triallate and trifluralin from 1 May to 15 November at Regina and Melfort. In general, triallate residues were found daily at both sites and the maximum concentrations were 40 ng/m³ on 27 May at Melfort and 36 ng/m³ on 15 July at Regina, the Regina results being reflective of the dry spring and early summer conditions. Airborne residues of trifluralin were detected daily at Melfort, the highest concentration being 35 ng/m³ on 6 October, suggesting perhaps a high use of this herbicide in the fall. Little or no airborne residues of trifluralin were found at the Regina monitoring site.

Surface runoff losses of 2,4-D

A first of its kind 5-yr study on the surface runoff losses of fall-applied 2,4-D has been completed. The magnitude of loss was a function of runoff volume, as expressed by the equation: $y = 0.45x + 2.45$ ($r^2 = 0.97$), where y is the amount of herbicide in the runoff (grams per hectare) and x is the runoff volume (millimetres). In terms of percentage

loss, the 5-yr average is 3%, with maximum observed loss approaching 7%.

Persistence in soils

For the third year, the soil persistence of May treatments of EPTC (4 kg/ha) and propanil (1 kg/ha) was studied at three field locations. Overall assessment of the 3-yr study is that propanil does not persist in the top 10 cm of soil and is completely degraded over a single growing season. Carry-over of EPTC in the top 15 cm of soil at the end of a growing season is less than 5%.

The presence of MCPA in MCPB-treated soils has been established. Although MCPA has been suspected as being a soil metabolite, this is the first report of its confirmed presence.

Herbicide residues in minor crops

Residues of trifluralin and metribuzin in fababeans, when treated with a preemergence tank mix application, were found to be less than the limit of detection (20 ppb) of the analytical methodology.

CROP MANAGEMENT

Long-term crop rotation studies

In 23 consecutive years, the continuous production of unfertilized wheat has produced an average yield of 102.8 kg/ha compared with 1653 kg/ha for crops fertilized with N and P at 84.0 and 44.8 kg/ha, respectively. Over the life of the trial, yields have fluctuated widely, reflecting annual rainfall patterns.

Continuous cropping of wheat has given rise to serious weed infestations. In particular, Canada thistle (*Cirsium arvense* (L.) Scop.), green foxtail (*Setaria viridis* (L.) Beauv.), thyme-leaved spurge (*Euphorbia serpyllifolia* Pers.), and wild buckwheat (*Polygonum convolvulus* L.) have been found difficult to control in most crop years. Weed kinds and numbers varied in response to soil fertility, with thistles and spurge finding greatest adaptation on soils that were deficient in N and P.

The continuous cropping of wheat, flax, and barley, with and without chemical fertilizers, has been under study for 12 yr, during which time wheat and barley failed to produce in 1 yr (1980) and flax in 2 yr (1974, 1980). Over the life of the test, unfertilized wheat and

barley averaged 23.1 and 28.3 kg/ha over an 11-yr period, whereas flax produced an average of 13.2 kg/ha over 10 crop years. Chemical fertilizer applied banded, with N at 100.0 kg/ha and P at 44.8 kg/ha, increased average wheat yields by 106.0%, barley by 122.9%, and flax by 81.1%.

The production of wheat on fallow with phosphatic fertilizer has averaged 41.2 kg/ha over the past 23-yr period, some 9.3% higher than for nonfertilized crop. Fertilized crop grown in a fallow-wheat-wheat sequence has averaged 42.3 and 28.9 kg/ha, respectively, over the same period, the stubble crop yielding 32.2% less than for wheat on fallow.

Although it is evident that continuous cropping of wheat can provide yields equal to wheat on fallow on a cultivated hectare basis, its long-term practice is hampered by inadequate weed-control measures, inability to incorporate trash, and periodic moisture constraints in southeastern Saskatchewan.

Protein analysis of wheat has shown that the protein content is higher when wheat is grown in a mixed rotation with legumes. Fallow and stubble wheat from an 8-yr mixed sequence averaged 14.68% and 13.10% protein, compared to 10.53% for wheat produced in a fallow-wheat rotation. Under continuous cropping, wheat averaged 10.68% protein.

Nonprotein nitrogen in grain legumes

Seed samples of nine grain legume species contained 16-75 mg nonprotein nitrogen and 17-32 mg of nucleic acid nitrogen per gram of total nitrogen. The corresponding ranges for

one species of field peas were 27-72 and 25-32 mg/g total nitrogen, respectively. The total nonprotein nitrogen was 3.6-5.7% of the total seed nitrogen. When a nitrogen-to-protein factor is used to calculate protein, that factor should be corrected for the nonprotein nitrogen.

SEED INCREASE AND DISTRIBUTION

In 1980, Agriculture Canada released to SeCan 43 627 kg of Fidler oats, 8374 kg of Johnston barley, and 11 810 kg of Columbus wheat, which were increased at Regina; and 8144 kg of Gordon winter wheat, 1257 kg of Manor buckwheat, and 231 kg of Musketeer tall rye, which were increased at other locations. Breeder seed of 37 varieties was released to 475 growers.

A 7.3-ha winter nursery in California was used by 26 breeders. Four small-hectare rapeseed increases were successfully completed. Improvements in mechanization of the winter nursery equipment continue to improve the efficiency of the planting operation. The plant breeders involved are making more use of the program as a selection nursery than as a bulk-increase program.

The Food Production and Inspection Branch and the Canadian Seed Growers Association supplied the 1866 seed samples grown for verification of varietal purity in 1980. In general, the contamination of samples was low again this year, with no variety showing consistent problems.

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Research Station

Saskatoon, Saskatchewan

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Departures

G. R. STRINGAM, B.S., M.S., Ph.D. Resigned 1 October 1980	Cytogenetics of <i>Brassica</i> spp.
M. E. TAYLOR, B.S.A. Retired 31 October 1980	Research Information Officer

VISITING SCIENTISTS

S. N. ACHARYA, M.Sc., Ph.D. Canola Council of Canada visiting fellow, 1980–1981	Plant pathology
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E. ACIKGOZ, B.Sc., Ph.D. National Research Council of Canada visiting fellow, 1980-1981	Plant breeding
J. R. KING, B.Sc., Ph.D. National Research Council of Canada visiting fellow, 1978-1980	Plant physiology
S. K. RAINA, B.Sc., M.Sc., Ph.D. Rotary Foundation Fellow, 1977; National Research Council of Canada visiting fellow, 1978- 1980	Insect physiology

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INTRODUCTION

The Saskatoon Research Station, in conjunction with the Scott Experimental Farm, made significant progress toward improved production and protection of grains and forage crops in 1980, despite the serious climatic difficulties of drought, hail, and frost. The release of the world's first low coumarin sweetclover, *Melilotus officinalis* (L.) Lam., is a major step toward greater and safer utilization of this important legume in North America. Similarly, the development of a high seed- and oil-yielding replacement for the low erucic acid, low glucosinolate rapeseed variety Candle will permit the smooth and complete changeover to canola-type rapeseed in Western Canada. The demonstration of the efficiency of bran baits for grasshopper control and the explanation of their effectiveness should lead to lower costs and reduced environmental risks. However, there were disappointments, such as the first identification in Saskatchewan fields of a serious disease of alfalfa, verticillium wilt, and the conclusion, after much investigation, that *Coniothyrium minitans* Campbell does not provide sufficient protection against sclerotinia disease to be commercialized as a biological control agent.

We regret the retirement of Information Officer M. E. Taylor and the unexpected resignation of Dr. G. R. Stringam. Their expertise will be greatly missed.

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.

R. K. Downey
Acting Director

CROPS

Oilseeds

Rapeseed breeding. Eighty percent of the 1980 Canadian rapeseed crop was seeded to varieties producing low erucic acid oil and low glucosinolate meal. These varieties are now widely referred to as canola in the industry. The complete changeover to varieties with these improved quality characteristics is largely dependent upon the displacement of the low erucic acid *Brassica campestris* L. variety Torch, which still constitutes about 15% of the crop. Release of a new double low *B. campestris* variety superior in performance to Candle will ensure that this is accomplished. Strain DH-716 has averaged 8% higher in seed yield than Candle and 0.7% higher in oil content in 2 yr of cooperative testing and will be proposed for licensing in 1981. In addition, DH-716 has a good level of resistance to white rust-staghead disease (*Albugo candida* (Pers. ex Lév.) Ktze.), and it will be the first Canadian *B. campestris* variety to incorporate this characteristic. It is similar to Candle in seed color, days to maturity, and plant height. By 1983 DH-716 is expected to occupy a major portion of the *B. campestris* area in Western Canada.

F₁ hybrids produced through natural field crossing of *B. campestris* subspecies have yielded 40% more than the check varieties Torch and Candle in 2 yr of preliminary evaluation. Although this material contains high levels of erucic acid and glucosinolates, the heterosis for seed yield and seed size is very encouraging. Development of suitable double low parents is under way. A program has also been initiated to utilize the self-incompatibility alleles in *B. campestris* and tissue-culture techniques for the production of hybrids.

Following the discovery of the virulent strain of blackleg disease (*Leptosphaeria maculans* (Desm.) Ces. & de Not.) in Saskatchewan, sources of disease resistance were sought. This resistance has now been transferred to canola-type rapeseed. A large number of lines showing excellent field resistance were grown in a disease survey in 1980. It is expected that blackleg-resistant canola lines could be ready for release within 2 yr if the disease were to become limiting.

Mustard breeding. The yellow mustard cultivar Ochre was approved for licensing in 1980. This is the first public condiment yellow mustard licensed in Canada, and its release

means that all mustard growers can have access to Certified seed. Originally selected from the available landraces, this material has been in test for many years as the standard variety, and its yield has not yet been exceeded.

Grasses

Licensing of Regar meadow brome grass. On the initiative of this Station, licensing was requested for the Regar variety of meadow brome grass, *Bromus riparius* Rehm. This strain is currently grown on a modest scale in Montana and adjacent states, and has been tested at Saskatoon for 10 yr. Its ability to regrow rapidly after cutting suggests it could be a useful pasture grass. When cut for hay, it is generally lower yielding than smooth brome grass. Private seed companies have indicated their intention to import Certified seed and establish some Canadian fields for Certified seed production in 1981.

Brome grass seed pests. Brome grass seed production at Saskatoon has suffered in recent years from damage by several insects. The brome grass seed midge caused serious seed losses from 1973 to 1977. Since 1977, however, the population has been low, possibly as a result of dry spring weather in 1978 and again in 1980. A thrips, *Limothrips consimilis* Pr., which usually causes floret sterilization, has been an important pest since 1977. In 1980, 18% of brome grass florets from 19 sites at Saskatoon carried this thrips, with a maximum of 37% of the florets being affected in one field. Larvae of the brome grass cutworm, *Septis finitima* (Gn.), occurred in 2% of brome grass florets and caused considerable damage to mature panicles in 1980. This pest had previously caused damage in 1972.

Legumes

Pasture bloat in cattle. This selection of alfalfa plants with bloat-safe characteristics is proceeding well. The second cycle of selection for alfalfa plants with low initial rates of digestion has been completed; this was accomplished with the use of a modified nylon bag technique on fistulated cattle. In addition, selections of slow-digesting alfalfa seedlings are being made using leaf disks incubated with pectinase and cellulase. Other strains are being selected for resistance to leaf damage by sonication. Leaf damage is measured by percent chlorophyll disappearance during

sonication. Strains arising from these selection programs will be tested in cattle feeding trials at the Kamloops Research Station.

Sweetclover breeding. Norgold, a low coumarin (LC) sweetclover cultivar developed at Saskatoon, was approved for licensing in 1980. The culmination of a 22-yr breeding program, this is the world's first LC yellow-flowered (*M. officinalis*) cultivar. It is basically an LC synthetic of Yukon, the best cultivar previously available in Canada. The program was initiated in 1959 with 10 LC strains obtained from H. J. Gorz (U.S. Department of Agriculture, Nebraska), who developed the strains through an interspecific transfer of the LC characteristic from LC *M. alba* Desr. A backcross method of breeding was followed through six consecutive backcrosses, with Erector as the recurrent parent for the first two backcrosses, and Yukon as the recurrent parent for the subsequent four. In regional tests from 1978 through 1980, Norgold yielded 16% more forage (dry matter) than Polara, the only other LC cultivar available. In addition, Norgold yielded 40% more seed than Polara. In flowering date, Norgold is 1 or 2 days later flowering than Yukon but 10–14 days earlier than Polara. Norgold contains only trace amounts of coumarin in contrast to high levels (2–3% on a dry-matter basis) in common sweetclovers. Thus, Norgold is similar to Polara in producing forage with no danger of causing hemorrhage or 'sweetclover disease' in farm livestock. The new cultivar Norgold is expected to replace Polara, a *M. alba* LC cultivar, because the yellow-flowered *M. officinalis* cultivars are much more popular with farmers and ranchers for their early maturity, shorter and finer stems, and finer leaves. Norgold should be grown wherever sweetclover is used for livestock feed.

Agronomy and weed control

Response of rapeseed to sulfur fertilizer. Pale yellow seedlings, retarded growth, delayed flowering and pod formation, fewer and smaller pods, delayed maturity, and low seed yield were observed when Regent rapeseed was grown on S-deficient soils in northwestern Saskatchewan. Where available soil N was also low, addition of N fertilizer without S intensified these deficiency symptoms and further reduced yield. Application of fertilizer containing S in the soluble sulfate form, at or just before seeding, produced a dramatic

effect, resulting in vigorous, healthy plants, large dark green leaves, numerous large and well-filled pods, earlier maturity, and large increases in yields. Elemental S fertilizers applied to the soil at or just before seeding produced little response in the plants. Elemental S should be applied the previous summer to allow time for it to oxidize and become available to plants.

In tests on two S-deficient soil sites, application of ammonium sulfate as a source of S at 25 kg/ha raised rapeseed yields by 73 and 267%. Application of ammonium sulfate at 50 kg/ha resulted in additional yields at one site but not at the other. There were no differences in response to S between *B. campestris* and *B. napus*, nor among high and low glucosinolate rapeseed varieties.

Cropping sequences on Gray Luvisol soils. Gray Luvisol soils are typically low in organic matter, have a relatively dense subsoil, and are prone to spring crusting. Cropping studies on such a soil, Loon River loam, have been under way for the past 14 yr. When wheat and barley were sown after alfalfa hay, yields averaged 90% of the summerfallow crop. Following other forage and grain crops, wheat and barley produced 68–77% of summerfallow yields on these soils. However, stubble yields of rapeseed were poor, depending on the preceding crop, and ranged from 56 to 74% of summerfallow rapeseed.

Soil moisture measurements in the fall indicated that summerfallow plots contained 2–4.5 cm more moisture than stubble plots, but spring measurements showed that snowmelt reduced this difference to 0.5–1 cm. Thus summerfallowing such soil is inefficient, and stubble moisture levels are normally adequate for recropping wheat or barley. Minimum yields of wheat and barley have exceeded 1000 and 1350 kg/ha when the preceding crop was alfalfa, wheat, oats, barley, flax, or rapeseed. In only 2 of the 14 yr, yields were below these levels, and at that time the preceding crop was brome or brome-alfalfa hay. The highest risk of crop failure occurred when rapeseed was stubble seeded. Protein content of wheat and barley was reduced except when these crops followed summerfallow or alfalfa hay.

Wild oat control. In attempts to improve methods of controlling wild oats in *B. napus* and *B. campestris* rapeseed, barban at 0.15 kg/ha, about half the recommended rate, was applied postemergence as a tank mixture with

benzoylprop-ethyl at 0.55 kg/ha. The latter is presently recommended for control of wild oats in wheat, but not in rapeseed. Approximately 85% wild oat control, acceptable crop tolerance, and yield increases of 100–180% resulted from application of this mixture to rapeseed crops at four locations. Application of benzoylprop-ethyl alone to rapeseed at the 1.4 kg/ha maximum rate recommended for wheat resulted in yield reductions of 20–30%. This tank mix would be applied at the two- to five-leaf stage of wild oats rather than at the two-leaf stage, as with barban alone.

Volunteer cereal and grassy weed control in oilseed crops. As a result of herbicide evaluation research, BAS-9052 (BASF) will be recommended for the control of volunteer wheat and barley and annual grass weeds in rapeseed, mustard, flax, and sunflowers. Two other herbicides with similar modes of action, TF-1169 (Chipman) and RO-138895 (Maag), were identified and evaluated extensively. Both provided virtually 100% control of heavy infestations of wild oats and volunteer wheat and barley. Yield increases of 650 and 800 kg/ha were recorded in Candle and Regent rapeseed, respectively.

Triazines for weed control in rapeseed. A strain of *B. campestris* rapeseed, resistant to the herbicide atrazine, was discovered in Eastern Canada corn crops several years ago. This characteristic was transferred into the genetic background of Candle rapeseed by researchers at the University of Guelph and made available for trials for the first time in 1980. Rapeseed that is resistant to atrazine and its triazine analogues could permit selective control of stinkweed and wild mustard as well as other important weeds in rapeseed crops.

When the triazine-resistant Candle strain was sown in stinkweed-infested plots, metribuzin, atrazine, and cyanazine gave 97, 85, and 50% control of stinkweed, respectively. Crop tolerance for atrazine and cyanazine was excellent, whereas metribuzin caused some reduction in seed yield. In weed-free plots, maintained by hand weeding, the atrazine-resistant strain yielded only 65% of the normal Candle variety. Considerable research remains to be done on the development of high-yielding atrazine-resistant strains and on the identification of the correct application methods and rates for the best triazine herbicide for use in Western Canada.

Interactions between wild oat herbicides applied postemergence to wheat. Reduced effectiveness of some postemergent wild oat herbicides has been observed under field conditions when they were tank-mixed with phenoxy herbicides or dicamba to broaden the spectrum of weed control. Tank-mixing 3,6-dichloropicolinic acid with flumprop-methyl, difenzoquat, diclofop-methyl, and barban caused reductions in wild oat control of 4, 7, 8, and 12%. DPX-4189 (DuPont) at 0.02 kg/ha tank-mixed with flumprop-methyl and diclofop-methyl reduced their efficacy on wild oats by 7 and 16%. As the rate of DPX-4189 increased to 0.04 kg/ha, the level of antagonism also increased, with losses of 14 and 21% observed for flumprop-methyl and diclofop-methyl. No loss in efficacy was observed when either rate of DPX-4189 was added to difenzoquat. These results indicate that indiscriminate tank-mixing of herbicides at the farm level may cost the producer much more than the potential benefits of a single application.

PLANT DISEASES

Diseases of oilseeds

Blackleg of rapeseed. The virulent strain of *L. maculans*, the blackleg pathogen, occurred in over 70% of rapeseed stubble fields in central Saskatchewan surveyed in the fall of 1980. It was detected for the first time in the southeastern part of the province, occurring in 7% of the fields. Infections generally were light throughout the growing season.

The saprophytic phase of development of the fungus, which takes place on stubble in the fall, provides a unique opportunity both for a substantial increase in inoculum and for considerable genetic recombination. Several strains of *L. maculans*, only one of which is highly virulent, may develop in close proximity and produce ascospores on stubble material still remaining in the field late in the following year. Repeated sampling of selected stubble fields indicated that in some instances weakly virulent strains were notably more successful than the virulent strain in the competition for available substrate.

Greenhouse studies have confirmed that the introduction of a mild and a virulent strain into intact rapeseed plants generally results in less severe disease than the introduction of a virulent strain alone. When the weakly virulent strain was introduced a week or more

earlier than the other, there was often substantial reduction in length of stem lesions. More striking results were obtained with the use of decapitated plants. Weakly virulent strains often colonized these stubble pieces to the exclusion of the virulent strain. The extent of suppression of the virulent strain depended upon the particular isolates used in the combinations. Pairings of several isolates, on agar plates and in decapitated plants, of the most prevalent weakly virulent strain with standard virulent cultures, revealed that the former differed considerably in aggressiveness toward the virulent strain. Studies utilizing field material indicated that certain weakly virulent strains from cruciferous weeds produced much larger quantities of ascospores than did a virulent and a weakly virulent strain from rapeseed. One of the heavily sporulating weed strains is becoming increasingly common on rapeseed stubble and has suppressed development of the virulent strain in decapitated plants. The antagonistic action of the weakly virulent strains may be one of the reasons why the virulent strain has not become a limiting factor in the production of rapeseed in Western Canada.

Sclerotinia stem rot of rapeseed. Four years of epidemiological work has shown that the most critical period for infection of rapeseed by *Sclerotinia sclerotiorum* (Lib.) de Bary is during the full-bloom stage of the crop. *S. sclerotiorum*, however, produces ascospore-bearing apothecia from early bloom until after harvest if the soil surface remains moist. In fields where apothecia were abundant, a single application of benomyl at 0.5 kg/ha, vinclozoline at 0.75 kg/ha, or a combination of benomyl and vinclozoline or glycophene applied at the time of 25% bloom provided excellent protection. Benomyl applied by aircraft at 1.0 kg in 55 L of water per hectare at the 25% bloom stage reduced the proportion of severely diseased plants from 46 to 12%. Yield in the untreated portion of the field was 28% lower than in the benomyl-treated plot, and numbers of sclerotia in the seed were substantially higher.

Rapeseed naturally infested with 0.7% sclerotia of *S. sclerotiorum* by weight could be cleaned to 0.025% with screens and a high-speed gravity table. Content of sclerotia was further reduced by passing the cleaned sample over a spiral cleaner.

The biological control agent *C. minitans*, in dosage experiments in the field, failed to

provide control of sclerotinia stem rot under conditions where 50% of the plants were severely infected. After several years of field testing, it has been concluded that this organism does not destroy a sufficient percentage of the soil-borne sclerotial population to achieve the required control of airborne ascospore infection.

Diseases of cereals

Common root rot. The estimated loss from common root rot in bread wheat in Saskatchewan in 1980 was 6.6%, slightly higher than in 1979 (5.5%). Screening and selection work was continued to identify material possessing a high degree of resistance to the disease. Over 1000 lines of barley from the U.S. Department of Agriculture World Collection and from Canadian plant breeders were evaluated and a few promising lines were found. In the recurrent selection program involving six crosses between fairly resistant parents, an increasing number of wheat lines from the F₃ to F₆ generation exhibited less disease than the parents. The generation frequencies were 21, 30, 37, and 68%. Some of the most advanced lines showed good yielding ability as well as high disease resistance.

Common root rot of Gateway 63 barley was reduced with seed treatments containing EL 228 (Elanco), A-6222 A (Ciba Geigy), A-6214 A (Ciba Geigy), BAS 38901 F (BASF), RH 2161 (Rohm & Hass), and Baytan (Chemagro), but this was not accompanied by increased yield over the nontreated control. Some treatments were phytotoxic, as indicated by reduced emergence.

Common root rot incidence and severity in Cypress and Neepawa wheat, grown from seeds treated with Baytan, EL 228, and imazalil at rates less than 0.5 g/kg of seed, were reduced significantly in field tests at three locations. A dosage response was apparent in all cases, but no significant yield differences among treatments were found.

Root rot severity, grain yield, and coleoptile-node-tillers (CNTs) of four spring wheat cultivars were compared in imazalil-treated and nontreated field plots of the same plant density. Although efficacy varied among cultivars, imazalil applied to seed at rates of 0.2 and 0.3 g/kg reduced the disease significantly. Except in Wascana, the treatment also

significantly increased the yield of all cultivars. CNTs were observed rarely in nontreated plots. In the treated plots, however, 9–19% of the total tillers were CNTs that mostly were firm and would produce fertile heads of grain.

Aversion factors, which may cause marked zones of inhibition between adjacent fungal colonies in culture, have been reported in several fungal species including *Bipolaris setariae* (Saw.) Shoemaker, and also *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, which is the major cause of root rot in the prairies. At Saskatoon, a random population of about 100 isolates of *C. sativus* were paired in all combinations to test for the distribution of these factors. In most combinations the colonies grew quite close to each other but their margins did not overlap. Less frequently the colonies actually grew over each other's margins or else there was a very marked zone of inhibition between them. When three isolates were grown on the same plate, the reaction between any two colonies varied, depending on the third isolate present. Two isolates sometimes grew over each other's margins in the presence of isolate A, but were markedly inhibitory to each other in the presence of isolate B. Although the majority of the isolates varied in their reaction patterns, it appears that there are some isolates that are consistently 'social' and some that are consistently 'antisocial.' The significance of aversion factors is not clear at present. However, it seems likely that they have a role, along with mating types and fertility factors, in the mating system of *C. sativus*.

The distribution of fertility factors in two populations of *C. sativus* has been examined. In one group about 50 isolates from widely separated geographic areas were intercrossed. In the second group about 100 isolates from the same field were intercrossed. In both groups the same general pattern emerged. Some isolates are very fertile (ascospores are produced in essentially all crosses involving them), whereas others are highly infertile (crosses involving them rarely progress beyond the protoperithecial stage). The majority of isolates fall between these two extremes.

Prematurity blight. Resistance of some common and durum wheat cultivars to prematurity blight caused by *Fusarium culmorum* (W.G. Sm.) Sacc. was assessed in growth chamber tests. Hercules, Pelissier, and

Wascana appeared susceptible; Neepawa and Wakooma resistant; and Macoun and Sinton intermediate in reaction.

Snow molds on winter cereals. Little snow mold injury was seen on winter cereals in Saskatchewan in the spring of 1980. However, crop loss studies on fall rye at Saskatoon gave unexpected results. The rye lines selected at Saskatoon for resistance to various snow molds and the cultivars Puma and Cougar were sown in field plots and inoculated in late summer in 1979 with three snow molds, *Gerlachia nivalis* (Ces. ex Sacc.) W. Gams & E. Muller (*Fusarium nivale* (Fr.) Ces.), *Coprinus* sp. nonsclerotial low-temperature basidiomycete (LTB) phase, and *Typhula ishikariensis* Imai. var. *canadensis* Arsvoll & Smith. No snow mold symptoms were seen at snowmelt, but average grain yield losses of 18, 13, and 10%, respectively, resulted from these pathogens. However, response to the pathogens varied among the rye lines tested, and some were not significantly affected by any of the fungi.

Diseases of legumes and grasses

Verticillium wilt of alfalfa. *Verticillium* wilt, caused by *Verticillium albo-atrum* Reinke & Berth., was identified in 1980 for the first time in one dryland and a few irrigated alfalfa fields in Saskatchewan. Symptoms were severe on individual plants, but incidence of the disease was low. Frost injury complicated the recognition of wilt. An isolate of the pathogen from alfalfa was pathogenic to potato, but not to fababeans, rapeseed, or sunflowers.

A low-temperature pathogen on alfalfa and orchardgrass. A low-temperature pathogen, *Plenodomus meliloti* Dearness & Sandford, was found associated with rotted crowns of alfalfa in the fall in northwestern Alberta and in the spring in northern Saskatchewan. At Saskatoon, its protopycnidia were found abundantly in winter-damaged orchardgrass, *Dactylis glomerata* L., in association with a brown root rot.

Snow mold on turf grasses. At Saskatoon, where snow mold on a turf was mainly due to *G. nivalis* in a complex with the LTB phase of *Coprinus* sp. on annual bluegrass, *Poa annua* L., benomyl with chloroneb and mercury chlorides was the most effective combination treatment tested. At Regina, on bentgrass turf with a light infection of the LTB phase of

Coprinus sp., several single materials gave effective control. At both locations some materials increased disease severely, probably by suppressing mold antagonists. A small *Coprinus* sp., *C. kubickae* Pilat & Svrcek, was found for the first time in North America. This mold, which is in the same group as the *Coprinus* sp. that causes snow mold, was associated with superficial fairy rings in bentgrass turf at Saskatoon.

ENTOMOLOGY

Oilseed insects

Flea beetles. The presence of *Phyllotreta conjuncta* Gent. in Saskatchewan was established. This is the eighth crucifer-feeding flea beetle species known to occur in the province. It was determined from winter sampling that the three most important flea beetle pests of rapeseed crops, the crucifer flea beetle, *P. cruciferae* (Geze), the striped flea beetle, and the hop flea beetle, show individual preferences in selecting overwintering sites and tend to be unevenly distributed within them. This information is valuable for assessing the merits of winter sampling for estimating flea beetle abundance.

The known range of the striped flea beetle has been extended to the open prairies of southwestern Saskatchewan, and it has been established that a population of this beetle present in the Boreal forest will attack rapeseed and can complete egg-to-adult development in experimental rapeseed plots sown in the forest.

Rapeseed seedlings collected from plots treated with granular carbofuran were analyzed for carbofuran and two metabolites, 3-hydroxycarbofuran and 3-ketocarbofuran, by a method developed at Saskatoon. Maximum levels of carbofuran, up to 2.9 ppm, occurred in seedlings within 2 days of emergence. The metabolite, 3-hydroxycarbofuran, had maximum concentrations up to 6.5 ppm in seedlings collected 5 days after emergence, as did 3-ketocarbofuran, with a maximum concentration of about 0.8 ppm. By 3 wk after emergence, concentrations of carbofuran and 3-ketocarbofuran had decreased to 0.01 ppm or less, whereas the concentration of 3-hydroxycarbofuran had decreased to about 0.3 ppm. These results indicate that carbofuran is present in the seedlings at time of emergence and could offer immediate postemergence protection against flea beetles.

Bertha armyworm. The bertha armyworm was present in northeastern Saskatchewan rapeseed crops for the second consecutive year. An estimated 20 000–30 000 ha were sprayed for bertha armyworm control. Larval populations up to 92/m² were found. However, in many fields it was observed that larvae continued to feed on rapeseed leaves even after pods had formed, rather than moving up to feed on the pods as in past occurrences. Thus, although larval numbers were often considerably above the previously established economic threshold level of 12–15/m², little damage to seed production was caused unless the larvae left the leaves and began feeding on the pods. Consequently, spraying was not always necessary when larval densities exceeded 12–15/m².

Insect pests of sunflowers. The abundance of the sunflower moth, the banded sunflower moth, and the sunflower seed maggot, *Neotephritis finalis* (Leow), were monitored in July and August collections of wild sunflower heads. Although these pests were absent or rare near Saskatoon, they were abundant at certain times in southern Saskatchewan. It was determined that the sunflower seed maggot has two generations per year in southern Saskatchewan, rather than one as previously believed. Thus this pest may be more serious than originally thought. These results show the need for a series of annual surveys to establish the frequency with which these insects can be expected to cause serious damage to sunflower crops in different areas of Saskatchewan.

Grasshoppers

Aerial survey of grasshopper damage. Survey by infrared aerial photography, a technique developed over a 3-yr period, showed that grasshopper damage to cereal crops was strongly influenced by weather and soil type. Crop loss from grasshoppers was greatest in light soil zones with low precipitation. In such an area northwest of Saskatoon, estimated cereal grain losses of 400 t on 1283 ha were detected, even though the 1980 forecast predicted light grasshopper infestations in this area. In a heavy clay soil area northwest of Swift Current, with 30 mm of precipitation by early May and a predicted moderate grasshopper infestation, no crop loss was detectable. Thus, attempts to extrapolate grasshopper damage estimates to a larger area than that actually covered by aerial

photographic flights must take precipitation and soil type into account.

Biological control. Considerable progress has been made toward establishment of a practical *in vitro* technique for production of viable spores of *Nosema locustae* Canning, a grasshopper pathogen that has shown potential usefulness as a biological control agent. Germination of 75–100% was obtained in a potato-broth medium after treating spores with a solution of 1.2% sodium hypochlorite at a pH of 12.1 ± 0.1. These germinated spores were then cultured in a newly developed medium, REAC-80. Horse serum had to be added to this medium to maintain spore viability. With this combination, the pathogen developed through the asexual parts of its life cycle, but died before completing the final stages of the sexual portion of the life cycle. Development to the sporont stage in the sexual part of the cycle was extremely slow, requiring at least 2 mo. By trial and error it was found that the concentration of several of the amino acids in the REAC-80 growth medium, especially D-glucosamine and tryptophan, affected spore development to the sporont stage and, in a few cases, these sporonts divided to produce sporoblasts, which is the next to last stage in the life cycle. Although we have not yet been able to produce the final spore stage *in vitro*, and the development of germinated spores in the growth medium is slow, it appears that manipulation of amino acid and vitamin concentrations in the growth medium is a promising approach to overcoming these obstacles. We believe that the final spore stage can be produced in quantity *in vitro* only by inoculating living insect cells with sporoblasts, because chitin produced by insect cells is a vital constituent of the spore wall.

Ultralow dosages of insecticide-treated bran baits. A new and effective method of grasshopper control, reported previously, involves the use of bran baits treated with ultralow dosages of insecticides. These baits are effective, even when the amount of bran is reduced to 1.7 kg/ha. The question arose as to why grasshoppers consumed the bran, present in such small quantities, rather than feeding entirely on fresh plant material available in their surroundings. In our investigations the migratory grasshopper did not survive or breed well on diets of fresh wheat, rye, or lettuce foliage alone. Apparently grasshoppers cannot consume a sufficient volume of fresh

plant material, which is about 90% water, to obtain adequate nourishment for growth and reproduction. Our studies suggest that under field conditions grasshoppers feed on green plants until their moisture requirements are met, and then they begin to forage and to chew on any available dry matter. If the material is attractive, they feed on it; if not, they continue to forage and return to it only if nothing else is available. Under the latter conditions, they even eat sawdust or fiber glass screens. So far, wheat bran is the most attractive dry material tested. Because bran is probably more attractive than most of the dry-plant materials available in nature, it is a very effective bait material.

Wireworms

Carabid and tiger beetles from a wireworm-infested field. Carabid and tiger beetles were trapped in a wireworm-infested field and its grassy borders during two growing seasons. Eighty-seven carabid species from twenty-five genera and seven tiger beetle species from one genus were identified in pitfall traps. Species diversity was greatest in the field border collections, but the abundance of individuals within dominant species was usually greater in the field collections. There were about 12 dominant species of carabids, mostly in the genera *Bembidion* and *Amara*. High numbers of some *Bembidion* spp., particularly *B. obscurellum* (Mtsch.) and *B. quadrimaculatum oppositum* Say, were present in the field at the same time that wireworm eggs were present. Therefore, these beetles may play a role as predators of wireworm eggs.

Forage crop insects

Integrated control. An application of the insecticide trichlorfon (Dylox, 4.2 LS formulation, Chemagro Ltd.), at 550 g/ha, effectively controlled infestations of the alfalfa

plant bug and plant bugs of the genus *Lygus* in alfalfa seed crops. This treatment was not hazardous to alfalfa leafcutting bee pollinators if applied in the evening, allowing a period of about 12 h between application and bee foraging activity.

Over the past 3 yr parasites of European origin have been released as possible biological control agents into *Lygus* and alfalfa plant bug populations at six alfalfa seed-producing locations in Saskatchewan and Alberta. To date no introduced parasites have been recovered by either sampling to capture the adults or by laboratory rearings of field-collected hosts.

Black flies

Larval instars. Seven larval instars were reliably identified for *Simulium luggeri* N. & M. by measuring the lengths of the postgenae of the head capsule under a binocular microscope. Instars were less reliably separated by measuring lengths of whole larvae. The presence of an egg burster on the head also identified the first instar, and separate cervical sclerites identified the final instar. Descriptions of the instars, now available, will permit improved precision in researching and larviciding this important pest of livestock and people.

Mosquitoes

Arbovirus vectors. Mosquito populations in southern Saskatchewan were unusually low in 1980 because of severe drought conditions. No viruses were detected in any mosquitoes. Seven sentinel chicken flocks, monitored by Dr. J. O. Iversen of the Western College of Veterinary Medicine, remained negative for circulating antibodies of western equine encephalitis and there were no reports of infections in horses or humans.

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Research Station

Swift Current, Saskatchewan

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Production physiology

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INTRODUCTION

The diversified program of research at the Swift Current Research Station emphasizes the improvement of cultivars of cereal and forage crops and the development of technology to improve 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, and agricultural engineering.

During 1980, new cultivars of intermediate wheatgrass (Clarke) and winter rye (Musketeer) were licensed. Both cultivars combine the better traits of former cultivars and have potential for increasing the area seeded to these crops and for improved yields. Optimum seeding rates, row spacings, seeding patterns, and fertilization rates were established for several cereal and forage crops, and it was determined that five sequential years were required for the field evaluation of forage crops. New equipment was developed for laboratory seed cleaning and zero-tillage seeding. Studies of snow management, sewage effluent irrigation, water use efficiency, soil salinity, and cereal harvesting led to improved management recommendations. Canola meal proved to be cost effective in formulating poultry diets.

These and other research accomplishments are described briefly in this report. More detailed information can be obtained from the publications listed at the end of this report, from P. I. Myhr, or from individual scientists. Requests and correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

W. L. Pelton
Director

FORAGE PRODUCTION AND UTILIZATION

Clarke—A new intermediate wheatgrass

Clarke is a new cultivar of intermediate wheatgrass released in 1980. It was developed from a breeding program designed to combine into one variety winterhardiness, drought tolerance, establishment vigor, good seed quality, and high forage and seed yield. Yield trials indicate that Clarke equals Chief in forage yield and produces 7% more forage than Greenleaf. Clarke yields 28% more seed than Chief and 45% more than Greenleaf. It has also shown excellent winterhardiness and drought tolerance. It is well adapted for hay and pasture use on both dryland and irrigated land in Manitoba, Saskatchewan, and Alberta, as well as in the northern Great Plains states.

Seed yield of Altai wild ryegrass as influenced by row spacing and fertilizer

A study was conducted from 1969 to 1977 to determine the effect of row spacings and applications of N and P fertilizer on the productivity of Altai wild ryegrass (*Elymus angustus* Trin.). The optimum row spacing

for highest seed production was 120 cm and the optimum fertilizer treatment was N at 25 kg/ha plus P at 25 kg/ha annually. Doubling the rate of N or N plus P did not significantly increase the seed yield over that obtained from grass receiving N at 25 kg/ha plus P at 25 kg/ha. Fertilizer treatments containing P tended to result in a more stable year-to-year response than those containing only N. Altai wild ryegrass grown in 30-cm row spacings produced higher dry matter yields for the first 4 yr than that grown in wider-spaced rows. However, in the last 4 yr the highest yields were obtained from grass seeded in rows spaced 150 cm apart. Grass receiving an annual application of N at 50 kg/ha plus P at 50 kg/ha produced significantly more forage than that given N at only 25 kg/ha, both of which outyielded unfertilized grass.

Productivity of grass-alfalfa pastures grown in different stand patterns in a semiarid region of the Canadian prairies

Russian wild ryegrass (*Elymus junceus* Fisch.) and alfalfa (*Medicago media* Pers.) pastures seeded in mixture, or in alternate rows, or in a cross-seeded pattern were grazed by cattle from 1974 to 1980 at Swift Current, Sask. The legume was retained in the two

component separation patterns but had declined to only 15% in the mixture stands.

Daily gains of liveweight cattle were largest from the cross-seeded pastures. On a land unit basis, the beef production from cross-seeded pastures was 13% higher than from alternate-row pastures and 17% higher than from mixture pastures.

The checkered pattern from cross seeding reduced runoff. No incidence of bloat occurred.

Number of sequential years and particular time periods in relation to valid results

Over a 13-yr period from 1966 to 1979, three identical tests starting in different years were each studied for nine sequential years. This arrangement provided for testing time periods that varied in precipitation and in climatic conditions in general. Main measurements included yield and forage stand changes.

Particular blocks of years tended to give similar and comparable results, provided that the number of sequential years exceeded five and that first-year data were excluded.

Vegetation surveys and classification

Vegetation surveys and classification of vegetation types were continued, with emphasis on wetland vegetation. Work on salt marshes and freshwater marshes was completed; the classification of these marshes shows strong affinities with similar Eurasian vegetation. Work on aquatic vegetation was begun, and water samples were taken for chemical and for phytoplankton analyses. Chemical analyses of these samples show that several lakes in the Parklands and Boreal forest may soon become severely polluted. Electric conductivity and soluble phosphorus content of polluted waters average 1.75 times and 33 times, respectively, that of unpolluted waters. Preliminary algal analyses show a great increase in blue green algae, resulting in damage to fish populations in the polluted lakes.

SOILS AND ENVIRONMENT

An empirical method of estimating soil temperatures on cropped land on the Canadian prairies

Agronomists often require quick, easy methods of estimating temperatures of soil

under cereal production, either to fill in missing experimental measurements or to help explain apparent discrepancies in results. Methods described in the literature allow such estimates to be made from meteorological measurements and physical characteristics of the soil, but these methods are often mathematically complex.

A simple empirical regression and correlation approach was used successfully at Swift Current, Sask., to relate soil temperatures under cereal and fallow cropping systems to soil temperature at corresponding depths under grass plots. The relationships between temperatures under cereals (y) and those under grass at corresponding depths (x) were generally represented by $y = x$. The best Swift Current relationships for the growing season were used successfully ($r^2 = 0.9$) to predict data for different years at Swift Current and Scott, Sask., and Lethbridge, Alta.

Effect of nitrogen, temperature, growth stage, and duration of moisture stress on yield components and protein content of Manitou spring wheat

Many studies have been carried out to determine the effect of temperature, moisture, and N fertility, either singly or combined, on yield and protein contents of cereals. However, the relative importance of these environmental factors is still not completely understood because of their complex interactions.

Manitou spring wheat (*Triticum aestivum* L.) was grown at combinations of three day and night temperatures (27 and 12°C, 22 and 12°C, and 17 and 12°C); three levels of fertilizer N (58, 116, and 174 kg/ha); and three moisture stresses (nominally -0.3, -15, and -40 bar). All plants were initially grown at -0.3 bar; one moisture treatment was carried through to maturity at this water potential and the remainder were stressed at -15 or -40 bar from either four-tiller, boot, or late-flowering stage to maturity.

Under the conditions of this experiment, temperature was the most important factor affecting yield and protein, and moisture stress the least important. Yields were equal at 17 and 22°C, but greater than they were at 27°C. Protein was equal at 17 and 22° but less than it was at 27°C. Yield increased with N fertility except at the highest temperature or when high moisture stress was applied from the boot stage. Plants grown under high

moisture stress through to the boot stage (i.e. stressed from tillering or boot) gave yield increases when fertilized with N at 116 kg/ha; but N at 174 kg/ha depressed the yield of plants that were stressed from boot stage to maturity. Yields of plants stressed from tillering were generally greater than yields of plants stressed from the boot stage, indicating that the plant has the ability to adapt to early stress.

In contrast to findings in a simulated irrigation study, moisture stress during the boot stage depressed rather than enhanced seed set. Optimal temperature for spikelet development was near 22°C. The growth stage most critical to the determination of number of seeds developed was the boot stage and that for kernel weight was at or after anthesis.

The effect of temperature on protein was independent of N or moisture levels. High moisture stress during the boot stage increased protein even at the lowest N level, but stress from late flowering rarely increased protein. The effect of N on protein was usually direct, whereas temperature and moisture usually acted by influencing the yield. The direct effects of N and of temperature on protein were twice and 15 times, respectively, the effect of moisture.

ENGINEERING

Snow management by swathing at alternate heights

Swathing stubble fields at alternate heights for snow management resulted in an average annual increase of 1.4 cm of entrapped soil water over an 8-yr period. This value represents a 30% increase in stored water compared with swathing stubble fields at uniform height. The range of soil moisture conserved varied between 0.38 and 5.19 cm. In 1977–1978 a large-scale farm trial conserved an extra 2 cm of available soil moisture as a result of this practice.

If 8 cm of available water is the requirement for a Brown soil to produce a crop of 773 kg/ha on stubble land, then the alternate height system of snow management makes it possible to seed stubble land for 4 yr out of 7. Without snow management, only 3 yr out of 7 can be considered suitable for seeding. The additional year represents a 33% increase in production, assuming an average yield of 773 kg/ha.

Equipment design

A simple laboratory seed cleaner with an oscillating scalping sieve and a precisely controlled air blast has been developed for forage and cereal samples. The machine has zero mixing between samples and can clean two 500-g samples per minute.

A John Deere hoe drill was converted into a zero-till drill by replacing the hoe openers with a two-disc opener and modifying the spring suspension system to the openers. The opener has a 375-mm vertical disc that acts as a colter and a 275-mm disc angled at 7° that opens the furrow. Trash-cutting ability and penetration are very good with a maximum force of 1100 N available per colter. This is an economical zero-till drill with superior performance as compared with commercial drills now available on the market.

Salt balance in a catena of four Birsay soils under effluent irrigation

In a test using Swift Current effluent for irrigation, the application rate was set to meet the water requirement of the crop and to supply 10–15% of leaching to maintain a favorable salt balance in the soil.

After 6 yr of effluent irrigation, the results indicate similar trends in salinity-profile changes for the Orthic Regosol, Calcareous, and Orthic soil series. In these three soils, salt content in the upper layers of the root zone increased slightly, whereas salt content in the bottom layers of these soils decreased substantially. A net reduction of total salt content in the top 200 cm was effected by effluent irrigation on the Orthic Regosol and the Calcareous soil series. In contrast, effluent application caused a small increase of salts in the Orthic soil because of the low initial salt content within this profile.

Among the four soil series, the greatest increase in total salt occurred with the Cumulic Orthic soil. This is primarily because of the very low salt content of this soil prior to irrigation. In this soil, salts were also distributed much more uniformly than in any of the other three soil types because the soil is located in the low-lying areas and receives considerably more water through runoff from irrigation and snowmelt.

Effluent irrigation produced a salt content in the upper layers of the Cumulic Orthic soil that was distinctly higher than that in the other three soil series. This higher salt content was attributed to the relatively high water

table in this area. Initially, alfalfa yields on the Cumulic Orthic soil were considerably higher than yields on the other three soil series, because the former soil had a better developed profile, and a higher humus and nutrient content. However, the yields on the Cumulic Orthic soil were lower than those on the Orthic soil after 5 yr of effluent irrigation. This yield depression was attributed to the considerably higher salinity in the upper layers of the Cumulic Orthic soil.

From this study, it is evident that the requirement for adequate drainage systems to effect salt removal by leaching is of prime importance. Without adequate drainage, downward percolating water fills the lower soil spaces and causes the water table to rise. A high water table favors upward capillary flow of water to the surface. The soluble salt carried upward then concentrates on the upper layers of the soil and may thus cause greater salinity. With proper management, alfalfa grows well under irrigation with sewage effluent that has a relatively high salt content.

CEREAL PRODUCTION AND UTILIZATION

Seeding rate of wheat

The yield potential of the two lines of wheat (*Triticum aestivum* L.) derived from Norin 10, namely Norquay and line X, and of the hard red spring wheat cultivar Neepawa were compared at six seeding rates: 75, 150, 300, 450, 675, and 1350 seeds per square metre. Over 2 yr, seven tests were conducted in northwestern Canada between latitudes 55°12' and 58°18' N. A yield component analysis was made at one location. All differences caused by seeding rate (S) and cultivar (C) were significant as were most S × C interactions. The yield curves usually followed the standard parabolic form, but the higher the potential yield of a cultivar, the higher the seeding rate required to realize its potential. Optimum seeding rates per square metre identified by inspection of yield curves were 675 for Norquay, about 450 for line X, and about 300 for Neepawa. Using an inverse polynomial formula the mean optimum rates were 672, 486, and 350 seeds per square metre, respectively. The ontogenically late yield components (kernels per head for Norquay and kernel size for line X) were

important for the yielding ability of these lines derived from Norin 10. Neepawa depended on the component heads per square metre for its maximum yield. Compared with the standard seeding rate of 300 seeds per square metre, the optimum seeding rate for the two cultivars derived from Norin 10 resulted in earlier maturity, similar plant height, increased lodging, smaller kernels, increased yield, increased test weight, and lower percentage of grain protein. The results suggest that new wheat lines and cultivars, particularly if they differ from existing cultivars, should be tested at a wide range of seeding rates in order to determine their full potential.

Genotype-environment interaction

Three cultivars of each crop, wheat (*Triticum aestivum* L.), oats (*Avena sativa* L.), and barley (*Hordeum vulgare* L.), were grown for 4 yr at five locations north of the 55th parallel in northwestern Canada. There were highly significant differences among all main effects and interactions. Galt barley produced the highest seed yield, followed by Centennial barley, Random oats, and Harmon oats. Victory oats, Olli barley, Neepawa wheat, and Pitic 62 wheat had similar yields, whereas Thatcher wheat was significantly lower yielding. Mean environment yields ranged from 2080 to 5610 kg/ha.

The genotype-environment (GE) interaction of species and cultivars was too complicated to be characterized by one or two statistics (e.g. stability variances or regression coefficients). However, variability in the frost-free period among years and locations contributed to the GE interaction, because, for example, some cultivars yielded well (e.g. Pitic 62) only in those year-location environments with a relatively long frost-free period, whereas other early maturing cultivars (e.g. Olli) performed well even in an environment with a short frost-free period.

Cereal harvesting

Research on harvest time of oats has shown that time of cutting has a substantial effect on commercial grades. Cutting at up to 35% kernel moisture content (KMC) was acceptable for feed grades, whereas cutting at lower moistures was required to produce CW grades.

The cultivars Random, Kelsey, and Harmon were cut at approximately 45, 40, 35, 30,

25, 20, and 15% KMC and were left to dry in the field or were dried artificially in a forced-air oven. Yield, grain N, and test weights were determined, and composite samples of each treatment combination were graded by the Canadian Grain Commission.

Time of cutting had no effect on yield or protein content. Both test weight and grade improved as harvesting was delayed until the lower KMC levels were reached. In general, there was little difference between field-dried and artificially dried material. Harvesting at 30–35% KMC produced No. 1 Feed oats. If cutting was delayed until the 20–30% KMC range, grades were generally No. 2 CW. It was necessary to wait until the crop dried below 20% KMC to obtain No. 1 CW grade oats. The major reason for downgrading of oats cut at greater than 20% KMC was the presence of green seeds, which result from the basipetal progression of ripening in the oat panicle.

Research with awned and awnless wheats has shown that awns have no effect on the rate of drying in either standing crops or in windrowed material. The closely related cultivars Napayo (awned) and Manitou (awnless) were studied for 3 yr. The cultivars dried at the same rate in all 3 yr, which included both hot and dry as well as cool and moist weather conditions.

A 3-yr evaluation test of the chemicals paraquat, diquat, and glyphosate for desiccation of Neepawa wheat showed that the chemicals did not improve the rate of drying of the mature crop. The chemicals were applied at 35–40% KMC. Drying rates were measured on treated plots and on standing and windrowed controls. The windrowed controls dried fastest in all years.

Zero-tillage

Zero-tillage research was initiated on three soil types (clay, clay loam, and sandy loam) in the spring of 1978. Zero-tillage treatments included continuous wheat as well as wheat on chemical fallow. They were compared with equivalent treatments using conventional tillage. Average yield increases for the zero-tillage continuous wheat were higher than for the conventional cultivated continuous wheat when grown on the clay soil (+125 kg/ha) but lower when grown on the sandy loam soil (–130 kg/ha). The clay loam soil showed little difference. Wheat yield on chemical fallow

versus conventional fallow favored the chemical fallow on two of the soils, with yield increases of +260 and +225 kg/ha on the clay and clay loam soils, respectively, but wheat yield showed a decrease of –410 kg/ha on the sandy loam soil. The yield results point out the advantage of zero-tillage systems in heavier-textured soils. However, yields alone can be somewhat deceiving, because better yields are not necessarily better economically. Chemical fallow costs are about \$60/ha compared with conventional fallow costs of \$30/ha.

Salinity mapping

A field resistivity meter (Wenner array) and two terrain conductivity meters (EM31 and EM38) were tested to examine their performance for mapping saline areas. It was found that all three meters functioned well and gave a clear distinction between areas of high and low salt content. The instruments could be a useful aid to extension personnel and soil surveyors. The terrain conductivity meters have the advantage of speed. These meters can measure salt content continuously as the operator walks across the affected field. The EM31 measures salts to 3.7 m whereas the smaller, lighter EM38 is effective to 1.2 m. The Wenner array offers the advantage of being able to distinguish salt distribution over depth. The other two conductivity meters measure the average salt content over depth. However, the Wenner array is somewhat bulky and is slower than the other meters, which is a disadvantage because probes must be inserted into the ground.

Water-use efficiency

Wheat water-use efficiencies on the prairies can vary from 40 kg of grain per hectare per centimetre of water used in a bad growing season to over 100 kg/ha per centimetre in a good year. Fertilization is important because it can improve water-use efficiency (WUE) by 15% on fallow land and up to 30% on stubble land. Water-use efficiency of cereal grains is about twice that of oilseed crops. Fall-seeded crops tend to have higher WUE values because they make more efficient use of spring moisture than spring-seeded crops. In the Brown and Dark Brown soil zones, summer-fallowed soils store only about 20% of the precipitation that falls, whereas in the Black and Gray soils, the efficiencies are often less than 10%. The manipulation of snow cover

could offer potential for increasing the water supply available for dryland crops. Calculations show that if an extra 5 cm of water could be entrapped and made available to the crop, then stubble yields could increase by about 20%.

Rye breeding and genetics

Support of the Expert Committee on Grain Breeding (ECGB) for the licensing of RT 124 was requested and received in February 1980. It was named Musketeer and subsequently licensed in July 1980 (License No. 2037). When seed supplies are available (fall of 1983), Musketeer could potentially be grown on 200 000 ha in Western Canada.

Musketeer was selected from the hybrid combination Harrach/Petkus/Dakold, which was produced in 1969 by S. R. Buzinski and D. S. McBean. It was first entered in the cooperative trials in 1975 as RT 124.

The test data indicate that Musketeer represents a distinct improvement over currently available cultivars in a number of characteristics. Winter survival was satisfactory and, in most cases, Musketeer was the best. During the period under test, it yielded 103–108% of the highest-yielding licensed cultivar each year. The hectolitre weight of RT 124 was equal to that for Cougar and Puma and greater than for Kodiak, whereas the 1000-kernel weight was equal to that for Kodiak. Heading and maturity for RT 124 were as early as for Frontier (2–3 days earlier than for Kodiak). Height of RT 124 was equal to that of Puma and Frontier; however, its resistance to lodging was greater than that of Frontier, Puma, and Kodiak but was not equal to Cougar.

The licensing of Musketeer has allowed the program to meet the establishment objective for the period ending in 1981.

The effect of dietary nutrient density level on strain, age, and meat yield of growing large white male turkeys

Studies in this laboratory have demonstrated that toms from the heavy tonnage commercial strains respond to higher nutrient density levels. This was accomplished by providing more nutrients within a lower feed intake, which allowed the birds to grow at a faster rate at each physiological age.

An experiment to determine the influence of nutrient density on feed intake was carried

out using heavy strains of toms. Three nutrient-density levels were fed, and growth performance was obtained at weekly intervals to 175 days old. The nutrient-to-joule ratio in this series of diets remained constant at 11.6, 12.9, and 14.2 kJ/g metabolizable energy (ME).

Four large white strains of male turkeys studied utilized the dietary nutrients with approximately the same efficiency at each of the three nutrient-density levels. The growth rate of the high feed-intake strains was significantly faster at all nutrient-density levels than that of the medium feed-intake strains.

Meat-yield data indicated that breast meat and total skin percentage increased with chronological age. Certain strains showed an increase in the yield of breast meat with an increase in nutrient density level. The percentage of thigh and drumstick decreased with age.

Nutrient-density level does not affect the percentage of fat in the skin and gravy sample as much as does chronological age. The percentage of fat in the breast and thigh meat tended to increase with chronological age and nutrient-density level. The nutrient quality of the finished product increased with the higher nutrient-density level.

Canola meal for broiler chickens

Candle canola meal (CM) was incorporated into wheat-based diets of broiler chicks at the following levels: in starter diets, CM at 281 g/kg, with a protein content of 230 and 210 g/kg; in finisher diets, CM at 121 g/kg, with a protein content of 190 and 170 g/kg (complete replacement of soybean meal in the low-protein diets). Nutrient-density treatments assessed the effect of maintaining dietary true metabolizable energy with added fat in CM diets.

Liveweight gains were not affected by either CM or nutrient density. Feed efficiency was not affected by CM when nutrient density was maintained with fat, but it decreased in diets of lower nutrient density. Low-protein diets reduced liveweights, feed efficiency, and carcass fleshing grades and increased abdominal fat. Carcass fleshing grades were not consistently related to actual meat yield.

Intensity of chicken flavor decreased and frequency of off-flavors increased when the starter diets contained CM at 281 g/kg and the finisher diets contained CM at 121 g/kg.

No adverse sensory effects occurred when the diets contained CM at up to 210 g/kg in the starter and 90 g/kg in the finisher. The effect observed at the highest level may be related to the levels of methionine and choline supplementation of the diets.

Economics of canola meal in poultry diets

Computer modeling studies indicate that CM is a profitable feedstuff for use in the production of turkeys and broiler chickens. Price ratios of CM to soybean meal (SBM) up to 0.63 increased net returns by at least 1¢/kg liveweight when CM was incorporated into turkey diets at levels of 75–150 g/kg. Corresponding CM-to-SBM price ratios for chicken production were more variable but tended to be higher for turkeys. Furthermore, diets of lower nutrient density were often more profitable for turkey and chicken production than those supplemented with fat to maintain dietary nutrient density.

Water absorption by turkey carcasses

Turkey carcasses absorb water when chilled in cold water or slush ice. The amount absorbed can vary from as little as 15–27 g/kg eviscerated carcass in our laboratory, to 73 g/kg reported from other laboratories. The effect of processing procedures on water absorption was studied. In comparison with normally scalded carcasses, dry plucking increased weight loss during plucking and evisceration, and reduced chilled carcass yield. Carcasses eviscerated when dry lost more weight than those kept wet, and they regained only part of the weight during chilling. Carcasses prechilled in running water, followed by ice slush, absorbed more water than those chilled in ice slush alone. Processing speed influenced water absorption, with more rapid processing decreasing water uptake during chilling. The factors studied failed to account fully for the large variation in carcass water uptake reported from different sources.

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Research Station

Beaverlodge, Alberta

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¹On a Canadian International Development Agency assignment from October 1980 to October 1982.

INTRODUCTION

The Northern Research Group, which comprises the Research Station at Beaverlodge and the associated experimental farm at Fort Vermilion, Alta., is largely responsible for research on agricultural problems of northwestern Canada. This report presents highlights of research for 1980.

Considerable progress was made in several of our research activities. For example, we determined the influence of solar irradiance on the pollination activity of the alfalfa leafcutting bee in our region. Once the temperature threshold, 16–17°C, was surpassed, activity was dependent on solar irradiance.

A first was achieved for Western Canada by the release of two strains of *Rhizobium meliloti* to legume-inoculant manufacturers.

The new Peace alfalfa variety developed at our Fort Vermilion Experimental Farm was licensed.

Two six-rowed feed barley lines were advanced to the stage for submission for licensing as new varieties.

Detailed information can be obtained from the publications listed in this report. Correspondence to individual research scientists should be addressed to: Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta. T0H 0C0; or Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta. T0H 1N0.

L. P. S. Spangelo
Director

APICULTURE

Behavior

Effect of weather factors on honey bee flight activity and colony weight gain. For three consecutive years, the flight activity from 10 honey bee colonies was recorded for a day at the beginning, middle, and end of the flow. The outgoing flights started at about 9.00 h, reached a maximum between 14.00 and 16.00 h, and ceased at about 21.00 h. Multiple correlation coefficients of humidity, temperature, wind speed, and light intensity with flight activity ranged from +0.701 to +0.978, all highly significant. Correlation coefficients of temperature with flight activity ranged from +0.532 to +0.947, also highly significant. There was a significant direct relationship between flight activity and colony weight gain 30 min later. This weight gain was correlated with honey bee activity and with the above four weather factors; the coefficients ranged from +0.490 to +0.837, all highly significant. The mean daily flight activity of a colony was highly significantly correlated with the total weight gain of the colony at the end of the season (+0.766 to +0.879). This relationship was not significant on a day with no weight gain. Mean flight activity significantly differed between

years. Overwintered colonies flew more than package colonies. A single day's activity was related to the total seasonal weight gain of the same colonies. The results suggested that a single day's gain is also related to the total seasonal gain, and that by weighing colonies on two consecutive mornings the highest-gaining colonies could be selected for breeding.

Outdoor wintering of Italian and Caucasian-Italian hybrid honey bees. Six colonies were wintered in each of the following treatments: Italians in three supers (I3), Caucasian-Italian hybrids in three supers (H3), and Caucasian-Italian hybrids in two supers (H2). These were insulated and packed in three groups of six colonies. Each colony had a 1 × 5-cm top and bottom entrance. During wintering in 1974–1975, the maximum daily temperature was always less than 10°C for 156 days.

Significantly more hybrid colonies (10 out of 12) than Italian colonies overwintered (1 out of 6). The weight loss during the 205 days was similar in all groups: 30.5 (I3), 28.4 (H3), and 28.4 (H2) kg/colony. When development of the colonies in spring was compared, the number of combs completely covered with bees was 2.0, 7.2, and 5.0 and

the capped brood area 595, 3990, and 2266.7 cm² for Italian in three supers, hybrids in three supers, and hybrids in two supers, respectively.

The effect of queen-related problems and swarming on brood and honey production of honey bee colonies. Colonies with queen loss or queen failure, or those that swarmed, produced less honey than did normal colonies. There was also less brood reared in colonies in which there was queen loss or queen failure, but brood production up to the time of swarming was 16% greater in colonies that swarmed than in normal colonies. On average, honey production in colonies with queen-related or swarming problems was only 58.5% of normal, showing the importance of eliminating these problems whenever possible.

CEREALS

Breeding

New six-rowed feed barley lines. Two six-rowed feed barley lines, one from the cross Jubilee/Olli and the other a selection from Alaska, have performed very well in central and northern Alberta. They are being presented to the appropriate expert committees.

ENVIRONMENT AND SOILS

Meteorology

Pollination activity of leafcutting bees influenced by solar irradiance. A limiting factor in the production of alfalfa seed is the efficiency of the associated insect pollinators, particularly the alfalfa leafcutting bee, *Megachile rotundata* (F.). The influence of solar irradiance, air temperature, and vapor pressure on the pollination activity of *M. rotundata* was examined. During four warm cloudless days at Beaverlodge, Alta., it was found that air temperature established an environmental threshold for the initiation of pollination activity. Once the threshold, which occurred at 16–17°C, was surpassed, activity was dependent on solar irradiance. Over the limited range of vapor pressures observed, no relationship between vapor pressure and activity could be discerned. These results have utility in defining optimum insect foraging activity.

The influence of humidity on the pollination activity of leafcutting bees. Pollination

activity of the alfalfa leafcutting bee, *M. rotundata*, in response to atmospheric humidity was considered. Although pollination activity shows a strong relationship to relative humidity, it is shown that 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. This suggests that care must be exercised in assessing the effects of atmospheric humidity on biological activity.

A method of assessing leaf area. A technique for evaluating leaf area that can be incorporated into a destructive plant analysis program was developed. The method exploits the linear relationship between leaf area and leaf dry weight. Leaf-area data used in deriving this relationship were obtained from photographs with the use of an image-analyzing densitometer.

Soil management

Soil moisture and temperature response to shallow tillage in the early spring. Surface soil moisture was conserved in a loam to clay loam soil receiving a single shallow cultivation in the early spring, whereas in an untilled soil surface, soil moisture declined markedly. Tillage effects were less marked at greater depths. Soil temperatures were found to differ only slightly between tilled and untilled soils.

Deep tillage of two Solonetz soils in the Peace River region. Studies on two Solonetz soils in the Peace River region, which have been conducted for the past 9 yr and are still in progress, involve deep plowing and ripping compared with conventional shallow plowing. On both soils, a Black Solonetz, Kleskun Si.C.L., and a Gray Solodized Solonetz, Debolt C.L., difficulties were encountered with subsequent cultivation, seedbed preparation, and establishment of crops. Gravimetric soil moisture measurements and some chemical soil analyses did not show consistent or conclusive improvement of these two soils. Neither did the yields of barley, bromegrass, alfalfa, or fall rye when obtained in the first years after treatment.

In 1976, gypsum, lime, and fertilizers were superimposed on the initial tillage treatments and the test areas were seeded to three grass species. Hay yields are being used to further assess tillage and soil amendments.

Plant survival

Winter injury in alfalfa. Many alfalfa fields in northern Alberta experienced stress during the 1979–1980 winter. Plant samples dug throughout the winter indicated that 5–15% of the plants in some fields had been killed by mid-January 1980. A reduction in plant population of this magnitude would not noticeably affect yield, because the remaining plants could compensate for the reduced population. However, growth of surviving plants was one-tenth that of growth in other years. This lack of vigor during winter suggested a reduced ability to compete with disease organisms or with weeds, particularly under conditions of a late, cool, wet spring. Fortunately, the spring of 1980 was early, warm, and very dry. As a result, alfalfa had a competitive advantage over weeds and disease organisms, and winter injury was minimized.

Two root- and crown-rot organisms, *Plenodomus meliloti* and *Fusarium nivale*, appear to have contributed to injury in the late summer and early fall of 1979 in one study at the Research Station. Beaverlodge received no precipitation after mid-July in 1979, and the dry conditions may have been conducive to the growth of these two organisms and the damage they caused. In addition, crown buds developed into shoots. These conditions appear to delay hardening and reduce the rate of hardening. In early November, soil temperature at 5 cm dropped to -3°C , and as a consequence of the delayed hardening, a number of plants were injured. Other tests indicated that stands suffered most injury by December 1979.

FORAGE CROPS

Breeding

Peace alfalfa licensed. Peace is a landrace cultivar developed at the Agriculture Canada Experimental Farm, Fort Vermilion, Alta. It is a hardy long-lived alfalfa, with good persistence and rapid regrowth after cutting in northern regions. It was granted license No. 2022 in Canada in April 1980.

Yields of Peace were up to 15% higher than those of Beaver over 12 station-years from 1976 to 1979 in northern Alberta. Following the severe winter of 1977–1978 in northern Alberta, Peace experienced the least winter kill of 10 cultivars seeded in 1976 and yielded more forage than Beaver at most locations in

1978 and 1979. Crude protein in Peace is higher than or equal to Beaver. Using leafcutting bees as pollinators, seed yields of Peace were equal to Beaver. Because Peace flowers 1–3 days earlier than Beaver, it offers greater potential for seed production in seasons with early fall frost. Peace is adapted primarily to the Peace River region of northwestern Canada, where winterhardiness and persistence are required and bacterial wilt is not a problem.

Seed production

The relationship between latitude and the emergence of alfalfa leafcutting bees. Studies in Western Canada from 1974 to 1977 on variations in time and duration of the emergence period after diapause of leafcutting bees, *M. rotundata*, reared at latitudes ranging from 29°N to 58°N showed that bees reared at northern latitudes emerged sooner and that the duration of the emergence period was shorter than for bees from southern latitudes. When southern bees were reared in the north, their emergence pattern was similar to the northern strain. However, the change in time required for emergence and duration of emergence period of northern strains reared in the south was less pronounced. Number of days to emerge varied inversely with length of cold treatment at 4°C , with greater variance in southern strains.

Nitrogen fixation

Selections of Rhizobium for alfalfa inoculants for Western Canada. Selection and evaluation of *R. meliloti* have identified strains that are capable of improved nodulation and N_2 fixation for alfalfa grown on moderately acid soils (pH 5.6–6.0) and that are also capable of maintaining activity in neutral soils (pH 6.0–7.0).

Following extensive laboratory and greenhouse testing, four strains, namely NRG-43, NRG-61, NRG-118, and NRG-185, were selected for field evaluation. In field tests on moderately acid soils, inoculating alfalfa with these strains and with combinations of them increased yield by 60–288% over uninoculated controls. The results from three test-years showed that alfalfa inoculated with NRG-185 outyielded alfalfa inoculated with the BAL-SAC strain by 8.5%. Although NRG-61 performed well in greenhouse tests, it is somewhat slower growing than the other strains, and field-grown alfalfa inoculated

with this strain yielded 14.3% less than that inoculated with NRG-185.

On the basis of the superior performance of NRG-185 in moderately acid soils and the ability of NRG-43 to perform well at soil pH above 6.0, these two strains have been selected for inclusion in inoculants that will provide effective nodulation over the soil pH range 5.6–7.0. These strains are effective on the three common species of alfalfa (*Medicago sativa*, *M. media*, and *M. falcata*) and on sweetclover (*Melilotus* spp.).

These two strains, NRG-43 and NRG-185, have been made available to inoculant manufacturers wishing to produce alfalfa and sweetclover inoculants for Western Canada.

Synergism between effective and ineffective strains of Rhizobium meliloti. Indigenous ineffective strains of *R. meliloti* occur extensively in moderately acid (pH 5.0–6.0) soils of Alberta. In these soils the percentage of ineffective nodules on alfalfa (*M. sativa*) increases as soil pH decreases. At pH 6.0, 23% of the nodules are ineffective, and all nodules are ineffective at pH 5.0. Strains of *R. meliloti* have been selected to produce

effective nodulation in the pH range 5.5–6.0. The ability of these effective strains to compete with the indigenous ineffective organisms was studied. Alfalfa seedlings were inoculated with four effective strains of *R. meliloti* individually, as well as in combination with each of two ineffective strains isolated from acid soils. Acetylene reduction rates, nodule numbers, nodule dry weights, and total plant dry weights were determined 7 wk after inoculation.

No ineffective nodules were observed on alfalfa inoculated with combinations of effective and ineffective strains. Ineffective nodules occurred only when the alfalfa was inoculated with the individual ineffective strains. These results indicate that the effective strains of *R. meliloti* selected for low pH tolerance readily out-competed the two indigenous ineffective strains for infection sites on alfalfa roots. Inoculation with the effective-ineffective strain combinations resulted in greater nodule dry weight, increased nitrogenase activity per plant, and higher total plant dry weight than inoculation with the individual effective strains. This synergistic effect on yield is an important factor to consider when selecting strains for use in low pH soils.

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Research

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VACANT

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Morden, Man., July 1980

Acting Director

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Forage crops

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INTRODUCTION

The Lacombe Research Station and the crops and soils 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 Solonchic 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 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 level and with consideration given to cooking quality and other factors related to consumer acceptance of the final product.

This report summarizes some of the results of research conducted at this Station during 1980.

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

Exotic sire breed effects on preweaning traits of their calves. In a project to evaluate the meat production potential of crossbred calves sired by exotic European beef breeds, Limousin bulls sired calves with the longest gestation, the least calving difficulty, the lightest birth weight, the lowest birth to weaning mortality, and the slowest preweaning growth. Most of these effects were highly significant statistically ($P < 0.01$). Charolais-sired calves exceeded Simmental-sired calves in calving difficulty and birth weight, but the progeny of these two sire breeds did not differ for other preweaning traits. The work, carried out at the Lacombe and Brandon research stations, involved 3939 calves from 48 Western Canadian cow herds of Hereford, Short-horn, or Angus breeding.

Sire evaluation for carcass traits with ultrasonic data from progeny. Data obtained by dissection of 98 steer carcasses were used

to investigate the value of live animal ultrasonic measurements of the subcutaneous fat depth of progeny in estimating their sire's merit for carcass composition traits. The steers were all born in the same season, were of Lacombe selected and control line Short-horn breeding, and represented 15 sires. Heritability estimates were derived from the sire variance component with the use of a statistical model that included line of breeding, slaughter or carcass weight, and (random) sire effects. The heritability estimates were 0.21 for rib fat thickness measured directly on the carcass, 0.23 for live animal rib fat thickness measured by the Ithaco Scanogram ultrasonic machine, and 0.19 for live animal rib fat thickness measured by the Krautkramer ultrasonic machine. Heritability estimates for the weight of dissectible lean and fat tissue in the carcass were 0.11 and 0.34, respectively, whereas the estimates for the percentage of dissectible lean and fat tissue in the carcass were 0.56 and 0.39, respectively. Product moment correlations of sire-predicted differences for live animal

ultrasonic fat depth measurements with sire-predicted differences in carcass composition ranged from 0.93 to 0.98 for the weight of dissectible tissue and from 0.86 to 0.96 for the percentage of dissectible tissue. The heritability estimates suggest that moderately high proportions of the total variance of carcass traits are associated with effects transmitted by the sire (even within these uniform populations), and the correlations suggest that carcass or live animal ultrasonic fat depth measurements on a sufficient number of steer progeny may be used to obtain reasonably accurate estimates of sire-predicted differences (genetic merit) for these carcass traits.

Growth patterns of hybrid cows under two environments. Growth patterns for 1000 crossbred females produced by crossing Charolais, Limousin, and Simmental sires with Angus, Hereford, and Shorthorn dams were compared under extensive range conditions at Manyberries, Alta., and semi-intensive conditions at Brandon, Man. One hundred and fifty Hereford \times Angus females served as controls. The females were born in 1970, 1971, and 1972, and weights were taken at calving, breeding, and weaning each year until 1979. The average weights of the two herds at the initial breeding (15 mo) and final calving in 1979 differed by less than 3%, but their growth patterns differed widely between locations. Weight gains of the Hereford \times Angus controls at Brandon diminished gradually from 15% during the first gestation to 2% in the last. In contrast, the Manyberries controls exhibited weight losses in 1973, 1974, and 1977, compensated by a large gain (approximately 40%) in 1976. The annual breeding weights of the other crossbred groups at the two locations averaged approximately 20% (Charolais crosses), 12% (Simmental crosses), and 8% (Limousin crosses) heavier than their contemporary controls. Nursing females at Brandon lost weight during the nursing period and gained weight during the winter gestation period. The converse was observed at Manyberries. Females that were not nursing a calf when they were bred gained weight throughout their nonproductive year. Manyberries recorded the highest frequency of barren years and larger growth increments for nonnursing females.

Swine

Meat quality in pigs selected for lean tissue growth rate. In a study of more than 600 carcasses over 3 yr, it was determined that genetic improvement in lean tissue growth rate was far less important than year differences in influencing the incidence of pork quality problems (pale-soft-exudative (PSE) or dark-firm-dry pork (DFD)).

MEATS

Beef tenderness

Shear values. Warner-Bratzler shear values were determined on four bovine muscles (longissimus dorsi (LD), psoas major (PM), semitendinosus (ST), and biceps femoris (BF)) such that the muscle fibers were sheared at angles of approximately 0°, 45°, and 90° to their longitudinal axes. The extent to which shear values were affected by the angle at which the muscle fibers were sheared was similar for LD, PM, and ST; the difference (approximately 2.9 kg) in shear value between muscle fiber angles of 0° and 90° was highly significant. The effect is of sufficient magnitude that it requires careful consideration as a source of variation or confounding or both in experiments where treatment effects on Warner-Bratzler shear values are being assessed.

Electrical stimulation (ES) of beef carcasses. Electrical stimulation during the dressing process is a highly acclaimed industrial technique that is gaining rapid acceptance in some countries. It has great economic implications because of the possibilities of reduced aging and storage required in addition to several other alleged benefits. Results from two separate ES experiments carried out at a small commercial abattoir by Lacombe scientists demonstrated that substantial improvement in both initial (24 h) and subsequent (6 days) tenderness could be achieved with typical Canadian feedlot cattle. Effectiveness of ES was found, however, to be highly dependent on both rate of carcass pH decline and carcass chilling rate in the early prerigor condition. The need to attain a sufficiently low pH (<6.0) while the carcass temperature still remains high (>35°C) could in part explain the failure to observe significant effects of ES in numerous other technical reports.

Ion content of beef and tenderness. A recently patented (U.S.) method analyzing beef carcass muscle for various metallic ions has been introduced as a possible industrial method for segregating beef carcasses into tenderness outcome groups. The relationship of concentrations of the minerals Cu, Fe, Ca, Zn, Mg, Na, and K in raw meat to Warner-Bratzler shear values of cooked meat was investigated with the use of 120 cattle classified by breed of sire and sex or by age. Both mineral contents and shear value were affected by breed of sire, sex, age, and muscle analyzed. Correlation analyses after adjustment for these sources of variation indicated that neither the mineral concentration of the raw LD nor that of the semimembranosus muscle could be used to predict the cooked-meat shear value (tenderness).

Collagen content, aging, and tenderness. A total of 108 LD and 36 ST muscles from predominantly 0.5 or 0.75 blood Charolais, Simmental, or Chianina cattle ranging in chronological age from 11 to 15 mo and with carcass weights of approximately 270 kg were utilized to evaluate the effects of postmortem aging upon tenderness and intramuscular collagen content and solubility. In general, the results of this study failed to provide direct evidence that up to 480 h (20 days) of postmortem aging significantly altered intramuscular collagen content or solubility in the LD or ST muscle. In addition, the results also failed to provide evidence of a significant relationship between intramuscular collagen content or solubility and shear force values in beef carcasses with similar chronological ages. Furthermore, no significant relationships between intramuscular collagen contents and solubilities of different muscles were observed.

Retail preservation of beef

Rapid detection of beef spoilage bacteria. Media and incubation conditions were compared to establish a rapid method for the detection of psychrotrophic (cold thriving) spoilage bacteria from beef and to determine the relationship between bacterial counts obtained by such a method and retail beef keeping quality. Of the methods tested, incubation of plate count agar (PCA) at 25°C gave the most accurate measure of psychrotrophic bacterial numbers within 24 h of sampling the meat surface. Comparison of this method with the recommended procedure

(7°C, 10 days) revealed no significant qualitative or quantitative differences in the psychrotrophic bacterial population or in the rate of bacterial growth on steak surfaces. Moreover, the initial bacterial load as determined following 25°C (24 h) incubation was directly related to the retail case life of steaks. The results show that by increasing the temperature of incubation of PCA to 25°C, the time required for psychrotrophic bacterial enumeration is substantially reduced, without loss of precision; this procedure provides a rapid and more useful estimate of retail beef keeping quality.

Effect of retail case blower temperature on beef spoilage. With the use of laboratory-simulated retail conditions, a variety of retail case blower temperatures were selected in order to determine their influence upon the surface temperature of rib eye steaks, bacterial growth, and steak shelf life. Steak surface temperature was found to be significantly correlated with blower temperature and to exceed the temperature of the incoming blower air by 9°C. Furthermore, bacterial growth rates and steak shelf life were significantly and inversely related to blower temperature. Under usual conditions of operation, retail case blower temperature was -0.5°C, resulting in a steak surface temperature of 7.3°C and a visual shelf life of 3.8 days for steaks on retail display. However, by adjusting the retail case blower temperature to a minimum of -8.6°C, the steak surface temperature was reduced to 1.9°C and the shelf life was extended to 8.2 days. From a practical standpoint, these results indicate that retail display cases may not be operating maximally and a relatively simple temperature adjustment by the retailer could improve microbial quality and more than double the shelf life of meats on display.

PLANT BREEDING AND PATHOLOGY

Rapeseed diseases

Effects of herbicides and fungicides on diseases in rape. Trials at Lacombe have demonstrated that some herbicides increased the severity of certain diseases in rape. Of eight herbicides tested, only trifluralin significantly increased the severity of staghead (*Albugo cruciferarum*). However, a fungicide, metalaxyl, included in the staghead

test gave good control of the disease. Previous work demonstrated that stem rot (*Sclerotinia sclerotiorum*) was increased by barban applications.

Cereal diseases

Cultural practices and root rot in cereals. Information in the literature on the effect of grass or fallow in a crop rotation with barley in reducing common root rot in the succeeding barley crop is inconsistent. Long-term rotation studies at Lacombe have shown that Galt or Gateway barley grown after bromegrass had 50% less root rot at harvest than when grown after fallow or continuous barley. It has generally been believed that grasses in the rotation enhanced root rot development. Root rot developed more slowly during the growth of the barley when the barley was sown after oats or rapeseed than when it was sown after barley or fallow, although at harvest, the barley from all these treatments was about equally diseased.

Agronomic studies with barley indicated that applications of P and potash fertilizer to soils lacking these nutrients significantly reduced root rot and yield losses. Nitrogen fertilizer did not affect root rot development.

In cooperative studies with scientists at Saskatoon, severity of root rot in a number of barley varieties was increased significantly when depth of seeding was increased from 4–5 cm to 10 cm.

CROP MANAGEMENT AND SOILS

Weed research

Effect of time of removal of wild oats on yield of barley and rape. Heavily seeded infestations of wild oats were allowed to compete with barley or rapeseed for various intervals of time before the wild oats were removed by hand. The loss of barley yield due to wild oat competition started 12 days after seeding (two-leaf stage) and continued in a linear relationship with time until the crop was fully headed, 60 days after seeding. The loss in rapeseed yield started 15 days after seeding and continued in a linear relationship with time until 65 days after seeding. These data indicate that postemergence wild oat herbicides should be applied within 20 days after seeding to obtain maximum benefit.

Control of wild oats and Tartary buckwheat with mixtures of metribuzin and

various postemergence wild oat herbicides. The phytotoxicity of difenzoquat, flamprop, barban, and diclofop to wild oats in wheat was reduced when each of these herbicides was applied in a tank mixture with metribuzin or metribuzin + MCPA. Further greenhouse data suggest that the antagonism may be occurring in the spray tank as a result of an interaction between the metribuzin active ingredient and each of the wild oat herbicides.

No loss of metribuzin or metribuzin + MCPA phytotoxicity to Tartary buckwheat occurred when these herbicides were tank mixed with each of the four wild oat herbicides.

Control of wild oats, green foxtail, and Tartary buckwheat with mixtures of propanil or propanil–MCPA and postemergence wild oat herbicides. The phytotoxicity of barban, diclofop, difenzoquat, and flamprop to wild oats was reduced when these herbicides were tank mixed with propanil or propanil–MCPA. Green foxtail control with propanil and propanil–MCPA was poor. Propanil–MCPA in a tank mixture with diclofop reduced diclofop control of green foxtail. Barban in a tank mixture with propanil increased green foxtail and Tartary buckwheat control compared with propanil alone. All other tank mixtures of propanil or propanil–MCPA with the four wild oat herbicides had no significant effects on green foxtail control compared with propanil or propanil–MCPA. Tartary buckwheat control with propanil was good, and the wild oat herbicides (except barban) in tank mixtures with propanil did not influence Tartary buckwheat control. There was an early chlorosis of wheat following treatments containing propanil or propanil–MCPA, but this disappeared later in the growing season. Because of the reduced wild oat control with tank mixtures of propanil or propanil–MCPA with barban, diclofop, difenzoquat, or flamprop, use of these mixtures for broad-spectrum weed control is not recommended.

Influence of nonionic surfactants, ammonium sulfate, water quality, and spray volume on the phytotoxicity of glyphosate. In field studies addition of the surfactants Tween 20, X-77, and Triton X-100 to glyphosate enhanced the effectiveness of low glyphosate rates (0.14 and 0.21 kg/ha) when applied on rape, wheat, oats, and barley. This suggests that the amount of surfactant in the commercial glyphosate formulation at these low glyphosate rates is insufficient for maximum

herbicidal activity. Concentrations of at least 0.5% v/v Tween 20 were required for enhancement of glyphosate phytotoxicity in barley. The surfactants Renex 36, Cittowet Plus, and Dupont WK reduced glyphosate phytotoxicity in field and greenhouse studies. Atplus 411F, Surfel, and Triton X-114 also

reduced glyphosate effectiveness in several field treatments. A number of other surfactants had no significant effects on glyphosate phytotoxicity. Thus, by addition of a suitable surfactant, it may be possible to use rates of glyphosate as low as 0.14 kg/ha for control of volunteer cereals.

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W. M. HAMMAN, B.Sc.(Agr.), Ph.D. Resigned 29 February 1980	Weed control
E. J. HAWN, D.F.C., C.D., B.S.A., M.Sc., Ph.D. Retired 30 December 1980	Forage and nematode diseases
A. JOHNSTON, LL.D., F.A.I.C., F.S.R.M., B.S.A., M.S. Retired 30 December 1980	Range ecology
M. OOSTERVELD, B.Sc.(Eng.), M.Sc., Ph.D. Resigned 19 September 1980	Hydrology
G. W. SWAILES, B.S.A., M.S., Ph.D. Retired 29 December 1980	Cutworms
S. A. WELLS, B.S.A., M.Sc., Ph.D. Retired 15 August 1980	Barley breeding

VISITING SCIENTISTS

J. P. FAY, Ph.D.

National Research Council of Argentina
(CONICET), postdoctorate fellow, 1978-1981

Rumen microbiology

R. G. HOLMBERG, Ph.D.

Athabasca University, on sabbatical leave, 1980-
1981

Grasshoppers

¹Seconded from Libraries Division, Finance and Administration Branch.

²On transfer of work to the Animal Research Institute, Werribee, Australia, from September 1980 to September 1981.

³Seconded from the Regional Development and International Affairs Branch, Agriculture Canada.

⁴On educational leave, University of Minnesota, Minneapolis, from September 1978 to September 1981.

⁵On transfer of work to the Agriculture Canada Research Station, Vancouver, B.C., from March to May 1980.

⁶On educational leave, University of Alberta, Edmonton, Alta., from September 1979 to September 1980.

⁷On leave of absence to the International Atomic Energy Agency, Vienna, Austria, from January 1980 to December 1981.

⁸On educational leave to Iowa State University, Ames, from August 1980 to August 1983.

⁹On leave of absence to the International Atomic Energy Agency, Centro de Energia Nuclear Na Agricultura, Piracicaba, Brazil, from September to December 1980.

INTRODUCTION

The Research Station at Lethbridge is the largest establishment in the Research Branch, with a wide variety of research programs that serve the most agriculturally diverse area of the prairies. Situated on the dryland area known as the Palliser Triangle, the Station also serves extensive irrigated farming and cattle-producing enterprises. The multidisciplinary research programs contribute notably to the continuing success and intensification of agricultural production in this area, as well as having impact at the regional and national levels.

The brief reports that follow exemplify the diversity of the research. Highlighted are some of the examples of progress that is being made in both basic and applied research to improve the efficiency of agricultural production. For example, Elbee, the first cultivar of northern wheatgrass to be licensed in Canada, was released this year, as was Nova, a more winter-hardy, higher-yielding cultivar of sainfoin. Methods for reclaiming a saline seep area have been demonstrated on a field scale. Highland cattle have been found to have valuable traits when used in breed crosses. New, more effective and less persistent pesticides have been identified to control such disease pests as cattle ticks and biting flies, grasshoppers, and seed pathogens. The use of sterile males in combination with insecticides proved effective in reducing cattle grub populations on a large ranching area. Progress in understanding basic mechanisms that control earliness and cold resistance in crops and resistance to pests in animals is laying the groundwork for the future development of crops and animals better able to succeed in environments that now limit their productivity.

New research topics, relating to Departmental priorities, aim to develop new technology that permits improved conservation of soil and efficiency of energy use; to develop new marketable crops for diversifying production, expanding markets, and reducing imports; to reduce dependence on pesticides; and to increase fundamental scientific knowledge. Specifically, new programs were established in soft white spring wheat breeding, control of verticillium wilt in alfalfa, and biological fixation of nitrogen.

Several scientists, who have made significant contributions to agriculture during their long careers, retired during the year. They include Dr. S. A. Wells, barley breeder; Dr. A. Johnston, agrologist; Dr. G. A. Swailes, entomologist; and Dr. E. J. Hawn, plant pathologist.

This report summarizes some of the main research results of 1980. Further detailed information may be obtained from the scientists or from publications listed in the report. Correspondence or requests for reprints should be addressed to: Research Station, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

J. E. Andrews
Director

ANIMAL PARASITOLOGY

Biting flies

Topical applications of permethrin, cypermethrin, and resmethrin were tested under field conditions as repellents to protect cattle from black flies.

Technical permethrin in ethanolic solution with active ingredient (ai) at doses of 1, 2, 4, and 6 mg/kg of body weight effectively repelled black flies by preventing at least 70% of the flies present from taking a blood meal for up to 8 days and for at least 11 days at doses of 12 mg ai/kg. Aqueous mixtures of 20% emulsifiable concentrate (EC) permethrin at doses of 1, 2 and 6 mg ai/kg

effectively repelled black flies for 2, 10, and 11 days, respectively. A ready-to-use 5% dust of permethrin at doses of 1, 2, and 4 mg ai/kg effectively repelled black flies for 4, 5, and 8 days, respectively.

Technical cypermethrin in ethanolic solution at doses of 1 and 2 mg ai/kg repelled black flies for 3 and 4 days, respectively. Aqueous mixtures of 40% cypermethrin EC at doses of 2 and 4 mg ai/kg repelled black flies for at least 5 days.

Technical resmethrin in ethanolic solution at doses of 2 and 6 mg ai/kg repelled black flies for 1 and 2 days, respectively.

Warble control

Host resistance to warble grubs in cattle. Biological experiments have provided clear evidence that cattle are born with some degree of resistance to warble grubs (innate resistance) and develop more resistance with infestation (acquired resistance). In first infestations of calves with varying numbers of eggs, percentage survival to the warble stage decreased as the number of eggs increased, in a dosage-response manner. A similar pattern occurred when the calves were infested by injecting hatched larvae, except that the percentage survival was greater for grubs than for eggs (e.g. 14% survival with an injection of 100 eggs versus 58% survival for 100 larvae).

With initial larval infestations most calves were susceptible or moderately susceptible, but about 5% of calves were innately resistant. Acquired resistance was shown to be caused by previous infestations and not by aging factors. Grub survivals were equal in animals receiving initial infestations in their 1st yr to 5 yr of age. When repeated infestations were administered at low levels (e.g. 200 eggs, with about 12% larval survival), resistance did not develop until the fourth annual infestation. However, with high-level first infestations (e.g. 100 larvae injected with 50-70% survival), the susceptible calves showed resistance on the second infestation, and resistance persisted or improved slightly in subsequent infestations. The small number of innately resistant cattle remained so through a series of infestations. The acquired resistance persisted even through a 3-yr period of noninfestation. These experiments have provided parameters of resistance and susceptibility in cattle for immunological studies now in progress.

Eradication of cattle grubs. Eradication of the common cattle grub, *Hypoderma lineatum* (de Vill.), by a combination of systemic insecticides and sterile-fly releases was achieved on a cooperating cattle ranch after the third annual release program. The eradication has persisted to the present, 2 yr later, despite nontreatment of parts of the herd with insecticides at various times. Neighboring ranches adjacent to the areas of sterile-fly releases have now failed to produce grubs of this species, which suggests a dispersal of the sterile flies. Grubs of the northern warble fly, *H. bovis*, subjected only to chemical control treatment, have persisted in the ranch herd

and neighboring herds. Releases of sterile *H. bovis* have now been initiated on the cooperating ranch.

Control of manure-breeding flies

In cooperation with a cattle feedlot, replicated experimental pens of 40 steers were arranged to assess the effects of stirofos oral larvicide premix in the cattle feed at 58 mg/kg diet under conditions of good and poor manure removal. Treatment began in mid-August, coinciding with the season's last cyclic increase of house fly breeding, and ended in mid-October. House fly breeding reached peak numbers in late September. Full fly emergence was only realized in the untreated uncleaned pens; in the treated uncleaned pens, numbers of flies emerging increased slightly for the first 2 wk of treatment then were suppressed to a level of 90-100% control for the remaining 9 wk. The manure from both untreated and treated cleaned pens never produced significant numbers of flies, probably because of weathering. This effect also appeared in bioassayed manure samples, even though they were processed in the laboratory for optimal house fly breeding. There was no evidence that the treatment suppressed the nontarget insects in the manure. Treatment of the cattle rations had no adverse effects on growth performance or morbidity levels among the cattle.

Cattle lice

A spot-on application of chlorpyrifos at 20 mg ai/kg body weight was safe and effective for controlling the short-nosed cattle louse during the winter. The treatment, applied to chronically infested pregnant cows on 6 February, reduced the louse population by up to 89% for 10 wk, and a retreatment was not necessary. The treatment met the special requirements for winter control of lice in that it caused neither the wetting and chilling of cattle nor the side effects associated with the death of warble larvae if the host is infected. The treatment did not significantly reduce the whole-blood cholinesterases, nor did it cause adverse clinical effects or abortions.

Before treatment, the cows were anemic and showed a 50% reduction in some of their blood components including the erythrocytes, leukocytes, hemoglobin, and the packed cell volume. Eighteen weeks after treatment, the cows had recovered from anemia and the

blood components had returned to normal levels.

Control of tick paralysis

In a field test in British Columbia, cattle either sprayed along the back line with 0.5% phosmet or 0.25% lindane wettable powders (2 L/animal) or treated with 8% phosmet (90 mL/animal) or 44% chlorpyrifos (14 mL/animal) pour-ons were protected from paralysis-causing Rocky Mountain wood ticks despite a heavy infestation that caused reversible paralysis in five of 10 untreated cattle. The 8% phosmet pour-on is the only preparation so far tested that is already registered for application to cattle and is as effective as the 0.25% lindane spray for which the registration is now under review.

Pesticide chemistry

In chemical research on livestock insecticides, the four stereoisomers of permethrin were isolated by reacting the individual acid components with *m*-phenoxybenzyl alcohol and purifying the crude products by column chromatography. The availability of these isomers has allowed the initiation of field tests with each of these chemicals as potentially important biting fly repellents for cattle. Procedures were also optimized for the synthesis of a new pyrethroid acid intermediate, derivatives of which have shown insecticidal activity in screening tests with mosquito larvae. A new analytical procedure, based on high-resolution gas chromatography with glass capillary columns, was developed that permits resolution of complex mixtures of closely related chemicals in various formulations and extracts of citronyl insect repellent. It was concluded that citronyl is composed of a mixture of four isomeric products.

Host resistance

Infestations of sheep ked, *Melophagus ovinus* L., stimulate the production of humoral antibody toward sheep ked salivary gland proteins. Both the primary and secondary antibody responses closely trace the rise and fall of two consecutively applied ked populations on both resistant and susceptible sheep, with the peaks occurring 5.5 and 4 mo postinfestation, respectively. Acquired resistance was demonstrated for both innately resistant and susceptible sheep by the determination of significantly lower secondary infestations in both groups, despite antibody

responses that were similar to those observed for primary infestations. Because secondary antibody responses are transient and not elevated above primary responses, antibodies are probably not the principal mediators of acquired resistance to sheep keds.

Bioeconomics of animal pests

The host-parasite relations of horn flies on cattle were modeled with a combination of mathematical simulations and quantitative measurements of host-parasite responses in experiments on irrigated pastures. These studies defined the parameters and the impacts of infestations on rate of growth and productivity of yearlings during the summer grazing season. Horn flies have evolved an adaptive obligatory relation with cattle, in which impact is mediated by herd behavior over a wide range of infestation levels. During most years, infestations are subject to host-parasite regulation, and changes in herd behavior are quantal so that impact remains nearly constant. This impact amounts to a reduction of 17–20% of potential rate of growth with mean infestations of 12–230 flies per animal, the range of host-parasite regulation. Definition and measurement of this biological parameter have facilitated an accurate estimate of the minimum loss of efficiency in beef production. From detailed statistics of cattle populations, losses to horn fly and similar biting fly attack were calculated to exceed 65 million kg of animal gain in Canada in 1979.

ANIMAL SCIENCE

Beef cattle

Legume bloat. Whole leaflets of three bloat-causing legumes (alfalfa, red clover, and white clover) and three bloat-safe legumes (birdsfoot trefoil, cicer milkvetch, and sainfoin) were incubated with rumen bacteria, and their digestion was monitored by dry matter loss, gas production, and electron microscopy. The bloat-causing species were characterized by high initial rates of leaching (loss of organic dry matter—proteins, amino acids, and carbohydrates), gas production, and microbial digestion (weight loss). The initial release of organic matter may elicit a positive chemotactic response in rumen bacteria, resulting in their attraction and subsequent attachment to stomata and damaged sites of the leaflets. Electron microscopy

showed that after penetration through these openings, bacteria multiply in the intercellular spaces of leaf tissue forming large populations before the plant cell walls are digested allowing actual bacterial digestion of cellular components such as chloroplasts and further bacterial proliferation. This bacterial invasion of the intercellular spaces (resulting in disintegration of leaf tissues in some legumes), and then of the cells themselves, proceeds more quickly in bloat-causing than in bloat-safe legumes. These results support our theory that the initial rate of digestion and disintegration of plant tissues appears to be an important determinant of the bloat-causing potential of forage legumes.

Monensin. Addition of monensin (Rumensin, Eli Lilly and Co.) to an artificial rumen immediately depressed the rate of digestion of roughage and of roughage-concentrate (50:50) feeds. Methane and propionate production were affected only with the roughage-concentrate feed. The beneficial effect of monensin on feed efficiency may therefore be due to a combination of the energetic advantages of a higher propionate fermentation, the reduced loss of carbon by methanogenesis, and the increased amounts of feed protein escaping microbial degradation in the rumen.

Rumen microbiology. All 54 bacteria picked from the clear zones of cellulose agar were identified as the cellulolytic bacterium *Ruminococcus flavefaciens*. However, using a cotton-enrichment culture technique, 11 of 15 cotton-solubilizing cultures were identified as *Bacteroides succinogenes* and the remaining four cultures were identified as *R. flavefaciens*. Therefore methods for assessing cellulolytic flora based on the formation of clearings in cellulose agar are unlikely to accurately reflect the numbers of *B. succinogenes* present. Our experiments have also illustrated the ability of *B. succinogenes* to compete successfully with *R. flavefaciens* and other cellulolytic rumen bacteria in adhering to the surface of plant cell walls on both alkali-treated and untreated cereal straws. These findings suggest that *B. succinogenes* is important in the rumen digestion of such highly ordered forms of cellulose as straws.

Feeding value of triticale. A feeding trial with beef steers was conducted to compare triticale and barley. Each of the grains was processed by two methods, tempered-rolled and dry-rolled. Tempered-rolled triticale and

tempered-rolled barley supported similar rates of gain (1.27 and 1.32 kg/day) that were higher than those obtained by feeding dry-rolled triticale or dry-rolled barley (1.14 and 1.09 kg/day). Triticale and barley were of similar feed value for the steers used in the experiment. Both triticale and barley must be processed to maintain coarse particle-size feed to obtain satisfactory rates of gain.

Reproductive efficiency of first-cross beef cows in two environments. Growth patterns and productivity were evaluated on 10 first-crosses of cow under farm (Brandon) and ranch (Manyberries) conditions in a joint program of the Brandon, Lacombe, and Lethbridge research stations. First-cross cows sired by Charolais were heavier at breeding and at weaning of their calves than those sired by Simmental or Limousin, whereas Hereford-Angus were the lightest. First-cross cows out of Hereford or Shorthorn dams were heavier than those out of Angus at Manyberries but not at Brandon. All the sire-breed (Charolais, Simmental, and Limousin) and dam-breed (Hereford, Angus, and Shorthorn) combinations (except Limousin crosses) ranked above the Hereford-Angus control for the weight of calf weaned per mating opportunity. At Brandon, Simmental-sired cows exceeded Charolais-sired cows and those out of Shorthorn exceeded those out of Angus dams for that trait. For both comparisons, the reverse was true at Manyberries.

Performance of Highland cattle under range conditions. The growth potentials of Hereford, Highland, Highland × Hereford, and Hereford × Highland calves were compared. Carcass traits were studied on steer calves, and heifer calves were evaluated as mother cows. Highland calves were smaller at birth and weaning and would have required a significantly longer feeding period to attain the final live and carcass weights, muscle development, and uniform fat cover achieved by the other calf groups. The superior slaughter weight progeny of Hereford × Highland dams were mainly due to heavier weaning weights. Those cows produced greater weights of milk, fat, solids-not-fat, and protein than the straightbred Highland and Hereford dams, and they appeared to have a productive advantage over the Highland × Hereford. On the basis of these results, the straightbred Highland cannot be recommended, but the crossbreds have proved to be excellent range cows.

Sheep

Mastitis. For 10 yr, udders of ewes were scored at lambing for 'meatiness' and mastitis, as determined by the California mastitis test (CMT). At weaning, the udders were again scored for mastitis, determined by palpation and stripping. They were also scored for lumps, nodules, and scars in the left and right halves, and for size and shape. About 10% of udders after lambing went through some degree of infection (CMT positive) but only 6% of these udders had mastitis at weaning. Of the 86 ewes culled for mastitis, 72 had no previous record of udders with lumps, nodules, or scars. Ewes with 'meaty' udders or udders with nodules did not appear to be handicapped in terms of weight of lamb weaned.

CROP ENTOMOLOGY

Forage crop insects

Alfalfa seed crops. The integrated pest management program for seed alfalfa in the county of Newell increased in grower participation by 25% and in area by 33% from 1979. Population levels were low for alfalfa weevils and moderate for lygus bugs; adelphocorids increased slightly over 1979. Pea aphid numbers increased in July but insecticides were not required because predator populations were high and provided adequate control.

Phenology modeling is being used as an aid in managing the alfalfa weevil and in warning when control is necessary. In this way, the impact of insecticides on beneficial insects and pollinators can be reduced. Initial levels of the adult population coupled with daily weather data, including maximum and minimum temperatures, are introduced into the computer model, which predicts the relative abundance and time of appearance of each life stage in the field. As the season progresses and inputs are updated, the forecast becomes progressively more precise and accurate.

Alfalfa pollinators. Surveys of alfalfa leafcutting beekeepers in Western Canada during the last decade show that on the average parasites or predators, or both, account for less than 1% of bee larval mortality. Good management by beekeepers has invalidated the criticism that the loose cell system of bee management with laminated grooved nesting materials is conducive to population increases of detrimental insects.

Twenty-one species of insects are now known to be capable of causing larval mortality of the leafcutting bee, an increase of nine species since 1968. Chalcidoid wasps are the most frequently occurring parasites, with *Pteromalus venustus* Walker the most common. *Dibrachy confusus* Girault has increased within the last 3 yr, and three other chalcidoid species are of lesser importance. The predators causing concern are dried fruit moths, cuckoo bees, and various debris-feeding beetles. A serious predator in the United States, the checkered flower beetle, has been collected in attractant traps in the southern Alberta foothills and from beekeeping operations in northern Alberta but not from major areas of alfalfa seed production.

Alfalfa forage crops. Thirty-six species of insects in five families of the order Hemiptera (Homoptera) were identified in collections from forage alfalfa in Alberta. Only one species, the pea aphid, was a major pest of alfalfa and most were pests of other crops. Although several of the leafhoppers collected are capable of transmitting various plant diseases, none appear to be causing serious damage to alfalfa in the province.

Pea aphid populations were above normal in forage alfalfa in late July but were reduced by five groups of predators, namely ladybird beetles, hover flies, lacewings, pirate bugs, and damsel bugs, and by the parasites *Aphidius* spp. The fungus *Entomophora* sp. was present in some fields but was not a major factor in reducing pea aphid populations in 1980.

Insect pest species trapped while migrating from cut alfalfa included aphids, lygus, adelphocorids, leafhoppers, alfalfa butterflies, blister beetles, and grasshoppers. Predators also captured in the sticky traps were ladybird beetles, hover flies, lacewings, anthocorids, and staphylinids. All these pests and predators can move readily from cut alfalfa to adjacent seed or forage crops.

Chemical control. In field tests on seed alfalfa, five candidate insecticides, namely isofenphos, cypermethrin, deltamethrin, fenvalerate, and permethrin, gave equal or better control at 72 h for *Lygus* spp. and third to fourth instar *Hypera postica* larvae than did currently registered insecticides. Of these five, only isofenphos and cypermethrin gave effective control of first and second instar alfalfa weevil larvae.

Cutworms

Sex attractants. Two three-component attractant blends, developed for army cutworm, exhibited a twofold increase in attractancy over the initial blend. Both blends contained a minor component that was synergistic at 0.002–2.0% but inhibitory at 8%, and both were effective for 4 mo at 100 µg/dispenser.

The main component of the pheromone of the European oak leaf-tier, *Tortrix viridana*, was identified and a synthetic blend was developed. It is being used to monitor this species in West Germany.

Male antennal olfactory responses to 200 synthetic compounds were determined for army, pale western, and striped cutworms, and for beet webworm. This indicated the main chemicals that may be involved (attractants and inhibitors) with these species. Minor pheromone components were identified from female extracts of the dark-sided cutworm, bertha armyworm, and *Mamestra brassicae*, a European species.

Attractant-treated dispensers (3500 involving 17 species) were provided to five research stations in Canada and to entomologists in Oregon, Nebraska, and North Dakota for field-monitoring purposes.

Four funnel-type sex attractant traps containing an insecticide to kill captured moths were field tested and were found to be more effective than cone-type traps for capturing male adults of army and redbacked cutworms. They were efficient throughout the flight period and required minimum maintenance.

Population monitoring. Density levels of eight lepidopteran species were recorded from sex attractant traps over a wide area of southern Alberta for the 3rd yr. Male adults collected in 1980 indicated an increase in clover cutworm, bertha armyworm, dark-sided cutworm, and pale western cutworm populations of 1.5–5.5 times those recorded in 1979. However, redbacked, army, and variegated cutworms and *Leucania commoides* showed decreased levels.

In 1980, infestations of army cutworm larvae were recorded in areas where adult males trapped in 1979 exceeded 1000/trap (29 locations). Larval populations of redbacked, dark-sided, and pale western cutworms (2.2/m²) were lower than 1979. Light infestations of the bertha armyworm were recorded in the survey area but larvae of the other species were not detected.

Chemical control. Field evaluation of insecticides for army cutworm control in winter wheat indicated that after 3 days under dry soil conditions, neither cypermethrin nor permethrin gave better control than chlorpyrifos. After 7 days, permethrin at 0.12 kg/ha gave 100% control, whereas cypermethrin at 0.12 and chlorpyrifos at 0.56 kg/ha gave 72 and 78% control, respectively.

Grasshoppers

Population studies. The annual survey for adult grasshoppers indicated that populations were 49% higher this year than in 1979. Severe and very severe infestations (5–10 and >10 adults per square metre) occurred for the first time since the 1976 survey. Areas of light infestation covered 16 311 km²; moderate, 6917 km²; severe, 2543 km²; and very severe, 539 km². Most of the areas of higher infestations were to the north and east of Calgary, extending to the Saskatchewan border, whereas areas south of Calgary had mainly normal levels (less than one adult per square metre).

Because in 1980 grasshoppers became adults several weeks earlier than normal in most areas, the egg-laying season was unusually long. Therefore populations of nymphs and adults are expected to be higher in 1981 and more insecticide controls will probably be required than the minimal amount that was reported used in 1980.

Chemical control. In laboratory tests with synthetic pyrethroid insecticides, deltamethrin, although twice as toxic as dimethoate, was not as effective as fenpropanate for controlling fifth-stage nymphs of *Melanoplus bivittatus*.

Row-crop insects

Pests of sugar beets, potatoes, and other vegetable crops did not cause economic damage in southern Alberta during 1980.

A survey of the European corn borer conducted in the corn-growing areas of southeastern Alberta using BAB-type traps baited with sex attractants failed to recover any males of this pest, nor were larvae detected in the fields examined.

In studies on sex attractants for males of the common June beetle, isoamylamine was the most consistent attractant of the synthetic amine compounds tested. Males responded from early May to late June and daily flight activity occurred during the first 1–2 h after

sunset. Peak counts were taken on clear calm evenings when air temperatures at sunset were 18°C or higher.

Circular areas of dead sugar beets, 4–5 m in diameter, caused concern in the Coaldale area. Upon examination, no soil insects or nematodes were found in the damaged areas and fungi within the shrunken root tissue were diagnosed as secondary saprophytes. It was concluded that this damage was caused by intense lightning strikes. The presence of dead sow thistle plants within the damaged area substantiated this conclusion.

Insecticide residues

The degradation of fenvalerate in soil was studied under controlled environmental conditions to determine whether the results would approximate those determined in the field. Pots of Lethbridge loam soil, treated at 70 g/ha, were incubated under simulated field conditions for 8 wk. Fenvalerate residues declined with a half-life of 5.2 wk, slightly faster than the half-life of 6.0 wk previously observed in a microplot field experiment.

Residue methodology was developed to determine fenvalerate in alfalfa forage. At fortification levels of 0.1–10 ppm, recoveries were 92–100%. In a field experiment, fenvalerate at 150 g/ha was applied to alfalfa on 27 June, and the residues were monitored for 28 days. Fenvalerate residues decreased at a first-order exponential rate, with the initial level of 8.75 ppm having a half-life of 11 days. In this experiment, the effect of new crop growth in diluting fenvalerate residues was minimal.

ECONOMICS SECTION

Beef cattle

Horn fly control. A farm-level simulation model was used to determine economic thresholds of horn fly control on farms of different grain and beef enterprise ratios in three soil zones, namely Dark Brown, Brown, and Black. Nine methods of control were analyzed under three levels of beef prices.

Repeated applications of insecticide throughout the horn fly season (June to September) were optimal under most conditions tested. However, even one or two applications of insecticide resulted in sufficient payoff to warrant the cost of control. The economic threshold level of control was found to be at very low fly populations under

most conditions. An increase in the relative size of the beef enterprise shifted the economic threshold in the direction of fewer flies for all control methods studied. Farms in the Brown soil zone generally had lower economic thresholds than farms in the other soil zones and thus could afford to control horn flies at lower population levels.

Poultry

Broiler nutrition. Modifications were made to an existing linear programming model to permit an analysis of canola meal in diets of broiler chicks. It was found that canola meal could profitably replace at least some soybean meal under most conditions. If the price ratio between canola and soybean meals is less than 0.7, at least 100 g/kg of the starter diets and 50 g/kg of the finisher diets should be canola meal. If the price ratio drops below 0.6, at least 200 g/kg of the starter diets and 90 g/kg of the finisher diets should be canola meal.

Forages

Pasture systems. Optimal stocking rates and pasture species were determined for grazing steers on irrigated pasture in southern Alberta. Legumes produced higher net revenues per hectare than did grass pastures due to higher digestibility of legumes and savings in nitrogen fertilizer that would be required on grasses. It was more profitable to use the flush of spring growth (a characteristic of grass pastures) than to sell it as hay. It could be used either as hay for feeding later in the year or as feed for additional purchased stock.

PLANT PATHOLOGY

Potato diseases

Virus and ring rot bacteria interactions. The relative seriousness of infection by ring rot bacteria (RR) or potato viruses S and X (V), or both, was indicated by the significantly different marketable yields obtained from uninfected plants (31.7 t/ha) and from plants infected with V (26.1), with RR (18.9), or with both V and RR (14.5).

Latent infection with ring rot bacteria. Failure to detect ring rot infection (latent infection) was dependent on bacterial dosage. In 1979, Netted Gem potato seed pieces each inoculated with about 300 bacterial cells caused infection of 9% of the developing plants but no symptoms. Inoculation with

lower dosages produced no determinable infection or symptoms. Of plants grown in 1980 from tubers that had developed from seed pieces inoculated in 1979 with 300 cells, 90% were infected and 39% had symptoms. For comparable plants from seed pieces inoculated in 1979 with 30 cells, the equivalent values in 1980 were 70% and 14%. Plants originating from three-cell inoculated seed pieces had no detectable infection or symptoms.

Forage crop diseases

Life cycle of the low-temperature Coprinus. Major advances have been made in studies of the life cycle of the low-temperature *Coprinus* sp. that causes crown rot (snow mold) in alfalfa and other overwintering forage crops. In addition to producing spores that can be dispersed by the wind, this fungus frequently produces resting bodies or sclerotia that allow it to survive warm summer periods and to persist in the soil. Strains that consistently produce sclerotia in culture are less pathogenic than nonsclerotial strains but have been shown to be genetically compatible with the low-temperature *Coprinus* in mating tests.

The identification of this pathogen on apples and pears in cold storage in Oregon has extended its host range and geographic distribution.

Verticillium wilt of alfalfa. Federal, provincial, and university plant pathologists cooperated in a national survey to determine the distribution and severity of verticillium wilt of alfalfa, which before 1980 had been reported only in British Columbia. The Lethbridge Research Station provided overall coordination by developing a standardized format for conducting the survey and recording the results. About 1% of farms growing alfalfa in each province, except Newfoundland, were sampled.

The high incidence of the disease in south central British Columbia was confirmed and five infected crops in both southern Alberta and southern Saskatchewan were detected. Only one occurrence of verticillium wilt was reported in Ontario and none in Manitoba, Quebec, New Brunswick, Nova Scotia, or Prince Edward Island.

Although verticillium wilt is now well established in British Columbia, the localized and small number of infested fields detected in Alberta, Saskatchewan, and Ontario makes it feasible to attempt eradication measures.

Plowing down infested fields and crop rotation have been recommended in Alberta and Saskatchewan. All alfalfa seed marketed commercially must now be treated with thiram fungicide to prevent the further spread of the disease by that means.

Pea diseases

The fungicide captan has been used in commercial practice for almost 20 yr to control seedling rot, a serious disease of peas in Canada. Studies over the past 3 yr have demonstrated that the new fungicide metalaxyl, applied to peas at rates as low as 5 g/100 kg of seed, controlled seedling rot more effectively than captan applied at the standard rate of 100 g/100 kg of seed. Results of this research are being used by the manufacturer to support an application to register metalaxyl for use on peas in Canada. Use of this fungicide should allow growers to reduce seeding rates by at least 10% and still obtain consistent, uniform stands of peas even when conditions are favorable for severe seedling rot.

Cereal diseases

Bunt of winter wheat. Bunt is a common problem of winter wheat in southern Alberta, and failure of registered fungicide seed treatments to control it has been reported. Three types of bunt spores are microscopically distinguishable: smooth-walled spores like *Tilletia foetida*, rough-walled spores like *T. caries*, and very rough-walled spores with a surrounding sheath like *T. controversa*.

Studies were carried out to characterize the *T. controversa*-like spores. They were found to be intermediate between *T. controversa* and *T. caries* in spore morphology, germination characteristics, and mode of infection. Although the intermediate type was like *T. controversa* in causing greater infection via soil-borne inoculum than via seed-borne inoculum, a candidate fungicide that is not effective against true *T. controversa* controlled soil-borne infection by the intermediate. Soil-borne inocula of *T. caries*, *T. foetida*, and the intermediates were not effectively controlled by the registered fungicide tested. This could account for the reports of inadequate control by seed treatments. True *T. controversa* has yet to be detected in the winter wheat growing area of southern Alberta.

Powdery mildew. The combined use of candidate seed treatment (triadimenol) and foliar (triadimefon) fungicides reduced the average incidence of powdery mildew on the top three leaves of the susceptible, soft white spring wheat cultivar, Springfield, from 42% to 7%. The yield of Springfield was concomitantly increased by 27%. In contrast, the yield of Fielder, the currently grown, mildew-resistant cultivar, was not increased by treatment and was equal to that of the fungicide-treated Springfield. The conclusion that the powdery mildew resistance of Fielder provides a yield advantage conservatively estimated at 20–25% over the previously grown cultivar, Springfield, is supported by comparative yield data for the two cultivars over the past 6 yr.

Coldhardiness of wheat

It was reported previously that coldhardiness was correlated with the ratio of the quantities of invertase I to invertase II in leaves of several varieties of wheat when these varieties were grown for the same length of time under the same conditions. However, when one variety was hardened for different lengths of time or under different conditions, the ratios of invertase I to invertase II were not related to the relative effectiveness of the cold-hardening treatments. This apparent discrepancy has now been traced to the increase in the ratio of invertase I to invertase II that occurs as the leaves age. When comparable tissues (roots, leaves, or elongating leaf tissues) in Kharkov 22 MC winter wheat were examined, the ratio of invertase I to invertase II was consistently higher in cold-hardened than in unhardened tissues, even though the ratios of invertase I to invertase II differed widely between the different tissues. Only the same tissue types of strictly comparable physiological age can be used if the ratios of invertase I to invertase II are to correlate with the levels of coldhardiness.

PLANT SCIENCE

Physiology

Photoperiodism in corn. Twelve early maturing inbred lines of corn (*Zea mays* L.) were grown in controlled environments at photoperiods of 14, 16, 18, 19, 20, 21, 22, 23, or 24 h. Days from emergence to anthesis increased as photoperiod increased for 10 of the 12 inbreds. The photoperiod response of the inbreds was adequately described by a

three-line model previously used for other plant species. Genotypic variability for the photoperiod response was identified.

The basic vegetative phase, which is the time from emergence to anthesis in optimal photoperiod conditions, ranged from 37 to 57 days. The photoperiod sensitivity, expressed in days delay to anthesis per hour increase of photoperiod, ranged from 0 to 2.5. The maximum optimal photoperiod, which is the longest photoperiod at which no photoperiod-induced delay in anthesis is observed, ranged from 14 to 24 h and the critical photoperiod, above which no further delay in anthesis occurs, ranged from 21 to 24 h. The photoperiod-induced phase varied from 0 to more than 17 days. A lack of correlation between components of the photoperiod response suggests independent regulation of these components.

Coldhardiness of wheat. Total aspartic acid, representing the acid and amide (asparagine) forms, increased markedly in the crown of cold-hardened winter wheat with increasing rates of N fertilizer applied alone. At the highest N rate, equivalent to 180 kg/ha, aspartic acid content was about double that at the zero N rate. When P was applied with the N, the increase in aspartic acid was considerably smaller. The content of most other amino acids decreased or remained essentially unchanged with the application of N. Phosphorus applied in the absence of N had little or no effect on the amino acid content.

In controlled environment experiments, N fertilization of the soil decreased coldhardiness of winter wheat, whereas P applied in the absence of N had little effect. When applied together, P counteracted the effect of N and produced plants as hardy as those that had received no fertilizer.

The characteristic changes in the total aspartic acid content of hardened winter wheat crowns, in response to N and P fertilization, could be utilized to evaluate the effect of various fertilizer regimes on the coldhardiness of the crop.

Forage crops

Elbee northern wheatgrass. Elbee, the first cultivar of northern wheatgrass, *Agropyron dasystachyum* (Hook.) Scribn., a native species, to be released in Canada, was developed at Lethbridge and licensed for sale in

1980. Its main attributes are excellent germination, high seedling vigor and drought tolerance, moderately aggressive creeping root system, early spring growth, and perennial growth habit. It is well adapted for pasture and hay production as seeded range in the Brown, Dark Brown, and Black soil zones of the prairies and for ecological repair and revegetation of industrially disturbed areas, roadsides, and other areas that receive little or no maintenance. It can grow in sandy soils, as well as on heavy clay but is best adapted to medium and coarse textured soils. The cultivar is an eight-clone synthetic, with six of the clones originating in Alberta and two from Saskatchewan.

Nova sainfoin. Nova, a new variety of sainfoin, was licensed in 1980. The release of Nova concludes a breeding program, started in 1964, that led to the release of the first Canadian sainfoin variety, Melrose, in 1969.

Sainfoin is a perennial forage legume that does not induce bloat in ruminant animals. It has proved to be particularly well suited to dryland pasture or combined hay-pasture usage in southern Alberta, and the new variety Nova is likely to be grown mainly in this area.

Nova is more winter-hardy and higher-yielding than Melrose or other varieties of sainfoin. During the severe winter of 1978-1979, Nova suffered only a 7% loss of stand in a Lethbridge test, compared with a 22% loss for Melrose and a 90% loss for two varieties from the United States. Nova's forage yield was evaluated for several years at seven locations in Western Canada. It had a 7% yield advantage over Melrose when considered over all years at all locations.

Weeds

Triallate herbicide and N fertilizer. Joint experiments were conducted with the Brandon Research Station to determine the efficacy of triallate herbicide and the availability of nitrogen (N) in combined applications of triallate plus urea. Triallate did not affect the conversion of urea to $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$. The concentration of triallate in solution was not altered by $\text{NH}_4\text{-N}$ at initial concentrations of N up to 1400 $\mu\text{g/g}$ of soil.

In the field, spring applications of triallate in all of the granular forms resulted in reduced wild oat control compared to triallate in the emulsifiable concentrate (EC) form. Triallate coated on urea gave similar wild oat

control to that obtained with commercial 10 G granules. Fall treatments resulted in similar wild oat control for all methods of triallate application. Combined and separate applications of triallate and urea fertilizer produced similar wheat yields when the wild oat control was similar. The results indicate that triallate can be applied with solution N fertilizer in both spring and fall and with dry N fertilizer in the fall.

Special crops

Soybean emergence. The moisture content of seeds of two early cultivars of soybeans were adjusted to 7, 13, or 23% to determine its effect on emergence from soil at air temperatures of 9, 14, or 17°C. Seedling emergence ranged from 88% to 95% over all treatments. Differences were observed in the number of days required to reach 50% emergence, an indication of seedling vigor. From the coolest to the warmest temperatures, time to 50% emergence averaged 27, 15, and 10 days. Increased seed moisture content caused slight reduction in time to 50% emergence only at the lowest temperature.

On the basis of these results, on-farm adjustment of seed moisture cannot be recommended as a means of hastening the development of soybeans. Instead, delaying seeding until the soil warms to 10-15°C and using sound seed is preferable. This failure to hasten plant development through management manipulation emphasizes the continuing need to breed earlier maturing varieties for the prairies.

Selecting beans for high dinitrogen fixation. Tolerance of beans, *Phaseolus vulgaris* L., to suboptimal temperatures is essential for growth under environmental conditions in Western Canada. When grown under a temperature regime typical of spring in southern Alberta with air temperatures increasing by 1°C/wk through a range from 10 to 23°C, cultivar Aurora fixed N at a rate of 433 mg/plant. Sanilac and Comtesse de Chambord averaged 307 mg/plant, and Kentwood, 214 mg/plant. At a higher temperature regime (15-23°C), Aurora again fixed the most N_2 (456 mg/plant); the other three cultivars fixed an average of 370 mg/plant.

The amount of N_2 fixed increased as the time to reach maximum acetylene- (C_2H_2 -) reducing activity lengthened. In Aurora, maximum activity occurred at physiological maturity. This finding indicated that contrary

to previous reports, N_2 fixation does not stop at pod set in beans but continues up to plant maturity. Results also suggest that to prolong the time of active N_2 fixation, it may be advantageous to select beans with as long a vegetative stage as is consistent with ensuring maturity. Although the lower temperature regime, compared to the higher regime, delayed the initiation of N_2 fixation by 21 days, Aurora compensated by producing 26% greater nodule dry weight and 40% higher maximum C_2H_2 reducing activity when fixation began. Growth and N_2 fixation of the other three cultivars were adversely affected by the lower temperature regime, not because of lower nodule numbers or mass but because of lower nodule activity. The vigorous root growth of Aurora at suboptimal temperatures may explain its superior N_2 fixation at lower temperatures.

Breeding early corn. Maturity, stalk strength, and yield were evaluated in 575 experimental hybrids in replicated trials at Vauxhall, Alta. Of these hybrids, 25 have been selected for further testing, using as the main criterion a kernel dry matter (DM) content of 55–60% after 1900–2000 corn development units had been accumulated. The hybrids were also selected for satisfactory stalk strength. Three or four of these hybrids are likely to be tested further in Alberta Corn Committee licensing trials.

SOIL SCIENCE

Soil-crop relations

Whole and cut potatoes for seed. Whole and cut seed pieces (70 ± 10 g) were compared at two plant spacings (21 and 28 cm) and four rates of N fertilization (0, 50, 100, and 150 kg/ha). Total yields from whole seed were not significantly different from those of cut seed (54.2 versus 53.0 t/ha), but whole seed produced 14% more tubers than cut seed. The 21-cm spacing produced 7% more tubers than the 28-cm spacing, but total yields were not different. Yields (ranging from 41.1 to 61.4 t/ha) were significantly increased with each increment of N. With increasing increments of N, the number of tubers were increased 23, 33, and 30% over those of the check, which also resulted in decreased specific gravity of tubers. Of the total yield in the experiment, 94% comprised marketable tubers. The results, which confirm

those of last year, showed that there is no yield advantage to using whole seed for commercial growers, but that there could be an advantage for seed producers.

Seasonal effects on decomposing grass roots. Root collections of blue grama, *Bouteloua gracilis* (H.B.K.) Lag., were made at various times near Manyberries, Alta., over a 3-yr period. The root samples were analyzed for C, N, ethanol/benzene-extractable C, methoxyl groups, lignin, soluble and structural carbohydrates, and calorific value. Significant seasonal fluctuations occurred for all characteristics. Over 50% of the root mass disappeared between October and May and this loss occurred regardless of soil moisture levels. Using the expression (C:N) (% lignin)/(% carbohydrate^{0.5}) as an index of decomposibility, roots collected in October 1974 and in October 1975 were potentially the least resistant, and roots collected in July 1974, May 1975, and May 1976 the most resistant to decomposition. The methoxyl group contents were also low in October 1974 and in October 1975. The chemical composition of the roots in the fall is apparently related to the root-mass losses between October and May. It is postulated that under the xerophytic conditions that are mandatory for blue grama to flourish, late winter – early spring represents a crucial time for the decrease of its root mass.

Response of soybeans to inoculation. Two soybean cultivars, with or without *Rhizobium* inoculant, were grown with five levels of N fertilizer (0, 20, 40, 80, and 160 kg/ha), with or without irrigation. The mean yield from the nonirrigated experiment was 1028 kg/ha compared to 1834 kg/ha from the irrigated experiment. When inoculant was used, there was no response to N. Without inoculant, yields on the irrigated plots increased with each increment of N from 1234 to 1716 kg/ha, but they did not reach that of the inoculated plants (2100 kg/ha). Maple Presto matured about 2 wk earlier and yielded slightly more than the cultivar X005. Soybeans may have a more important role to play as a soil-improving crop as the cost of fertilizer N increases.

N fixation and coldhardiness in alfalfa. In a controlled environment experiment, rhizobial activity or applied N in the absence of P significantly reduced the coldhardiness of alfalfa seedlings. Although the rhizobia fixed

only slightly more N than 20 kg/ha, the coldhardiness was reduced to a level equivalent to the addition of N at a rate of 100 kg/ha. Plants that received P at 100 kg/ha developed a high degree of coldhardiness regardless of the level of added N or rhizobial activity.

Irrigated soils

Water requirements of sorghum. The seasonal and periodic water requirements of irrigated grain sorghum were determined at the Vauxhall Substation over a 3-yr period. Daily water use peaked at a relatively low 6 mm. Because of its long growing period, the potential seasonal water use of 500 mm for sorghum was 10–20% higher than that of other cereals, but it appears to have appreciable yield tolerance for restricted water supply.

Nitrate-nitrogen movement in irrigated sandy soils. The downward movement of $\text{NO}_3\text{-N}$ was studied in farm fields of sandy soils first broken and irrigated either in 1975 or 1976. Sites were divided into two groups according to the characteristics of the soil texture profile, with one uncultivated check site for each soil group. Samples taken at regular intervals to a depth of 210 cm in the spring and the fall of 1979 showed that the $\text{NO}_3\text{-N}$ content was higher in the cultivated than in the check soils. The average total $\text{NO}_3\text{-N}$ stored in the group I soil (sandy loam to 60–90 cm and clay loam to 210 cm) from 90 to 210 cm depth was about 73 kg/ha; the average in group II soil (sandy loam to 210 cm) from 75 to 210 cm depth was about 32 kg/ha. These amounts of $\text{NO}_3\text{-N}$ could be attributed to the downward movement of $\text{NO}_3\text{-N}$ from the high initial mineralization of newly broken soil. The annual N fertilizer application seemingly contributed very little to leaching losses of $\text{NO}_3\text{-N}$ under proper fertilization and irrigation, even in these sandy soils.

Denitrification in irrigated soils. The application of rendering plant effluent high in nutrients (1060 kg N + 60 kg P per hectare each year) to soil through irrigation was found to have no effect on the populations of denitrifying bacteria. However, the addition of feedlot manure (180 t/ha a year) to irrigated soil was found to increase the numbers of denitrifying bacteria in the surface soil (0–15 cm) by a factor of 10 (from 2.1×10^6 bacteria per gram of soil to 1.7×10^7). The high organic matter content of the

feedlot manure is probably responsible for the increase in numbers of denitrifying bacteria. Nitrate concentrations up to 300 ppm $\text{NO}_3\text{-N}$ have been measured in surface horizons (0–15 cm) of soils receiving feedlot manure (180 t/ha a year). Thus, denitrification is one possible mechanism of removing excess N from soils receiving waste and of preventing NO_3 contamination of the groundwater.

Salt-affected soils

Causes and remedies of dryland salinity. Shallow groundwater and surface runoff were identified as the main sources of water that caused salinization of soil in a closed drainage basin near Nobleford, Alta. Disturbance of the naturally equilibrated ecosystem and drainage courses, creation of retainers to hold snow and water, drainage of runoff water into the basin, and features of the bedrock, soil, and topography contributed to the problem.

Various management practices to arrest, and possibly reduce, salinity problems were identified as: continuous cropping and thus using the moisture where it falls; growing perennial forage crops to use more moisture; removing retainers that collect snow and surface runoff; avoiding drainage of excess water into the lowland; and draining the discharge areas by using the water for irrigation or by pumping it out of the basin. These remedial practices are proving effective in the reclamation of this site.

Irrigation of Solonetzic soil. After four seasons of sprinkler irrigation, 120 sites on a Solonetzic soil were resampled. The irrigation study was established in 1975 on a Hemaruka–Halliday complex at Enchant, Alta. Total soluble salts in the top 90 cm had decreased by an average of 25% for all sites as indicated by electrical conductance and cation analyses. Salt concentration increased slightly in soils initially low in soluble salts (<2 mS/cm) but declined by about 50% in those with a high initial level. The sodium adsorption ratio of the soil to the 90-cm depth also decreased as a result of the decrease in salt concentration. Salt concentration was unchanged in the 90–120 cm depth but had increased by about 10% in the 120–150 cm depth. These changes in salinity levels suggest that the soluble salt concentration of Solonetzic soils can be lowered to acceptable values with proper irrigation management.

Biological reclamation of Solonetzic soils. Laboratory studies comparing the leaching of

disturbed Solonchic soil in columns (15 cm diam. × 60 cm) indicate that dilute H₂SO₄ removed 38% more sodium and increased the flow rate through the column four- to five-fold over that observed with distilled water leaching.

Under laboratory conditions, *Thiobacillus thioparus* and *Thiobacillus thiooxidans* were compared for their abilities to oxidize elemental sulfur applied to Solonchic soils. *T.*

thioparus oxidized 84% of the sulfur in 12 wk and lowered the surface pH of the soil from 9.1 to 3.5. In contrast, *T. thiooxidans* was inhibited by the initial alkaline pH and the salt content of the soil, and oxidized only 34% of the sulfur in 12 wk. A mixed culture of the two organisms did not act synergistically, but again oxidized 30–35% of the available sulfur in 12 wk.

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Research Station

Agassiz, British Columbia

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INTRODUCTION

During the year Dr. E. E. Gardiner transferred from the Lethbridge Research Station to continue research on poultry nutrition here. Dr. S. G. Fushtey was appointed to undertake research in turf management. Dr. D. K. Taylor had continued to carry that research program since his retirement in 1978.

Research highlights during the year included the discovery, in cooperation with the University of Manitoba, of a noninvasive technique for measuring whole-body protein turnover; the assurance that selenium supplements to dairy cattle present no hazard to humans drinking the milk; and a demonstration that an analogue of napropamide shows promise for weed control in strawberries.

The text summarizes highlights of research conducted in 1980. The list of publications provides a more detailed indication of research activities. Requests for information on these and other projects and for reprints or correspondence should be directed to: Research Station, Research Branch, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0.

J. E. Miltimore
Director

ANIMAL SCIENCE

Performance of Limousin × Holstein (F₁) crossbreds. A comparison was made in efficiency of feed utilization between 39 purebred Holstein steers and 92 Limousin × Holstein crossbreds (42 steers and 50 heifers). The two steer groups had similar rates of gain but the crossbreds were more efficient. The two steer groups gained faster and were more efficient than the female crossbreds. When slaughtered at 500 kg, the females had the fattest carcasses (20.6%), followed by the Holsteins (18.1%), and then the crossbred males (16.0%). The crossbred steers had approximately 4% more lean meat than the females or the Holsteins. The Holsteins had the most bone, 11.8%, followed by the crossbred males with 9.8%, and then the females with 8.9%.

Carcass characteristics of Hereford steers reared on grass and finished on high forage rations. Sixty red whiteface steers gained 0.7 kg/day on lush pasture for 168 days from 9 May to 24 October. Ten steers reared on grass were slaughtered, and the remaining fifty gained 1.0 kg/day for an average 70-day period on grass or corn silage with a minimum of grain. During the finishing period, dressing percent, rib fat depth, and rib eye area increased by 1.4, 6.0, and 7.5%, and white marbling score and carcass color decreased by 10.8 and 30%, respectively. Of the ten steers finished on grass, four graded Canada A1, five graded B1, and one graded C1. Of the 50

steers finished on maximum silage, 37 graded Canada A1, 12 graded A2, and 1 graded B1.

Selenium in dairy cattle rations. Selenium in the form of sodium selenite was added to the grain mixture fed lactating cows at levels that provided daily intake of 0, 6.0, 12.0, 24.0, 48.0, or 100 mg sodium selenite. The Se content of the milk, urine, and feces was determined in samples taken on the last 2 days of the 8-day feeding period. There was an increase in fecal levels of Se with each dietary increment, and there was a marked but variable response in the Se content in the urine. The amount of Se in the milk was not influenced by the quantity of sodium selenite in the diet. In a subsequent trial, theoretically toxic levels of sodium selenite (170 and 260 mg/day) were fed to lactating cows. This resulted in a 10- and 40-fold increase in the Se content of feces and urine, respectively, but only a threefold increase in the Se content of milk. The results of these two trials have indicated that lactating cows have an effective mechanism for maintaining relatively normal levels of selenium in the milk, even when dietary intake of Se is abnormally high.

Additives for grass silage. A series of trials have been carried out at the Research Station, Agassiz, with the use of lactating cows to test the effectiveness of various additives in improving the quality of grass silage. These products included three general categories: mixtures that stimulate a rapid increase in acidity; dried cultures of lactic acid bacteria;

and enzyme mixtures that stimulated lactic acid fermentation. The compounds that dissociated to stimulate a rapid drop in pH were effective in preventing a secondary butyric acid type of fermentation and in decreasing surface spoilage. The dried culture of lactic acid bacteria, although it stimulated fermentation, did not improve animal performance. The last category of products was not effective in changing the characteristics of fermentation or in improving animal performance compared with untreated silages. The results of these trials have been used to assist in the decisions on whether such products should be registered as silage additives in Canada.

Estimation of whole-body protein turnover. A radioisotope method for the estimation of whole-body protein synthesis, accretion, and degradation was developed in cooperation with the University of Manitoba. The method utilized single injections of L-[1-¹⁴C]leucine or DL-[1-¹⁴C]lysine, collection of expired ¹⁴CO₂, and measurement of amino acid and N balance. Accumulation of ¹⁴C in protein-bound lysine, body lipids, perchloric acid soluble material, urine, feces, and gastrointestinal contents 3 or 9 h after injection was measured to evaluate the method. The results showed that the new procedure should be readily adaptable to larger animals.

Refuse-screening studies. Refuse screenings contain weed seeds, straw, chaff, dust, and soil particles. In two experiments where refuse screenings replaced ground wheat in the broiler diet at 15 and 20% of the diet, it was found that replacing 15% wheat with refuse screenings depressed growth by 1.5% while depressing feed efficiency by 4%. Similar results were found when the diet contained 20% refuse screenings. Other parameters such as mortality, leg problems, and carcass grade were unaffected by the inclusion of refuse screenings in the diet. All four strains of broilers used in the above tests responded similarly to refuse screenings, which are currently too expensive for inclusion in broiler diets.

Factors influencing roaster grades. Several years ago, the expected percentage of birds that graded Canada A was 70-80%, but it is now common to find only 20-30% grade A birds in a flock at slaughter time. In a series of experiments it was noted that growth rate was not an important factor. Reducing growth by decreasing the protein content of the starter

diet from 23 to 20% for the first 4 wk of life in the broiler house reduced the final body weight by more than 5%, but the percentage of grade A carcasses was not affected.

Strain of bird has been found to be an important factor. Six strains have been tested, with yield of grade A carcasses ranging from 20 to 70%. The best strain of bird for roaster production had a good carcass grade with fewer leg problems, but it exhibited the marked disadvantage of slower growth rate and reduced efficiency of feed conversion. These latter two attributes create difficulty in a controlled-marketing system, where chicks are used both for roaster and broiler production, and the system does not allow extra placements when roaster stock hatches exceed expectations. However, of the strains of broiler stock tested, differences in carcass quality were of sufficient size to recommend that the local broiler industry change to a different strain providing the change did not affect the returns to the producers of hatching eggs.

CROP SCIENCE

A comparison of napropamide, R23758, and trifluralin for weed control in strawberries. In a preplant trial, R23758 (analogue of napropamide) at 2.24 kg/ha gave slightly better control of broad-leaved weeds than napropamide at 4.5 kg/ha, with only a few shepherd's-purse escaping. R23758 gave excellent control of lady's-thumb, whereas a few escaped in the napropamide-treated plots. Both herbicides gave excellent control of annual blue grass. Trifluralin at 0.75 and 1.5 kg/ha gave poor broad-leaved weed control, with shepherd's-purse, common groundsel, and pineappleweed escaping. Lady's-thumb was partly controlled. However, it gave good control of common chickweed and fair to good control of annual blue grass. Napropamide and R23758 caused some initial injury to Totem and Tyee strawberry plants.

Fruit rot control in raspberries. Several fungicides were tested for fruit rot control in raspberry cultivars Haida and Willamette. Captan and iprodione produced a significant increase in sound berries in Willamette; and captan, chlorothalonil, vinclozolin, and iprodione produced significant increases in Haida. In the postharvest trials, both iprodione and vinclozolin proved most effective, whereas thiophanate-methyl was least effective in

reducing *Botrytis*. Captan, chlorothalonil, CGA 64251, and iprodione caused significant reduction in *Penicillium*. No treatment controlled *Rhizopus*. In another test, captan and anilazine were equally effective for the control of *Botrytis* and *Penicillium*, but neither fungicide controlled *Rhizopus*.

Sodium hypobromite digestion for boron analyses. A sodium hypobromite digestion method was developed for determining total B in plant materials. The lower temperature of digestion, as compared with muffle furnace ashing, and alkaline conditions result in negligible volatilization losses. The method is fast, simple, and compatible with a curcumin colorimetric procedure for B. In fact, the digestion conditions contributed to eliminating nitrate, fluoride, and Fe interferences that can occur using the curcumin colorimetric method. Attempts to apply the sodium hypobromite digestion to determine total B in soils were unsuccessful. Published alternatives (sodium carbonate fusion and hydrofluoric acid dissolution) for total B were also unsuccessful on the range of soils examined. The unsuccessful attempts to determine total B shows a basic gap in our knowledge of soil B.

Filbert response to fertilizer applications. A fertilizer trial conducted over 3 yr on two locations with two cultivars showed that soil

extraction values and leaf nutrient concentrations have potential for predicting fertilizer requirements. The two cultivars responded similarly to soil conditions and fertilizer applications. A concentration plateau of leaf N, P, K, Ca, Mg, Zn, and Mn occurred from mid-August to mid-September, which makes this period a suitable sampling time for diagnostic purposes. Leaf B concentrations were not as stable over time, and there was considerable variability of concentration at a given sampling time. Positive correlations were found between soil extraction and leaf concentration values for P, K, and Mn.

Response of raspberries to fertilizer nitrogen and boron applications. A field fertilizer trial conducted over a 4-yr period showed that B and N soil applications can increase raspberry yield. The 4-yr yield was increased 23% by yearly applications of 1 kg/ha. There was a 45% increase from B in 1 yr. High rates of N application (134 and 201 kg/ha) increased the 4-yr yield by 10% and at least part of this increase was due to increased berry size. A rate of 67 kg/ha did not increase yield. The yield increases from high N applications were probably not economical. Fertilizer N and B recommendations from leaf tissue analyses do not appear to be possible because of erratic fluctuations of concentrations of these nutrients within a given year and from year to year.

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Research Station

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INTRODUCTION

The program at the Range Research Station, Kamloops, and at the Experimental Farm, Prince George, emphasizes research on forage production and utilization in British Columbia rangelands as well as forage crops grown for pasture and winter feeds. Basic studies on poisonous plants, bloat, and winterhardiness are also conducted.

Only highlights of our 1980 research are reported. Details of our work can be obtained from the Director, Agriculture Canada, Range Research Station, 3015 Ord Road, Kamloops, B.C. V2B 8A9.

J. D. McElgunn
Director

FORAGES

Method to determine membrane freezing injury

The release of hydrogen cyanide from *Amelanchier alnifolia* was monitored at 30°C and -10°C following lethal freezing at both slow and fast rates. Assuming that hydrogen cyanide release indicates membrane damage, it was concluded that during a fatal freeze-thaw cycle, membrane damage occurred during cell contraction and therefore was not dependent upon membrane area expansion during thawing.

Alfalfa coldhardiness studies

Water stress at a nonacclimating temperature (18–20°C) increased the coldhardiness of *Medicago sativa* L. (alfalfa) plants. This increased coldhardiness was retained when the previously water-stressed plants were cold acclimated (2–9°C) in the absence of water stress. Water stress during cold acclimation also increased coldhardiness. Alfalfa was demonstrated to suffer injury, measured as decreased growth following freezing, at sublethal temperatures. During cold acclimation, the turgor potential (ψ_p) of watered plants increased, whereas the solute potential and the water content per unit of dry weight decreased. The large positive ψ_p of acclimated plants indicates that the decreased water content per unit of dry weight is related to an increased proportion of tissue dry matter rather than to tissue dehydration.

Pinegrass herbage removal and its effects on yield

Pinegrass (*Calamagrostis rubescens*) was clipped at several frequencies and at varying

intensities at three sites in the Douglas fir (*Pseudotsuga menziesii*) zone of British Columbia. The effect of herbage removal on pinegrass vigor could be assessed by measuring tiller height, tiller numbers per square metre, or yield per square metre the year following clipping. Variability in pinegrass cover at a site necessitated measuring initial plot cover so that an analysis of covariance could be done to statistically isolate its effect. Initial pinegrass cover did not affect the tiller's highest measurement, however. The decrease of plant vigor as a result of herbage removal depended upon the degree and time of herbage removal and either the environmental conditions during the year of clipping or the plant history before herbage removal, or both. Pinegrass vigor was most sensitive to clipping during the first half of July, when growth is slowing down and summer dormancy is setting in. To maintain pinegrass vigor it is recommended that pinegrass be grazed for a short time while it is actively growing (early in June) and then later when midsummer dormancy is well established (August). If pinegrass must be grazed in July, then it should be rested during July of the following year. Further work is required to establish grazing schemes that will maximize animal production and maintain adequate pinegrass vigor.

Color—the critical photo interpretation elements in the identification of rangeland plant communities on color and color-infrared aerial photography

A review of the literature indicates color-infrared is preferred over normal color film for range vegetation identification. This preference leads to difficulties when attempting to

identify variable colored grasses, forbs, and shrubs.

On color-infrared photography, blue and green plants appear as magenta hues. Confusion exists when attempting to identify senescent yellow and white grasses, because both appear white. Purples, reds, and browns appear as hues of yellow. Color shifts also occur when the effects of flowers or stems that are not green interact with the color of the plant. This leads to the general conclusion that color-infrared original transparencies are best suited for the identification of green vegetation, whereas normal color transparencies are best used in identifying healthy vegetation that is not green.

Further complexities arise because species progress through a dynamic range of seasonal color changes, with many having two to four phases. Therefore, color criteria for species identification in July are different from those for June or September.

Color is the critical element of photo interpretation but is not the only diagnostic tool in plant identification. Other photo interpretation characteristics, such as growth-form distribution, habitat, and pattern and texture, must be used in conjunction with species and photographic colors to accurately identify rangeland species and plant communities. The elements of photo interpretation for the identification of approximately 30 dominant plant species have been identified, with special emphasis on interactions of plant colors with multirate-multiscale color and color-infrared aerial photography.

BEEF: COW-CALF

Biochemistry

Arrowgrass toxicity during the growing season. The cyanide potential of arrowgrass (*Triglochin maritima*) was monitored during the growing season for 2 yr (1978 and 1979) to determine periods of peak toxicity. Arrowgrass samples from various sites were collected about every 2 wk, ground in dry ice, and incubated to release hydrogen cyanide, which was trapped in alkali. The highest concentration of the cyanogenetic glucoside triglochinin was revealed in new growth of leaves and spikes in spring. Saline habitats yielded arrowgrass with lower triglochinin levels than nonsaline sites. Cyanogen levels in leaves were elevated substantially when severe moisture deficits prevailed on rangelands

during the latter part of the growing season in 1979. The results of this survey provide a basis for predicting arrowgrass toxicity to ruminants.

Metabolism of aliphatic nitro compounds in bovine rumen fluid. Metabolic studies with rumen fluid were conducted to determine rates of disappearance for 3-nitropropanol (3NPOH) and 3-nitropropionic acid (NPA), forage constituents that can be toxic to ruminants and nonruminants. The in vitro rate of disappearance for NPA was substantially greater ($P < 0.01$) than for 3NPOH. The nitro compounds were metabolized most effectively when the inoculum originated from cattle that were fed orchardgrass soilage rather than orchardgrass hay - alfalfa soilage or alfalfa hay. The in vivo ruminal clearance rate was substantially greater ($P < 0.05$) for 3NPOH than for 2-nitropropanol, a nitro compound that was not metabolized in vitro, which would be predicted if metabolism in the rumen contributed to the rate of 3NPOH disappearance.

Bloat studies. Although herbage proteins are generally recognized as foaming agents in pasture bloat, a possible secondary role for saponins has not been ruled out. The role of saponins in pasture bloat was reexamined by feeding fresh herbage from high saponin (HS) and low saponin (LS) near-isogenic strains of alfalfa to rumen-fistulated cattle. Each alfalfa strain was fed to six animals for 100 days. Feeds from the two alfalfa strains differed significantly in saponin concentration but were equal in protein concentration. At 1.5-2 h after feeding, the cattle were examined for evidence of frothy rumen ingesta and bloat. The HS and LS alfalfa produced 86 and 103 cases of frothy rumen ingesta and 50 and 61 cases of bloat, respectively. There were no significant differences ($P > 0.1$) between HS and LS alfalfa in the occurrence of bloat or of frothy rumen contents. Generally, saponin concentrations in rumen fluid were below detectable levels and below the estimated level of toxicity to the animals. In view of these results and other strong evidence opposing the saponin theory of pasture bloat, we conclude that saponins do not contribute to the occurrence of alfalfa pasture bloat by either the toxic or the foaming modes of action.

Beef cattle management

Growth of bluebunch wheatgrass. Vegetative and reproductive growth of bluebunch wheatgrass in interior British Columbia have been documented for a 3-yr period. Plants began growing immediately after the snow melted in the spring, with measurable growth occurring where soils had warmed to $6 \pm 0.5^\circ\text{C}$ at 10-cm depths. Growth ceased from 7 May to 15 July, and plants fully matured from 7 July to 10 August, with actual dates for each particular site dependent upon the local microclimate. Fall regrowth was not predictable, occurring only during 1973. Seed production was erratic, unpredictable from our data, and not of sufficient magnitude to sustain the grass population if improper grazing was allowed. Management implications are a rotation of early grazing to allow spring regrowth and fall grazing when plants are mature and dormant.

Brush and shrub survey (1980)

A bulletin entitled *Nutrient distribution in major shrubs and grasses in interior British Columbia* was prepared to assist range users

in evaluating the benefits of grazing 16 of the major shrubs in British Columbia. Forage samples were collected at 2-wk intervals from a total of 72 sites at nine locations from the growing season and were also collected periodically when dormant. These were then analyzed for dry-matter digestibility, nitrogen, acid detergent fiber, lignin, calcium, phosphorus, and several minerals. The information on both minerals and on several secondary species is not included in this bulletin.

Deer-cattle compatibilities (1980)

Studies conducted over the past 8 yr have indicated a niche or separation in the living environments of cattle and deer. Proper management of cattle enhances the range for forage utilization by deer, when grazing to prescribed utilization limits is maintained.

This is accomplished when cattle graze a fall range to the extent that the cured stalks of bunchgrasses are removed. The new growth of grass is then available to deer. Deer are reluctant to use this growth if long stiff stubble is present. Similarly, cattle also prefer ranges where the old growth of plants has been removed before grazing.

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Saanichton Research and Plant Quarantine Station

Sidney, British Columbia

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M. A. WATSON, ¹ B.A., M.Lib.	Librarian

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W. C. LIN, B.S., M.Sc., Ph.D.	Plant physiology—ornamentals
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B. WARNAR, B.S.A.	Tree fruit viruses

Departure

C. M. WINTER, ² B.S.A.	Plant quarantine
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EXTENSION SERVICES

VACANT

D. P. ELLIOTT,³ B.Ed.

Greenhouse and vegetable crops

Greenhouse biological control

¹Seconded from Libraries Division, Finance and Administration Branch.

²Food Production and Inspection Branch.

³British Columbia Ministry of Agriculture and Food.

INTRODUCTION

The Saanichton Research and Plant Quarantine Station has a dual responsibility. Firstly, it is the ornamentals and greenhouse vegetable research center for British Columbia, and secondly, 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 in research 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 quarantine program is responsible for testing for virus infection of all imported tree fruit, grape, and small fruit plant material that is not accompanied by an acceptable phytosanitary certificate, and for verifying the reliability of recognized foreign certification programs for fruit nursery stock by testing plant samples from imported commercial shipments for virus infection (audit program). Tests are conducted on promising selections from Canadian tree fruit and grape breeders to ensure that original releases to the industry are free from detectable viruses. We have established plantings of valuable virus-free fruits and grapes as a repository for Canadian fruit industries and research programs.

Requests for information or publications should be addressed to the Saanichton Research and Plant Quarantine Station, Agriculture Canada, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

J. M. Molnar
Director

ORNAMENTALS

Carbonated mist and high-intensity supplementary lighting in cutting propagation. Injection of CO₂ into the intermittent mist water (CO₂ mist) promoted rooting of *Ilex aquifolium* 'Short spr', *I. aquifolium* 'Italian', *Juniperus sabina*, *Magnolia soulangeana*, *Magnolia sieboldii*, and *Rhododendron* 'Anah kruschke'. *Ilex crenata*, *Juniperus squamata*, *Rhododendron* 'May Day', and *Rhododendron* 'Elizabeth' failed to respond to CO₂ mist. Daily 16-h supplementary lighting with high-pressure sodium (HPS) lamps increased rooting of *M. soulangeana* and *Rhododendron* 'Anah kruschke' and reduced rooting of *J. sabina*, *J. squamata*, and *Rhododendron* 'May Day', but the treatment had no effect on rooting of five other genotypes tested.

Accelerated growth of woody ornamentals. Growth of seedlings of *Pseudotsuga menziesii*, *Tsuga canadensis*, and *Picea glauca* was greater under HPS lamps and low-pressure sodium (LPS) lamps than in natural daylight. For continuous growth of *P. glauca*, a cold treatment (2°C) for 8 wk was required. HPS lighting was more effective when it was given before than after the cold treatment. In

a separate experiment, both HPS and LPS increased the growth of *I. crenata*, *Rhododendron catawbiense*, and four cultivars of *Rhododendron*. Weekly application of commercial fertilizer (20-20-20) at 200 ppm enhanced the lighting effects more than did 100 ppm.

Larval age in relation to black vine weevil control with soil drenches. Permethrin 50% emulsifiable concentrate (EC) with active ingredient (ai) at 0.1 g/L, acephate 15.6% EC at 1.0 g/L, and malathion 50% EC at 1.2 g/L were applied as soil drenches on 4-, 8-, and 12-wk old black vine weevil larvae on container-grown fuchsia. On 4-wk larvae, malathion and acephate gave complete control, permethrin treatments had an average of 1.8 larvae, and untreated checks had 8.6 larvae per pot. On 8-wk larvae, malathion continued to give almost complete control, acephate treatments had 3.2 larvae per pot, and permethrin was ineffective at 8.2 larvae per pot compared with 9.2 for untreated checks. On 12-wk larvae, none of the treatments were effective.

Phytophthora root rot. Ridomil (metalaxyl), representing a new class of fungicides,

holds great promise for the control of *Phytophthora* root rot of ornamentals. A preplant plus a postplant drench of Ridomil 5% wettable powder (WP) at 400 and 800 mg/L has prevented the development of root rot for over 8 mo in Lawson cypress var. *allumi* in pots of soil infested with cultures of *P. cinnamomi* (inoculum dose 4.5% v/v).

Virus diseases. The following viruses or virus-like agents from ornamentals with mottled leaves (ML) or with flower breaking (FB) or with both symptoms were detected by mechanical transmission to herbaceous indicator plants and by electron microscopy or serological tests: *Daphne* (ML)—small spherical viruslike particles, possibly nepoviruses, from both *D. mezereum* and *D. odora*, long flexuous rod-shaped particles, tentatively thought to be *Daphne* virus Y, from *D. mezereum*, and bacilliform particles, probably alfalfa mosaic virus, from *D. odora*; *Gladiolus* (ML, FB)—cucumber mosaic virus and long flexuous rod-shaped particles; *Cymbidium* (ML) and *Saintpaulia ionantha* (FB)—particles typical of tobamoviruses.

SMALL FRUITS

Virus eradication in grape. Shoot tips from 38 heat-treated accessions were established in vitro and all but one was successfully rooted. Sixty-eight percent of the resulting plants tested negative on herbaceous indicators compared to 52% for plants produced by the standard shoot-tip graft method.

Over 64% of the plants produced from tissue heat-treated in Erlenmeyer flasks for 7–42 wk at intermittent 36 or 40°C, which were indexed, were negative on herbaceous indicators. The majority of the positive readings were for plants produced from tissue which had less than 16 days heat treatment.

Rapid propagation of virus-free grapes. The cause of the difficulty in establishing and growing some shoot tips in vitro was found to be due to light, nutrient, or moisture stress in the mother plant, and not to genotype differences. The abnormal growth caused by the stress can be overcome by adjusting the cytokinin or by eliminating adenine sulfate in the medium or by both methods.

Over 100 plants of each of 25 accessions were increased in cooperation with the British Columbia Ministry of Agriculture and Food

for establishing virus-free propagation vineyards.

VEGETABLES

Greenhouse

Tomato variety trials. Eleven new and eleven superior cultivars, hybrids, and selections from previous years were tested. Quanto, Vendor, Lucy, Nancy, and three selections from Vendor were the most promising. The three selections from Vendor had larger fruit than Vendor, ranging from 109 to 120 g compared with 106 g for Vendor.

Effect of supplementary light and the temperature of soil and air on greenhouse tomatoes. Tomatoes (var. Vendor) were seeded on two dates 3 wk apart in two air temperatures (19/14°C and 22/16°C day/night) and two soil temperatures (15 and 18°C), both with and without supplementary HPS lamps for 16 h/day.

The high air and soil temperatures had no beneficial effects, but decreased the number of flowers on the first truss except in the treatment without supplementary light. Supplementary light decreased the time required to grow plants for transplanting from 61 to 42 days, decreased the flowering from 80 to 64 days, increased early yield (27 May) an average of 0.5 kg/plant, and increased total yield an average of 0.4 kg/plant. Average fruit size, however, decreased from 115 to 106 g. The late seeding produced a higher early yield but smaller fruit than the early seeding under the HPS lights.

Biological control program for whitefly and mite control on greenhouse vegetables. A private company, Applied Bio-Nomics Ltd., was formed in 1980 under the provisions of a grant issued under the Agricultural and Rural Development Subsidiary Agreement to rear and distribute mite predators and whitefly parasites to commercial greenhouse growers. Agriculture Canada and the British Columbia Ministry of Agriculture and Food continue to cooperate in this project.

Field

Early zucchini production with polyethylene tunnels and mulches. Zucchini plants transplanted from the greenhouse into 110-cm wide clear polyethylene mulches covered with 50-cm high clear polyethylene tunnels were most vigorous and produced an early (June)

yield of 2.6 kg/plant and total (15 August) yield of 9.2 kg/plant compared with 1.0 and 8.7 kg/plant in the uncovered clear polyethylene mulch. Plants in black polyethylene mulch covered with a clear polyethylene tunnel produced 2.0 and 8.5 kg/plant compared with uncovered plants in black mulch with 0.8 and 6.8 kg/plant for early and total yields, respectively.

Survival, yield, and head size of overwintered cauliflower. Ninety-three percent of Armado April cauliflower plants seeded on 16 July 1979 and transplanted to the field on 13 September survived. The heads were harvested from 22 April to 6 May and averaged 586 g. Comparable figures for 1 August seeding and 21 September transplanting were 88% survival, with an average head size of 457 g (cooperative test with Agassiz Research Station).

PLANT QUARANTINE

During 1980, four tree fruit and 11 grapevine samples were received for research and two samples for audit purposes. Material was indexed onto 1976 woody indicator plants for tree fruits and 1003 woody plants for grapevines as well as onto 2000 herbaceous indicator plants.

As a result, 38 tree fruit accessions, of which 29 came from heat therapy, as well as 29 grapevine accessions, of which two were produced from heat therapy, were indexed and released. Most of these releases were added to the material in the Repository for national and international distribution. The Repository now contains 796 cultivars, of which 546 are tree fruits and 250 are grapevine cultivars. A total of 90 tree fruit plants and 157 grapevine plants were subjected to heat treatment.

PUBLICATIONS

Research

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Research Station

Summerland, British Columbia

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A. J. HANSEN, Dip. Agr., M.Sc., Ph.D.	Tree fruit virus diseases
W. J. MCPHEE, B.A., M.Sc., Ph.D.	Tree fruit fungus diseases
H. F. MADSEN, ² B.A., Ph.D.	Integrated control
M. D. PROVERBS, B.Sc., M.Sc., Ph.D.	Control of codling moth by the sterility method
J. T. SLYKHUIS, B.S.A., M.Sc., Ph.D.	Stone fruit virus diseases
J. VAKENTI, B.Sc., M.Sc.	Orchard mite control

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regulators
Fruit storage and biochemistry

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Food biochemistry
Control of codling moth by the
sterility method

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INTRODUCTION

The Research Station, Summerland, is the center for tree fruit research in Western Canada and also has a major role in grape production research. This report contains results of research in plant breeding; physiology; nutrition; insect, disease, and weed control; irrigation; and agricultural engineering. Research into new processes and products, storage conditions, and diseases is also reported.

Only a few highlights of the research conducted during 1980 are contained in this report. Further information and more detailed reports are available from Agriculture Canada, Research Station, Summerland, B.C. V0H 1Z0.

G. C. Russell
Director

ENTOMOLOGY – PLANT PATHOLOGY

Male removal for codling moth control

Work was continued for the second year to determine whether removal of male moths by sex pheromone traps would prevent this pest from increasing to injurious numbers in areas where a previous program of sterile-moth release had almost eliminated the insect.

In a nonisolated area, four male moths were captured (17 traps per hectare) in each of two apple orchards (2.5 and 4 ha) compared with 19 males in a neighboring 12-ha monitored orchard (one trap per hectare). At harvest, fruit damaged by the codling moth was less than 0.02% in each of the three orchards, that is, well below the economic threshold level (ca. 0.5%). However, the codling moth is evidently becoming reestablished; 1980 is the first year in which codling moth damage was observed in the two orchards where males had been removed following cessation of sterile-moth release in 1978.

In a semi-isolated area, two apple and pear orchards (17 ha each) were subjected to the male-removal technique (17 traps per hectare), and two neighboring orchards (3.5 and 12 ha) were monitored (one to two traps per hectare). Two male moths were captured in one of the male-removal orchards, but no moths were taken in the other three orchards. For the second consecutive year, no fruit damaged by the codling moth was found in any of the four orchards. Orchard isolation plus the suppressant effect of a mid-July spray of azinphos-methyl or diazinon for leafroller control may be responsible for the virtual absence of codling moths in these orchards.

Codling moth vigor enhanced by fluctuating rearing temperatures

Field investigations comparing the vigor of codling moths reared on artificial diet at fluctuating temperatures (21–32°C) and constant temperature (27°C) indicated that the adult male response to sexually receptive females, to synthetic sex pheromone, and to ultraviolet light was enhanced by fluctuating rearing temperatures and was indirectly proportional to prevailing field temperatures. However, fluctuating rearing temperatures did not enhance the sexual attractiveness of the female moth. During copulation, newly emerged males from the fluctuating-temperature colony transferred marginally fewer eupyrene sperm bundles than constant-temperature males of similar age. Sperm transfer with older males was not measurably affected by the rearing regimen. However, 5-day-old males of both colonies transferred two times or more sperm than 1-day-old males. Field population males reared on apple transferred more sperm than colonized male insects of the same age reared on artificial diet. This suggests that the artificial diet is somehow deficient or, more likely, that genetic changes induced by prolonged colonization have adversely affected the laboratory insect.

Peach twig borer control on peach

Damage to Redhaven and Valiant peach fruits by first- and second-brood peach twig borer larvae was effectively controlled by one summer spray of deltamethrin at 40 g/ha or azinphos-methyl at 1.4 kg/ha, applied by hand gun at 1725 kPa in 3370 L/ha during the first-brood moth flight. Treatments were applied 10 days after male moths captured in

traps baited with peach twig borer pheromone reached an average of two or more moths per trap per week. These single treatments were only marginally less effective than two applications of each insecticide, one at the pink-bud stage and one during first-brood moth flight. At harvest, fruit damage in blocks that received only the first-brood flight spray of deltamethrin or azinphos-methyl was 0.8 and 0.9%, respectively, whereas those that received sprays at both pink-bud stage and first-brood moth flight had 0.0 and 0.2% damage, respectively. Damage in an untreated check block was 34.2%. Flagging injury on terminal twig growth caused by overwintered larvae was effectively controlled by deltamethrin or azinphos-methyl applied at the pink-bud stage. Two weeks following petal fall, trees in plots that received these treatments had an average of 0.2 and 1.3 flagged twigs per tree, respectively. In blocks that did not receive a pink-bud stage spray, there was an average of 23.9 flagged twigs per tree. In late summer, European red mite populations were much higher in the blocks sprayed with deltamethrin than in the check and the azinphos-methyl treated blocks.

Pest management for peach twig borer

Peach twig borer pheromone trap captures of two moths per week for the first-brood moth flight and five moths per week for the second-brood moth flight were evaluated as indicators of population levels requiring treatment to prevent significant economic loss due to damage by this pest. Traps baited with peach twig borer pheromone were deployed at one per hectare in 23 ha of orchard comprising 19 contiguous blocks of mixed apricot and peach plantings. Sprays of azinphos-methyl were applied to only those blocks where the above-critical levels of trap capture were attained. The sprays were applied 10–14 days after the critical level was reached. Of the 19 blocks, 11 required treatment during the first-brood moth flights and 12 during the second-brood moth flights. At harvest, there was no detectable damage to fruit by the peach twig borer in 10 of the blocks, whereas in eight blocks the damage ranged from 0.04 to 0.20%. Damage in the remaining block averaged 2.65%, which was considerably above the 0.5% acceptable limit. In comparison, fruit damage by the peach twig borer in these blocks during the previous 2 yr ranged from 0 to 80% when control treatments were applied

according to conventional calendar date recommendations and grower practice.

Peachtree borer monitoring

Pherocon 1C traps baited with laboratory-prepared septums containing synthetic peachtree borer sex pheromone were much more attractive to male moths than three other combinations of traps and attractant. Two replicates of each combination were tested over a 12-wk period in a 1-ha nursery block of seedling peaches. The traps and pheromones were renewed after 6 wk. During the season, Pherocon 1C traps baited with laboratory septums caught an average of 36.0 moths per trap, Pherocon 1C traps baited with Conrel hollow-fiber dispensers or septums impregnated with pheromone extracted from Conrel hollow-fiber dispensers caught 23.0 moths per trap, and Kitterman traps baited with laboratory septums caught an average of 11.5 moths per trap.

Integrated leafhopper control on grapes

For the second consecutive year, good control of the Virginiacreeper leafhopper was obtained by two applications of carbaryl at 0.28 kg/ha, applied by a low-volume airblast sprayer, with 1120 L of spray per hectare. The sprays were applied to Baco Noir grapevines when 80% of the eggs of the first generation and second generation were hatched and the majority of the leafhoppers were at early nymphal stages susceptible to the pesticide. In 1980, maximum parasitism of leafhopper eggs by *Anagrus epos* was only 10.3%, whereas in a duplicate experiment in 1979, egg parasitism was 97.0%.

Berry russetting of fresh market grapes

Much of the russetting injury attributed to feeding by adults and nymphs of the western flower thrips on the developing berries of fresh market grapes during the blossom period appears to be caused at later stages of development, possibly from wind-induced friction. No reduction of fruit russetting on Bath grapes resulted from application of several pesticides effective for control of thrips applied at the 0–5% and 33–50% blossom stages. Counts of thrips in both the insecticide-treated plots and the untreated control plots were near zero 1 wk after treatment. In addition, assessments of the degree of berry russetting at intervals through the growing season disclosed gradually increasing amounts

of berry russetting in all plots. At harvest, berry-russetting damage varied from 26.8 to 35.5% in the insecticide-treated plots compared with 26.0% in the untreated control plot.

Effect of Ribavirin on chlorotic leafspot virus in apple

Previous experiments with chlorotic leafspot virus (CLSV) in *Chenopodium quinoa* had shown that the carboxamide Ribavirin (ICN Canada) can inhibit CLSV multiplication. These experiments were expanded to determine whether Ribavirin also inhibits virus multiplication in apple trees.

Five groups of five apple seedlings were chip-inoculated with CLSV and treated at various times and intervals with 80 mL of 500 ppm Ribavirin. After 3 mo, the seedlings were individually checked for CLSV content by sap transmission to the indicator *C. quinoa*. All treated trees gave a negative reaction, whereas those from an untreated control group contained CLSV.

These results show that Ribavirin can inhibit CLSV multiplication in growing apple trees. It should therefore be possible to use this compound for the elimination of CLSV from nursery material destined for virus-free collections or budwood programs.

Apple replant problems

The growth of apple seedlings in pots of soil from several orchards in which replanted trees grew poorly was increased substantially in some soils by treating with disinfecting chemicals or heat before planting. The most effective treatments were fumigation with methyl bromide or chloropicrin, heating to 60°C or higher for 1 h, or mixing captan in the soil. Liming also was beneficial in several soils. Tests are under way to determine the effectiveness of such treatments to prevent replant problems in orchards.

Little cherry disease

In some sweet cherry orchards where some trees have been found affected by the little cherry disease, several associated trees that have consistently produced normal fruit have been found to carry an agent that causes red leaf symptoms resembling the effects of little cherry virus on Sam test trees. Tests are under way to determine if any of these agents are mild strains of the little cherry virus that do not affect the fruit; such strains might be

used to immunize cherry trees against natural infection by severe strains of the virus.

Control of postharvest rots on apple

Pressure infiltration of Ca to reduce internal breakdown of apples can result in high incidences of storage rot problems. This is primarily due to a buildup of rot organism propagule and spore loads in the Ca solution that is recycled during use. The value of the addition of a suitable fungicide to the Ca infiltration solution was demonstrated in an experiment using intentionally reinforced inoculum levels of *Penicillium* and three varieties of apples, McIntosh, Spartan, and Golden Delicious. Without reinforced inoculum, zero pressure, and without fungicide, the rot incidence after 3.5 mo in storage was 6.6, 0.8, and 3.3%, respectively, for each variety. At an infiltration pressure of 138 kPa, with reinforced inoculum level, and without fungicide, the rot incidence was 38.3, 22.4, and 36.9%, respectively. With the addition of 250 ppm of benomyl to the above pressurized infiltration system and with reinforced inoculum level, the rot incidence was reduced to 2.8, 0.0, and 0.0%, respectively.

FOOD PROCESSING

The manufacture of fruit leathers

Fruit leathers are in commercial production in two British Columbia processing plants. Current production methods based on trial-and-error technology produce a product subject to considerable variation in color, aroma, flavor, and texture. A pilot-plant project investigated the effect of variations in the following factors: total solids, soluble solids, alternate sugar sources, acidity, pectins, film thickness, inclusion of particulate material, cooking versus raw purees, sulfur dioxide, dehydrator air velocity, drying temperature, and humidity of dehydration air. Low-sugar leathers (12%) dried more rapidly and had a more pulpy texture than moderate to high sugar levels (18–20%). Alternate sugar sources could not be distinguished organoleptically in the finished leathers. Sugar-to-acid ratio descriptors ranged from very sweet (67) to bland (13). Sulfur dioxide was the most effective means of controlling browning. Up to 900 ppm SO₂ could be added to apple puree without creating an off-flavor in the leather. Apple puree was the most versatile fruit pulp tested. It produced acceptable leathers alone

or blended with other tree fruits or berries. Leathers enriched with skim-milk powder or soya flour developed off-flavor rapidly. Case-hardening during drying was reduced to an acceptable level if dehydration air was maintained at not higher than 90–93°C and at not less than 5% relative humidity. Higher temperatures accelerated loss of aroma and caramelization. A special set of jaws was constructed for an Ottawa texture measurement device and a standard dye was used for cutting samples. Work is in progress to relate treatment variables to tensile strength of fruit leathers.

Compressed survival rations

A semiautomatic bar compression unit was designed, built, and used by a cooperating processor to produce a 24 000 unit pack of various types of fruit, biscuit, and meat bars. These bars were test marketed and were well accepted. Meat and biscuit bars vacuum packed in foil have presently undergone a 2-yr shelf-life test without significant loss of quality.

Fruit juice in large drums

Fruit canned in pear juice is becoming increasingly popular. Unfortunately use of reconstituted concentrate gives an undesirable dark color and burnt flavor. Single-strength juice has the desired quality, but it must be either frozen or sterilized and held in a hermetically sealed container.

Tests conducted on cooling of 204-L drums with cold-water sprays showed that a barrel standing on end could be cooled from 97°C to 38.5°C in 20 min. Drums lying on their sides took longer to cool, even when agitated. This is presumably due to the more favorable configuration for convection currents in the upright drums. This short cooling time makes it practical to hot fill, seal, and store standard 204-L barrels of single-strength fruit juice at room temperature. This system will be used commercially in the 1981 season.

Extruded fruit milk snack bars

A stem-jacketed extruder head with 6 × 30 mm aperture was designed, built, and used to produce a series of fruit snack bars. A typical base formula for protein-enriched bars contained 46% drum-dried fruit sauce flakes, 9% skim-milk powder, 36% pear-juice concentrate, and 9% honey. This was extruded at 100°C and cut into 90-mm bars weighing 25

g. Samples of this formulation alone and formulas with 10% added chopped dried apricots or 10% unsweetened dried coconut were vacuum sealed in foil laminate pouches stored at 0, 20, and 37°C. After 6 mo at 37°C, all samples showed significant nonenzymatic browning but were judged to be marginally acceptable for flavor and color. Samples stored at 20°C were still acceptable after 8 mo of storage.

Drum drying fruit purees

A laboratory drum drier has been modified by addition of automatic feed, a vapor-removal system beneath the rolls, chilled air supply for cooling the dry product sheet, and variable speed takeoff rolls. Use of these attachments and additives to increase the fiber content of fruit purees and to improve their sheet-forming characteristics has made it possible to dry successfully such difficult-to-dry products as cherry, raspberry, and strawberry purees.

The most effective additive to aid sheet formation was found to be low-methoxyl pectin at 0.5–1.0%. Dry berry flakes produced by this system have made potential uses in low-moisture products including powdered drink and milk-shake mixes, dry-fruit bars, and fruit-flavored baking mixes.

Safety caps on juice bottles

A safety hazard occurs in reclosed bottles of fruit juice, which may explode in the home owing to fermentation. Pilot-plant tests on breaking pressures of bottles have led a closure manufacturer to design a screw cap with a built-in pressure release that relieves gas before dangerous pressures are reached.

POMOLOGY AND VITICULTURE

Orchard soil management and soil temperatures

A micrologger was installed in an orchard of Starkrimson Red Delicious on M26 rootstock with temperature-measuring probes at 20- and 100-cm depths in plots with a grass sod, plots kept clean with herbicides, and plots tilled periodically. Soil temperatures during the summer of 1980 were affected appreciably by the soil surface treatments. The highest mean temperature at 20 cm under grass was 23.0, whereas under a clean surface it was 27.1, and under the tilled surface, 25.3°C. At

100 cm depth, the differences were not as great, but in the same order: under grass 18.6, under herbicide-clean surface 21.0, and under tilled surface 20.5°C. By mid-September, however, the mean temperatures were all similar and by the end of October, mean temperatures under the grass surface were higher than those under the clean surface.

Dichlorprop shows promise as a preharvest fruit drop control agent for apples

Dichlorprop sprays, at concentrations of 20–40 ppm, provided generally satisfactory protection against preharvest drop of McIntosh apples in each of three seasons. The protection was comparable to that provided by 10–20 ppm fenoprop, a material no longer registered for this use in Canada, and frequently superior to 20 ppm naphthaleneacetic acid (NAA). An examination of chemical residue levels in fruits harvested 2 h to 10 days after spraying showed that dichlorprop is more persistent than NAA. NAA residues decline rapidly in fruits on the tree; therefore the period of effective drop protection is short.

Effect of Amid-thin on maturity and storage behavior of Bartlett pears

Nicotinamide adenine dinucleotide (NAD) (Amid-thin, Union Carbide) effectively thins Bartlett pear fruits when applied shortly after bloom. However, it has been suggested that this spray advances maturity and thus affects fruit storage behavior. A study to test this assertion involved 15 commercial orchards in the Okanagan and Similkameen valleys. Treated and untreated fruits were evaluated at harvest and after 60 days of -1°C storage. Results at harvest showed no differences in flesh firmness or skin color and only very small differences were detectable after the 60-day storage period. However, core browning of stored fruits was slightly higher in the NAD-treated lots. Future work is needed to confirm this effect on core browning. At present the fruit-thinning benefit heavily outweighs the risk of a significant core browning problem.

NAA and carbaryl combination applied in various spray volumes effectively thins Spartan apples

Within the range of 560 to approximately 3350 L/ha the amount of water applied with constant amounts of NAA and carbaryl per hectare did not appear to influence the

amount of fruit removal achieved in chemical thinning experiments conducted in two seasons. The sprays were applied 15 days after full bloom in each year. In two of three experiments, significantly superior fruit removal was achieved with NAA (25 g actual per hectare) tank-mixed with carbaryl (4.5 kg of 50% wettable powder per hectare) than with either chemical applied singly. In all experiments, NAA alone was more effective than carbaryl alone.

Pear rootstock evaluation, management practices

Four Old Home \times Farmingdale clonal rootstocks continue to rate as significantly better than seedlings for stimulating productivity of Swiss Bartlett pears during the first 6 yr after orchard establishment.

In another trial, pear planting and training methods were confirmed as having a significant influence in promoting fruiting of Anjou pears in the first 7 yr after planting.

Increased seed set from mentor-like pollination with unrelated pollen

Unrelated pollen that was either heat killed at 65°C for 2 h or viable was applied to emasculated apple, apricot, and sweet cherry flowers, followed the next day by application of compatible pollen. The control was heat-killed compatible pollen. The unrelated pollen (*Balsamorhiza sagittata*) increased seed set from 100 to 177% of the mentor pollen control. The stimulation of seed set was effective when the foreign pollen was killed or viable and was negatively correlated with percent seed set of the control. Other pollens (*Taraxacum officinale* and *Juniperus communis*) also increased set, and the degree of stimulation was positively correlated with pollen grain volume. Mineral analysis of the pollen indicated that the physiological basis of the effect was not inorganic ions, and proteins implicated in incompatibility reactions are unlikely to have survived the heat treatment. The results of the experiments indicate that stimulation of seed set by the foreign pollens could have been due to release of pollen tube growth promoters such as gibberellic acid.

Selective media for dwarf growth habit of apple in vitro

Three strains of McIntosh apple with standard, spur, and extremely spurry growth habit were grown in vitro as meristem-tip

cultures. The optimum concentration of benzyladenine (BA) for both shoot production and weight increase was 6 μM BA, but the strains' tolerance for toxic concentrations varied greatly, with the spur strains tolerating higher concentrations than the standard, and the extreme spur tolerating more than the spur. By adjusting the BA concentration, it was possible, therefore, to have a selective medium that allowed vigorous growth of spurs but killed standard strains. The medium should be useful for selecting mutations to spur growth from cultures of standard habit.

Low-oxygen storage of McIntosh apples

Oxygen levels of 1% in the storage atmosphere resulted in superior retention of quality in McIntosh apples compared with fruit stored in atmospheres of 2% or more oxygen. Firmness values after 60 days of storage were similar to those at harvest. Shelf life was also enhanced by the low-oxygen treatments. No injury was found in fruit from the 1% oxygen storage treatment.

Storage of Okanagan-grown table grapes

Storage of Himrod and Interlaken grapes after 30 and 60 days, respectively, resulted in poor quality from excessive berry rot. Incidence of berry rot, primarily *Botrytis*, was reduced by changing the Grape Guard (the SO₂ generating pad) after 30 days and by precooling grapes for 24 h with the polyliner open rather than precooling with a closed polyliner. High moisture retention in the polyliners may be responsible for the progressive deterioration of the stems during storage of the grapes.

SOIL SCIENCE AND AGRICULTURAL ENGINEERING

Soil calcium applications

Five years of leaf and fruit analyses were completed on a soil Ca application experiment started in 1974–1975. By 1979 soil exchangeable Mn had been significantly decreased down to a 20-cm depth in the Ca(OH)₂ treatment, whereas exchangeable Mg was decreased down to 30 cm in the CaSO₄ treatment. Fruit Ca concentration at harvest was not significantly increased by soil Ca applications in any year. Leaf Mg was significantly reduced each year by CaSO₄ applied in excess of 3000 kg/ha. Significant leaf Mn

reduction occurred only in the fourth and fifth years of Ca(OH)₂ treatments at 6000 and 3 × 2000 kg/ha.

Trickle irrigation of soil columns with saturated Ca(OH)₂ solutions resulted in the most effective depth penetration of soluble Ca (to 20 cm after 80 cm irrigation). Depth incorporation, slurry application, and application of Ca combined with high N fertilization rates (N at above 250 kg/ha) were of intermediate effectiveness (to 10 cm). Doubling irrigation quantities had no measurable effect on downward leaching of surface-applied Ca.

Nutrition survey

Chemical analyses were completed for soil and leaf samples collected in a 1979 survey of 48 Starkrimson Red Delicious trees in 16 orchards on seedling rootstock and 48 McIntosh trees in six orchards on M2 rootstock. A considerable pH decline had occurred in the soils, and soil P and K levels were high, whereas soil Mg was low. Leaf N was more frequently high than low. Leaf Mg, Zn, and Ca were frequently low (necessitating annual Mg and Zn foliar sprays), though leaf B was adequate. Leaf P and K levels both appeared normal and nondeficient.

Manual bin hauler

An inexpensive (\$200 for materials) bin hauler has been designed, constructed, and orchard tested. The unit rolls easily on two large automobile wheels when pulled by hand. A fork frame slides under the bin whose frame is connected to the wheel frame at a pivot point. A hydraulic jack between the frames forces them apart and lifts the bin. The unit is capable of lifting and setting down a 450-kg bin of apples. The bin hauler frees a farmer's tractor and permits a picker to keep his bin nearby.

Calcium infiltration

The Ca content of Spartan apples was increased 35–50% by applying pressure to a CaCl₂ solution surrounding the fruit. For most years when the Ca content is low, this increase would be enough to bring the Ca level to the 250 ppm level required to prevent storage breakdown. A larger facility was built this year, and more pressurizing experiments were done on this year's crop. Some vacuum techniques were also tried. Test results next spring will hopefully point out the optimum

procedure, and work can begin on the design of a packinghouse unit.

Fumigation of fruit for export markets

Low-temperature fumigation with methyl bromide at 48 g/m³ for 2 h at 17°C killed more than 30 000 codling moth eggs and larvae on infested cherries. Fumigant residues were within internationally accepted tolerance levels.

Fumigation and dip treatments developed at Summerland to kill mites and fire blight on apples were applied to infested apples, which were then shipped to plant quarantine officials in South Africa for examination. They accepted our treatments as a basis for commercial shipments. Several bins of Red Delicious apples were fumigated with ethylene dibromide, dipped in acetic acid, packed, and sent to South Africa. Market acceptance will, in part, determine future shipments.

Lysimeter studies: apple yields in 1980

For the year 1 October 1979 to 30 September 1980, although the amount of irrigation water applied was raised from 50% in 1979 to 60% in 1980 of the usual amount for the Summerland area, and the total precipitation and irrigation received by the lysimeters

increased from 900 to 1176 mm, the percentage of drainage water from the sandy loam soil increased marginally over the previous year to 22 and 23% from grassed and cultivated lysimeters, respectively. The higher level of drainage from cultivated than from grassed plots was not so evident as in other years. Drainage from the silt loam soil was again almost nil for the year.

Apple yields from the McIntosh trees on the sandy loam were 15.8 kg and 20.4 kg/tree under grass and cultivation, respectively. Corresponding yields on the silt loam were 31.9 kg and 35.8 kg/tree. These differences, though showing a trend toward higher average yields with cultivation than with grass, were not significant. However, the difference between the two soils was most striking with an overall average yield (calculated on the basis of tree spacing) of 48 t/ha on the silt loam, almost twice the 26 t/ha on the sandy soil. This difference cannot be attributed to N fertilizer. There appears to be an inherent higher productivity in the silt soil than in the sandy soil. These fruit production levels were on trees grown from nursery stock planted in 1974 with relatively low yearly applications of N and with less than half the irrigation quantities that are normal for the Summerland area.

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Research Station

Vancouver, British Columbia

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D. G. FINLAYSON, B.A., M.A., Ph.D. Retired 29 December 1980	Root maggots, toxicology
F. C. MELLOR, B.S.A. Retired 29 December 1980	Strawberry viruses, thermotherapy
P. ZUK, B.A. Retired 29 December 1980	Stored-product insects

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INTRODUCTION

The research programs of the Vancouver Research Station continue to reflect its dual role as the national center for plant virus research and as the regional center for helping to solve problems presented by pests, diseases, and weeds in vegetables, small fruit, and other horticultural crops. This report gives only the highlights of these programs, which range from the strategic laboratory research needed for background information to rapid transfer of the new knowledge and technology to the clientele of the programs—the primary producer of horticultural crops.

This year saw the retirement of three experienced scientists, two entomologists and a plant virologist. However, their replacements are expected soon, so that research in these areas can continue uninterrupted.

Requests for details of our research program, for reprints of this report, or for reprints of publications listed should be addressed to the individual scientists or to: Research Station, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Physical, chemical, and serological properties of viruses in vitro

When protein of the bean strain of southern bean mosaic virus (SBMV) was cleaved with cyanogen bromide (CNBr), a highly basic peptide, CB-1, was isolated by ion exclusion and ion-exchange chromatography. Twelve peptides were separated from a tryptic digest of CB-1 by ion-exchange chromatography; their composition was similar to that of peptides released from ethylenediaminetetraacetic acid swollen virus particles by limited tryptic digestion. The composition and *N*-termini of the tryptic peptides indicated CB-1 was from the *N*-terminus of SBMV protein and contained 48 amino acid residues. In polyacrylamide gel electrophoresis (PAGE) at pH 3.9, CB-1 moved rapidly to the cathode and contained nine arginine residues, three lysine residues, and no acidic amino acid residues. It interacted with purified viral RNA, sodium dextran sulfate, and calf thymus DNA. Antiserum to the CB-1 peptide, conjugated to tomato bushy stunt virus, reacted with SBMV, but SBMV antiserum did not react with CB-1 or the CB-1-tomato bushy stunt virus conjugate. Electrophoresis patterns of CNBr peptides from the proteins of four strains of SBMV showed marked similarity between the cowpea and Ghana strains, and between the bean and

Mexican strains. From the cowpea strain a highly basic CNBr peptide, cCB-1, was isolated, which resembled the peptide from the bean strain.

Virus infection

To determine the minimum wound size required for effective virus establishment, commercial abrasives were fractionated by elutriation and ultrafiltration, and their particle modes were determined by light microscopy. On the basis of local lesion development the 12–15 μm size range (based on the largest dimension of the highly irregular particles) was the most effective for infection. However, hardness, particle geometry, quality of cutting edges, and pressure applied during inoculation are important contributing factors. Crude juice from leaves of *Brucea antidysenterica* and semipurified preparations obtained from leaf extracts were tested for antiviral activity. Both reduced infection by 90–100%, whether mixed with the virus inoculum or applied to leaves up to 1 h after inoculation. The antiviral agent in these preparations is probably bruceantin. Pure bruceantin at 7.5 μg reduced the infectivity of 70 μg of tobacco mosaic virus per millilitre on *Nicotiana glutinosa* by 87%.

Ultrastructural responses to virus infections

A pollen-borne virus from the sweet cherry cultivar Stella induced in systemically infected cells of *Chenopodium quinoa* and *C. amaranticolor* large, complex X-bodies and

two other types of inclusions: cylindrical virus aggregates, apparently not reported before, and virus crystals. The cylindrical aggregates occurred in many nuclei, often in great numbers and occupying a large portion of the nucleoplasm; they were less abundant in the cytoplasm. Virus crystals, found exclusively in the cytoplasm, contained complete virions and sometimes virus capsids.

Virus transmission by seed and pollen

An improved method for rapid serologic diagnosis of pea seed-borne mosaic virus (PSbMV) in pea seeds appears promising. This technique utilizes electron microscopy of seed homogenates previously treated sequentially with PSbMV antiserum produced in rabbits and antirabbit serum produced in goats (double decoration immunoelectron microscopy).

The virus from the sweet cherry Stella was seed-transmitted to more than 90% of the progeny in *Chenopodium quinoa*. Plants from infected seeds were stunted and deformed, and ultrathin sections of leaf tissue contained cytoplasmic viral crystals.

Aster yellows disease

Spiroplasmas that can be cultured *in vitro* have been suggested as the true agent for aster yellows (AY) disease. We found that mycoplasma-like organisms (MLO) from AY-diseased plants degenerated in callus cultures, and that at one stage filaments resembling spiroplasmas occurred. Attempts to isolate and culture spiroplasmas from primary and secondary calluses derived from AY-diseased plants failed. This suggests either that filamentous MLO are not spiroplasmas or that the so-called AY spiroplasm is in fact 'spiroplasm citri', carried as a contaminant by the AY vector.

Cell cultures to obtain virus- and mycoplasma-free progeny

Cell cultures were obtained from potato explants infected with potato viruses X, S, and M (PVX, PVS, and PVM) and were maintained in a synthetic medium. Calluses regenerated from these cells were found to be free of PVX when assayed by electron microscopy (EM). Five cell lines were cloned for evaluation of their susceptibility to virus *in vitro*. As a prerequisite, naked protoplasts were prepared from the potato cell cultures, and their ability to regenerate cell walls and

divide was determined. Cell walls reformed by the fourth day of culture, but only a few newly formed cells underwent complete cell division. Cell cultures were also obtained from explants of aster, tobacco, and *Vinca* infected with AY. Calluses regenerated from these cultures failed to show MLO in the EM, and regenerated plants appeared healthy.

Little cherry disease

A procedure to isolate little cherry disease (LCD) agents directly from infected cherry tissue was applied to some 60 leaf samples, mostly from infected field trees. Yields of LCD-linked virus-like rods were too low for physical-chemical analysis, but they sufficed for determination of their isoelectric point and for bioassay on cherry seedlings. Fractions from one field tree contained a spherical virus, identified as peach rosette mosaic virus, which also causes decline in grapes. It has not been previously isolated from cherry. Its possible role in the LCD syndrome will be investigated.

Migration in PAGE was identical for dsRNA from sweet cherry inoculated by grafting with LCD from Shiro-fugen flowering cherry, Vancouver; sweet cherry, Chilliwack; and dodder-transmitted LCD, Creston. No evidence of a viroid-like RNA was obtained in nucleic acid preparations of several LCD-infected trees. No dsRNA was obtained from sweet cherry seedlings, slash-inoculated in 1979 with LCDA-dsRNA purified by PAGE or with crude phloem extracts from LCD trees.

A simple procedure was established for rapid development of terminal calluses in petioles of excised cherry leaves. These calluses continued to grow for several months without differentiating. The leaves survived for at least 2 mo beyond their normal life span on the trees. Cells of petiole tissue from LCD trees retained all three LCD-related cellular inclusions for up to 22 days after excision, but callus cells were free from these inclusions.

PLANT PATHOLOGY

Virology

Blueberry leaf mottle virus (BBLMV) is serologically related to grapevine Bulgarian latent virus (GBLV). Relationships were determined after purification through sucrose density gradients between BBLMV, a European isolate of GBLV, and an isolate from

New York state reported to be serologically related to GBLV. The molecular weight of the coat protein subunit for all three viruses was 54 000 in 5% sodium dodecyl sulfate polyacrylamide gels. The RNA of BBLMV was single-stranded and exhibited a $T_M = 60^\circ\text{C}$ and 15.4% hyperchromatism when melted over a temperature range of 30–99°C. RNA-1 and RNA-2 of all three viruses were resolved in 2.4% polyacrylamide gels and had molecular weights of 2.35 and 2.15×10^6 , respectively.

Sixty-nine red raspberry cultivars and selections in the British Columbia breeding program were indexed in 1980. Symptoms in some of the inoculated *Chenopodium quinoa* plants were unlike those of tomato ringspot virus or of raspberry bushy dwarf virus, detected in previous years. Reaction of a range of host plants suggested that the virus might be tobacco streak virus (TSV), and agar gel serology tests confirmed the diagnosis. TSV has occasionally been isolated from red raspberry in the United States, and it has been found in the wild trailing blackberry and from several blackberry cultivars in British Columbia, but it has not previously been detected in raspberry in British Columbia. The virus was detected in the cultivar Pathfinder, which was imported from Wyoming via Oregon, and in eight selections: one from Scotland, five from Oregon, and two from British Columbia. Possibly the cultivar Pathfinder and the five Oregon seedlings were infected when imported. The Scottish selection and the two British Columbia selections were probably infected by pollen transmission from the Oregon material during 3 yr of exposure in the field.

Virus-free potatoes

Twenty-one new accessions were rendered virus-free by heat therapy and meristem tip propagation. Seven seedlings, deemed unlikely to become useful cultivars, were discarded. The current collection, free from all known viruses and viroids, contains 141 selections including the 56 cultivars on the current list of Canadian-licensed cultivars. In 1980, 269 tuber samples were sent on request to potato improvement agencies, growers, or research establishments in seven provinces, 11 states, Australia, the Philippines, Indonesia, Taiwan, Sri Lanka, Vietnam, Korea, and France.

The annual survey for potato viruses X and S in seed potato control areas involved 162 ha of Elite and Foundation seed. Neither virus was found on 16 of the 25 farms surveyed. Of the total, 108 ha (67%) were apparently virus-free; the remainder contained up to 12% infection as estimated from confidence intervals ($P = 0.05$).

Small fruits

Strawberry. The incidence of *Botrytis* in 1980 was the highest since 1976, allowing evaluation of strawberry and raspberry selections for fruit rot resistance. Among the strawberry selections tested, 73-9-79 and Tyee showed the most resistance to postharvest *Botrytis* fruit rot; 73-9-79 also showed the greatest resistance to *Penicillium* but was only moderately resistant to *Rhizopus*; and W72-012-82 had a particularly low preharvest fruit rot.

Strawberry seedlings that ripen 2 wk earlier than Totem were selected from the cross of two early ripening parents, BC70-22-82 and Earliglow. The fruit was of good quality, and the plants were productive and appeared to be virus-tolerant, a combination of traits that has been difficult to obtain.

Raspberry. Evaluation of raspberry breeding selections to preharvest and postharvest fruit rot were continued. Selections showing low preharvest *Botrytis* fruit rot were Malling Leo and SCRI 6820/54. Postharvest *Botrytis* resistance was shown by 72-6-104, Nootka, Skeena, and 74-10-66; *Rhizopus* resistance by 72-6-104, SCRI 6820/54, Nootka, and Skeena; and *Penicillium* resistance by 76-6-104. Correlations between cane *Botrytis* and preharvest and postharvest *Botrytis* fruit rot were not significant, indicating cane reactions are not associated with fruit reactions. Chilcotin, Meeker, and Nootka showed strong resistance to cane *Botrytis*.

Two dominant genes in the native North American red raspberry, *Rubus strigosus*, give immunity or high resistance to the aphid *Amphorophora agathonica*. The combination of these genes with the immunity gene Ag₁ from *Rubus idaeus* cultivar Lloyd George should prevent or delay the emergence of new resistance-breaking strains of the aphid. The use of *R. strigosus* as a parent also brings other useful characteristics, such as resistance to spur blight, into the gene pool.

Bacteriology

The serogroup typing scheme developed for *Erwinia carotovora* permitted identification of specific strains of the blackleg – soft rot organisms in field samples. Persistence of these bacteria in the field differed: some strains were isolated from potato plants throughout the growing season; others were present only shortly after plant emergence. Furthermore, virulence on potato varied among *E. carotovora* var. *atroseptica* strains in four serogroups.

Serological cross-reactions occurred when antisera against *Corynebacterium sepedonicum* were tested with two plant pathogenic *Corynebacterium* spp. and a nonpathogenic coryneform bacterium isolated from a symptomless potato plant. The cross-reactions were detected by both the immunofluorescence and immunodiffusion tests. Ratio of cross-reaction titer to specific activity titer was lower in sera collected soon after immunization than in sera collected several weeks later. The usefulness of serological tests for diagnosis of bacterial ring rot in potato was limited because of cross-reactions with other organisms.

Nematology

The effects of fall and spring applications of NemaCur, a systemic nematocide to control root lesion nematodes in raspberries, on yield and soil nematode densities were measured with active ingredient (ai) at two rates, 8 and 16 kg/ha. In untreated plots nematode densities increased 50%; in treated plots densities were decreased by 55%, 6 mo and 1 yr after treatment. There were no effects on yield in the 1st yr after treatment. Residues in fruit were 0.2 and 0.4 ppm in plots treated in April at 8 or 16 kg ai/ha. No residues were detected in fruit from plots treated in the fall with up to 32 kg ai/ha. The value of fatty acid derivatives for nematode control was studied. With 1-decanol, the LD95 for root knot nematode eggs was higher than for juveniles. In greenhouse soil infested with *Meloidogyne hapla* eggs or juveniles, a drench of 2000 ppm of potassium caprate gave only 25% control, and drenches of 1000 ppm of formaldehyde, methyl decanoate, or 1-decanol gave 93.3, 90.4, and 72.3% control, respectively. However, in microplots with soil treated with 1000 ppm of 1-decanol or methyl decanoate, nematode survival was variable but generally high.

A nematological survey of nurseries of the lower mainland included 103 fields with a

variety of stock in 33 nurseries. Most fields had a light infestation of *Pratylenchus penetrans*, but nematode damage was slight. A survey of alfalfa fields in the Okanagan and Kootenay valleys and adjacent areas demonstrated the relatively widespread presence of the alfalfa stem nematode (*Ditylenchus dipsaci*), a new pest of alfalfa in British Columbia.

ENTOMOLOGY

Vectors

Little cherry disease (LCD). Tests at the Summerland Research Station between 1977 and 1980 strongly suggest that the apple mealybug, *Phenacoccus aceris* (Signoret), is the vector of LCD. Assessment by electron microscopy at the Vancouver Research Station of the trees used in these tests shows that the mealybug can transmit the cellular inclusions associated with LCD from diseased to healthy trees. In a survey of the lower Fraser valley and Vancouver Island, no apple mealybug was found on any of its common hosts, although it had been previously recorded in these areas.

Morphology and fine structure. The stylets of the asparagus aphid, *Brachycolus asparagi* Mord., were sectioned and examined by transmission electron microscopy. As with all true aphids previously examined, the mandibular stylets are innervated by two dendrites contained in a central canal.

Aphid survey. New records brought the number of known aphid species in British Columbia to 326. The asparagus aphid, *B. asparagi*, which was first found in British Columbia in 1979, is now a serious pest of asparagus in the southern interior of the province.

Aphid ecology. Aphidophagous mites (*Anystis* sp.) have been implicated as a regulating factor of populations of pea aphids on alfalfa. In a survey of the lower mainland, these mites were found in 21 of 102 aphid samples, mostly on wild host plants in non-agricultural habitats. This suggests that pesticides or agricultural practices reduce populations of these mites in crops.

Aphid vector-virus relationships. In transmission tests of mild and severe potato leaf roll virus (PLRV), one, two, or four *Myzus persicae* (Sulzer) were used to transmit the

virus from infected to healthy *Physalis floridana*. The greater the number of vectors, the higher the rate of transmission. The original severity of symptoms was not always reproduced in the indicators.

Pest control

Pests of small fruits. The root weevil, *Sciaphilus asperatus* Bousd., was found for the first time, and in large numbers, on strawberry in association with three *Otiorynchus* spp. This weevil is a pest in England and Sweden. Larvae of the curled rose sawfly, *Allantus cinctus* L., were observed on strawberry for the first time in Richmond, B.C. For control of leafrollers and spanworms on blueberries, methoxychlor, Ambush, carbaryl, diazinon, parathion, and guthion, applied as prebloom and postblossom sprays, were effective. All were superior to malathion, the present method of control. Decamethrin applied to cranberry uprights that were heavily infested with larvae of the blackheaded fireworm, *Rhopobota naevana* (Hübner), reduced the numbers of larvae found alive in uprights from 40 in the untreated plots to seven in the treated plots.

Wireworms. In a test to control the European wireworm, *Agriotes obscurus* (L.), in corn in silt loam, four granular insecticides, cloethcarb, fonofos, bendiocarb, and chlorpyrifos, were applied in the furrow at 1.7 kg ai/ha. Bendiocarb and fonofos reduced the wireworm population by 90%, cloethcarb by 76%, and chlorpyrifos by 73%. In potatoes, broadcast treatments of granular fonofos, bendiocarb, and chlorpyrifos reduced unmarketable tubers to 5%, 11%, and 18%, respectively. In the check plots 43% of the potatoes were unmarketable. In a comparison of band and furrow treatments, the percentage of unmarketable tubers for the furrow treatments at 1.7 kg ai/ha were: fonofos, 10; chlorpyrifos, 16; bendiocarb, 17; and cloethcarb, 19; and for the band treatments at 3.4 kg ai/ha they were: bendiocarb, 18; cloethcarb, 25; and chlorpyrifos, 33. In the check plots 56% of the tubers were unmarketable.

Aphids and tuber flea beetles on potatoes. A pest management program has been developed for aphids and tuber flea beetles on potato. First-generation beetles are controlled

by granular insecticides, incorporated in preplanting. Aphids and second and third generations of flea beetles are controlled by sprays that are timed to prevent a buildup of populations.

Root maggots, aphids, and caterpillars on brassica crops. A pest management program has been developed for cabbage maggots and leaf-feeding insects of seeded or transplanted brassica crops. Cabbage maggots are controlled by a band of granular insecticides, applied and incorporated by the seeder or by sprays applied immediately after transplanting. Birlane, Dasanit, and Furadan granules provide good protection; drenches of Amaze, Birlane, carbosulfan, or Lorsban, applied immediately after seedling emergence and again 28 days later, also give good results. Aphids, caterpillars, and second and third generations of maggots are controlled by sprays of a pyrethroid (cypermethrin, decamethrin, or fenvalerate), applied jointly with pirimicarb, an insecticide specifically for aphids. The number of applications is kept to a minimum by treating only when assessments of populations deem it necessary. Thuricide did not control larvae of the diamondback moth.

Weeds. Ceutorhynchus litura F., a weevil whose larvae mine the stems and crowns of Canada thistle, was released at Ladner in 1975. In 1980, 44% of the thistles at the release site were infested, compared with 55% in 1979. The gall fly, *Urophora stylata* F., which attacks the flowers of bull thistle, was released near Ladner in 1973. In 1980, 40% of the seed heads were infested, compared with 46% in 1979. Larvae of the flea beetle, *Longitarsus jacobaeae* (Waterh.), released to control tansy ragwort, were found in the roots, crowns, and adjacent soil of 17 of 19 tansy ragwort plants examined at Nanaimo, B.C. The density of flowering plants in 1980 was half that of 1979.

Residue chemistry

An analytical method was developed to determine residues of Namacur, Namacur sulfoxide, and Namacur sulfone by gas chromatography. The method provides for the individual determination of the three compounds, without the need for an oxidation step.

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POSTGRADUATE THESIS

In partial fulfillment of a degree by the Department of Plant Science, University of British Columbia, all or a significant portion of the research was carried out at the Research Station at Vancouver.

Donnelly, D. J. 1980. In vitro culture of four *Rubus* species.

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 which assures: (a) a dependable supply of safe, nutritious food at reasonable prices to consumers; and (b) equitable returns to producers and processors.

Branch objectives and goals

LAND RESEARCH

1 Soil management and conservation

To obtain an understanding of the properties that limit the productivity of selected soils.

GOAL 1: SOIL MANAGEMENT AND CONSERVATION. By 1982, to have produced information that will provide a basis for improved management of selected problem soils, by studying their chemical, biological, and physical properties.

2 Land inventory and evaluation

To obtain a reliable inventory of Canadian soils and to develop improved methods for their characterization, classification, and evaluation.

GOAL 1: LAND INVENTORY AND EVALUATION. By 1984, to have promoted better utilization of the soil resources in selected regions of Canada, by developing a soil inventory and more reliable methods and criteria for classifying and mapping soils; and to have developed procedures for evaluating the capability of Canadian soils for agricultural production.

WATER RESEARCH

1 Irrigation, drainage, and desalination

To improve water management, irrigation, and drainage on Canadian soils in order to increase productivity.

GOAL 1: IRRIGATION, DRAINAGE, AND DESALINATION. By 1982, to have increased the production of selected soils, by improving water use efficiency and by developing superior methods of irrigation, drainage, and desalination.

2 Meteorological and climatic indices

To increase the use of climate resource information.

GOAL 1: METEOROLOGICAL AND CLIMATIC INDICES. By 1982, to have increased the use of climatic resource information in weather-sensitive agricultural operations, in assessing productivity, and in research applications by improving methodology, assessing and interpreting available data, and deriving selected meteorological and climatic indices.

ENERGY AND ENVIRONMENTAL QUALITY

1 Energy utilization and conservation

To improve on-farm production and the use and conservation of energy.

GOAL 1: ENERGY UTILIZATION AND CONSERVATION. By 1982, to have reduced the farmers' dependence on fossil fuels and to have reduced energy costs, by applying known technology and developing and applying new technology.

2 Environmental quality

To develop agricultural management practices consistent with production and environmental requirements.

GOAL 1: ENVIRONMENTAL QUALITY. By 1982, to have provided information and to have developed and applied technology for controlling pollution from plant nutrients and residue components of selected animal and crop production systems, by conducting field and laboratory studies; and to have determined the environmental acceptability of existing and new pesticide management

systems by using models and performing chemical analyses of new pesticides and their residues in the soil.

ANIMAL PRODUCTION RESEARCH

1 Beef cattle

To improve the efficiency of beef production and the quality of beef products.

GOAL 1: BREEDING, NUTRITION, AND MANAGEMENT. By 1983, to have provided new information that will make possible a 5% increase in beef yield per breeding cow, while maintaining or improving carcass and meat quality, through a program of selection, crossbreeding, and reproductive physiology; to have developed new or improved cow-calf systems, rangeland management, crop residue use, and feedlot feeding systems; and to have developed measures against metabolic disorders and deficiencies.

2 Dairy cattle

To improve the efficiency of milk production.

GOAL 1: BREEDING, NUTRITION, AND MANAGEMENT. By 1982, to have provided new information that will make possible a 10% improvement in overall efficiency of milk production, by improving crossbreeding and intensive management systems; and through a systems approach, to have provided improved techniques that will make possible more economical utilization of feed resources for milk production under various geographic and economic environments.

3 Swine

To improve the efficiency of swine production and the quality of pork and pork products.

GOAL 1: BREEDING, NUTRITION, AND MANAGEMENT. By 1983, to have provided new information that will make possible a 5% increase in yield of pork per unit feed energy, while improving pork quality, through research on breeding, reproductive physiology, and improved feeding and management systems.

4 Poultry

To improve the efficiency of production of eggs and poultry meat and the quality of the products.

GOAL 1: BREEDING, NUTRITION, AND MANAGEMENT. By 1983, to have provided new information on breeding, nutrition, and management of laying hens that will make possible increases of 4% in the weight of eggs and 10% in yield of meat per unit feed energy, and new information on the factors influencing interior and shell quality of eggs, through breeding and selection, reduction of metabolic disorders, and development of superior feeding and management systems.

5 Sheep

To improve the efficiency of sheep production and the quality of mutton and lamb products.

GOAL 1: BREEDING, NUTRITION, PHYSIOLOGY, and MANAGEMENT. By 1983, to have provided new information that will make possible increases of 10% in lamb production per year and 5% in growth rate of lambs, through breeding, improved reproductive efficiency, and development of superior feeding and management systems.

6 Other animals and honey bees

To improve the efficiency of production of other animals and honey bees, and the quality of their products.

GOAL 1: DISEASE, PHYSIOLOGY, FEEDING, AND MANAGEMENT. By 1982, through extramural research, to have made possible a 5% increase in the productivity of fur-bearing animals, by improving feed products, reducing losses caused by disease, and increasing understanding of reproductive processes; and, through in-house research, to have provided new information that will make possible a 2% increase in the productivity of honey bees, by applying knowledge of pheromone chemistry, genetics, and disease control, and by improving overwintering and other management practices.

CROP PRODUCTION AND DEVELOPMENT RESEARCH

1 Wheat

To increase production and protection of wheat through multidisciplinary research.

GOAL 1: BREEDING AND MANAGEMENT. By 1982, to have provided new information and technology that will make possible a 5% increase in unit yield of wheat, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

2 Other cereal crops

To increase production of barley, oats, corn, and rye and buckwheat through multidisciplinary research.

GOAL 1: BARLEY. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of barley, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 2: OATS. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of oats, while maintaining quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 3: CORN. By 1981, to have provided new information and technology that will make possible a 10% increase in unit yield of grain corn and silage corn, while maintaining quality to meet market demand and to have obtained a 1% increase in area cropped with corn, by developing superior inbred or hybrid varieties of grain and silage corn and improving management practices.

GOAL 4: RYE AND BUCKWHEAT. By 1981, to have developed one winter rye and one buckwheat cultivar and improved management practices that will increase the yield potential by 5%, while maintaining or improving quality to meet market demands.

3 Oilseed crops

To increase the efficiency of production through multidisciplinary research on rapeseed and mustard, sunflowers, soybeans, and flax.

GOAL 1: RAPESEED AND MUSTARD. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of rapeseed and mustard, and an improvement in the quality of the seed and processed products to meet market demand, by developing superior varieties and improving management practices.

GOAL 2: SUNFLOWERS. By 1981, to have provided new information and technology that will make possible a 10% increase in unit yield of sunflower seed in the Black soil zones and a 10% increase in the commercial production of sunflowers in the Brown soil zones, while maintaining or improving the quality of the seed and processed products to meet market demand, by developing superior inbred and hybrid varieties and improving management practices.

GOAL 3: SOYBEANS. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of soybeans and to have given an indication of their value as a crop in nontraditional regions, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 4: FLAX. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of flax, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

4 Forage crops

To increase the efficiency of forage crop production systems and the quality of forage crops through multidisciplinary research.

GOAL 1: LEGUMES AND GRASSES. By 1984, to have provided new information and technology that will make possible a 10% increase in unit yield of digestible dry matter in forage legumes and forage grasses, by developing superior varieties, improving management practices, and increasing seed production.

5 Horticultural crops

To improve the efficiency of production of tree fruits, berries, vegetables, potatoes, and ornamentals through multidisciplinary research.

GOAL 1: TREE FRUITS. By 1980, to have developed new information and technology that will make possible a 10% increase in unit yield of tree fruits, while maintaining or improving their quality for fresh and processed use, by developing superior cultivars and improving management practices.

GOAL 2: BERRIES. By 1980, to have developed new information and technology that will make possible a 5% increase in berry yield, while achieving higher standards of quality for fresh and processed use, by developing superior cultivars with greater winterhardiness and disease resistance, and improving management practices.

GOAL 3: VEGETABLES. By 1980, to have developed new information and technology that will make possible a 5% increase in unit yield of vegetable crops, while achieving higher standards of quality for fresh and processed use, by developing superior cultivars and improving management practices.

GOAL 4: POTATOES. By 1980, to have provided new information and technology that will make possible a 5% increase in unit yield of potatoes, while achieving higher standards of quality for fresh

and processed use, by developing superior cultivars and improving pest control and management practices.

GOAL 5: ORNAMENTALS. By 1980, to have developed and introduced six new and improved cultivars of greenhouse crops, nursery stock, and turf grasses that are needed by the ornamentals trades; to have achieved a 5% increase in the yield of commercial ornamental crops, by improving cultural practices; and to have reduced energy consumption in greenhouses to 10% lower than previous levels.

6 Field crops

To improve the efficiency of production through multidisciplinary research on tobacco, field peas, beans, and other pulses; and new crops.

GOAL 1: TOBACCO. By 1980, to have provided new information and technology that will make possible a better understanding of tobacco quality and a 10% increase in unit yield of tobaccos improved to meet market demand, by developing superior cultivars, improving management practices, and applying knowledge of tobacco quality characteristics.

GOAL 2: FIELD PEAS, BEANS, AND OTHER PULSE CROPS. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of field peas, beans, and other pulse crops, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management and postharvest storage practices.

GOAL 3: NEW CROPS. By 1981, to have determined the potential and suitability for commercial production of 10 selected new crops, through assessment of their production and market aspects, and to have demonstrated the method of growing, protecting, and utilizing five new crops previously identified as having this potential.

PRODUCTION SUPPORT RESEARCH

1 Supportive research and development

To provide new research information on crops, animals, and soils.

GOAL 1: WINTERHARDINESS. By 1984, to have defined and described selected physiological activities in plants, by completing biochemical and physiological studies, and to have shown how these properties can be used to improve efficiency of crop production.

GOAL 2: NITROGEN FIXATION. By 1984, to have developed information on new or more effective ways of fixing atmospheric nitrogen, by studying hosts, bacteria, and the biological processes.

GOAL 3: CYTOGENETICS. To develop methods of producing doubled haploids for breeding cereal and crucifer species; to establish cell and protoplast cultures for more efficient selection of useful mutants, for parasexual hybridization, and for whole-plant regeneration in several crop species; and to analyze cytogenetic relationships that facilitate interspecific transfer of genes in cereal and brome grass species.

GOAL 4: RESEARCH SERVICES. To continue to maintain a Canadian collection of plant gene resources and a storage and retrieval system for gene data; to produce and distribute special seed for plant breeders; to provide research and service in electron microscopy and analytical chemistry; and to provide editing, text processing, and graphics services for research programs and to maintain computerized national information systems on agricultural research and on pesticides.

GOAL 5: ENGINEERING AND STATISTICS. To continue to support Branch and Departmental research and development, by providing services in statistical design, analysis, and interpretation and by developing instruments, apparatus, and equipment.

2 Protection

To provide new broad research information on the protection of animals and crops from diseases, insects, and weeds.

GOAL 1: BIOLOGICAL AND CHEMICAL CONTROL AND ECOLOGY OF WEEDS. By 1984, to have developed new information and technology for determining the potential for biological control of 25 major weeds, by selecting, establishing, and assessing suitable biotic agents; to have developed environmentally safe and effective methods for controlling selected weeds with herbicides, by studying their mode of action, methods of application, and persistence in the environment, and to have provided technological information that will make it possible to reduce crop losses caused by weeds, by studying the ecology of 30 selected weeds and gathering information on their biological importance, reactions to herbicides, cultural management practices, and other biological characteristics.

GOAL 2: INTEGRATED CONTROL OF INSECT PESTS ON RAPESEED. By 1984, to have provided new information and technology that will make possible the development of one or more

management systems for controlling insect pests in rapeseed crops, by studying insects and their natural control factors, and evaluating the benefit-to-cost and benefit-to-risk relationships and the impact of control procedures on environmental quality.

GOAL 3: DISEASE AND INSECT CONTROL. By 1984, to have achieved a better understanding of the mode of action, degradation, and side effects of selected insecticides and fungicides, and to have improved the control of injurious insects and fungal diseases with the use of chemical pesticides and with the development of more effective chemical agents.

GOAL 4: CONTROL OF PLANT VIRUSES AND MYCOPLASMS. By 1984, to have improved control of plant viruses and mycoplasmas, by developing further information on their biochemistry and ultrastructure, their vector-host relationships, and their mechanisms of movement and infection in plants.

GOAL 5: CONTROL OF NEMATODE DISEASES. By 1984, to have improved control of nematode diseases, by identifying the species on major agricultural crops, studying their host-parasite relationships, and improving the effectiveness of nematocide use in integrated control systems.

GOAL 6: ANIMAL PROTECTION. By 1984, to have developed efficient, economical, and environmentally acceptable methods for protecting livestock from arthropod pests and parasites, and to have increased livestock productivity, through improved animal protection and improved management of parasites.

3 Biosystematics

To clarify the taxonomy of and provide identification services for vascular plants, insects, arachnids, nematodes, and fungi found in Canada.

GOAL 1: VASCULAR PLANTS. By 1981, to have resolved the taxonomy of selected groups of vascular plants, particularly those relating to Canadian agriculture, by completing floristic surveys and inventories of selected areas, developing and maintaining a National Vascular Plant Herbarium and a collection of living plants, and providing an efficient identification and information service.

GOAL 2: INSECTS, ARACHNIDS, AND NEMATODES. By 1981, to have completed the taxonomy of selected groups of insects, arachnids, and nematodes, particularly those relating to Canadian agriculture, by making faunal surveys and inventories of selected areas, developing and maintaining a national collection of these biota, and providing an efficient identification and information service.

GOAL 3: FUNGI. By 1981, to have improved the taxonomy of selected groups of fungi, particularly those relating to Canadian agriculture, by completing fungal surveys and inventories of selected areas, developing and maintaining a National Herbarium and Culture Collection, and providing an efficient identification and information service.

FARM INPUT SUPPLY RESEARCH

1 Machinery and structural research

To provide information and technology needed for improving and better utilizing farm structures and machinery.

GOAL 1: MACHINERY AND STRUCTURES TECHNOLOGY. On a continuing basis, to support branch and departmental programs on farm machinery and structures, by providing, developing, and assessing new and existing technology.

PROCESSING RESEARCH

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.

GOAL 1: FOOD PROCESSING. By 1985, to have developed or improved technology and equipment for extracting and utilizing components of selected plant and animal agricultural products and converting fresh material into attractive and stable processed foods.

GOAL 2: FOOD QUALITY. By 1985, to have developed new or improved technology for measuring and improving the quality of selected food products at intermediate and final stages of processing, and to have improved food quality in the finished product, by studying the reactions that take place during processing.

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.

GOAL 1: NEW FOOD PRODUCTS AND INGREDIENTS DEVELOPMENT. By 1985, to have developed methods and processes of interest to industry for new food products and ingredients with valuable functional or nutritional properties with commercial potential.

DISTRIBUTING RESEARCH

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.

GOAL 1: STORAGE OF FRUITS AND VEGETABLES. By 1985, to have developed new information and technology that will make possible a 10% extension of the storage life of fresh fruits and vegetables, while maintaining or improving product quality, by physiological studies and the development of optimum storage conditions.

GOAL 2: STORAGE OF GRAINS AND OILSEEDS. By 1985, to have developed methods and provided recommendations that will make possible a 10% reduction in losses caused by infestation of insects, mites, and fungi in cereals, oilseeds, and their products during storage, by conducting surveys of pest populations and research on control measures.

FOOD SAFETY AND NUTRITION RESEARCH

1 Food safety

To increase consumer protection by conducting research to reduce antinutritional factors and microbiological and chemical contaminants in agricultural products and foods.

GOAL 1: TOXICANTS AND CONTAMINANTS. By 1985, to have defined potential hazards caused by selected undesirable material in feedstuffs and foods, by studying their occurrence and their interactions in the food system, and to have developed control procedures for their prevention or removal.

2 Nutrition

To assist in improving the general level of nutrition of Canadian consumers.

GOAL 1: FOOD COMPOSITION AND NUTRIENT AVAILABILITY. By 1985, to have provided new information and technology that will make it possible to improve human nutrition, by monitoring the composition of animal and plant material, formulating food products derived from them, and determining the availability of selected nutrients.

STRUCTURE DU PROGRAMME DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

Objectif du Ministère

L'objectif fondamental du ministère de l'Agriculture du 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, de l'aider à répondre aux besoins des marchés national et étrangers, et à remplir ses engagements en matière d'aide internationale 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 buts de la Direction générale

RECHERCHE SUR LES TERRES

1 Gestion et conservation des sols

Trouver les principales causes qui nuisent à la productivité de certains sols.

BUT 1: GESTION ET CONSERVATION DES SOLS. D'ici 1982, chercher de nouveaux moyens d'améliorer la pratique de sols sélectionnés, par l'étude de leurs caractéristiques chimiques, biologiques et physiques.

2 INVENTAIRE ET ÉVALUATION DES SOLS

Constituer un inventaire complet des sols canadiens et améliorer des méthodes pour mieux les caractériser, les classer et les évaluer.

BUT 1: INVENTAIRE ET ÉVALUATION DES TERRES. D'ici 1984, rendre possible une meilleure utilisation des ressources pédologiques dans certaines régions du Canada, en constituant un inventaire et en établissant des méthodes et des critères plus efficaces de classification et de cartographie des sols; et élaborer des méthodes d'évaluation des ressources pédologiques canadiennes pour la production agricole.

RECHERCHE SUR LES EAUX

1 Irrigation, drainage et dessalinisation

Améliorer les techniques d'utilisation des ressources hydriques, l'irrigation et le drainage des sols canadiens dans le but d'en améliorer la productivité.

BUT 1: IRRIGATION, DRAINAGE ET DESSALINISATION. D'ici 1982, augmenter la production de sols sélectionnés, en accroissant l'efficacité de l'utilisation des ressources hydriques et en mettant au point de meilleures méthodes d'irrigation, de drainage et de dessalinisation.

2 Indices météorologiques et climatologiques

Accroître l'utilisation des données sur les ressources climatiques.

BUT 1: INDICES MÉTÉOROLOGIQUES ET CLIMATOLOGIQUES. D'ici 1982, accroître l'utilisation de l'information climatologique, particulièrement en ce qui a trait aux opérations agricoles tributaires du climat, au chapitre des prévisions sur la productivité et dans le domaine de l'application des recherches, grâce à l'amélioration des méthodes, l'évaluation et l'interprétation des données disponibles, et l'élaboration d'indices météorologiques et climatiques choisis.

ÉNERGIE ET QUALITÉ DE L'ENVIRONNEMENT

1 Utilisation et conservation de l'énergie

Améliorer la production, l'utilisation et la conservation de l'énergie sur l'exploitation.

BUT 1: UTILISATION ET CONSERVATION DE L'ÉNERGIE. D'ici 1982, atténuer la dépendance des agriculteurs envers les combustibles fossiles et réduire les coûts de l'énergie, par l'application des techniques actuelles et par l'élaboration et l'application de techniques nouvelles.

2 Qualité de l'environnement

Élaborer des pratiques de gestion agricole correspondant à la production et respectant l'environnement.

BUT 1: QUALITÉ DE L'ENVIRONNEMENT. D'ici 1982, grâce à des études sur le terrain et en laboratoire, mettre au point des données et des techniques nouvelles de contrôle de la pollution

causée par les éléments nutritifs végétaux et les résidus de divers systèmes de production animale et végétale; et déterminer jusqu'à quel point l'environnement peut tolérer les systèmes actuels et futurs d'utilisation des pesticides, par l'emploi de modèles et d'analyses chimiques des nouveaux pesticides et de leurs résidus dans le sol.

RECHERCHE SUR LA PRODUCTION ANIMALE

1 Bovins de boucherie

Accroître l'efficacité de la production bovine et améliorer la qualité des produits.

BUT 1: REPRODUCTION, NUTRITION ET CONDUITE. D'ici 1983, mettre au point de nouvelles données qui permettront d'accroître de 5% les rendements en viande par vache reproductrice, tout en maintenant ou en améliorant la qualité des carcasses et de la viande, grâce à la mise en oeuvre d'un programme de sélection, de croisement et de physiologie reproductive; mettre au point des systèmes d'élevage vache-veau nouveaux ou améliorés ainsi que des systèmes de gestion des pâturages, d'utilisation des résidus de cultures et d'alimentation du bétail en parcs; et perfectionner des mesures préventives contre les troubles et les déficiences métaboliques.

2 Bovins laitiers

Accroître l'efficacité de la production laitière.

BUT 1: REPRODUCTION, NUTRITION ET CONDUITE DES TROUPEAUX. D'ici 1982, mettre au point des données qui permettront d'accroître de 10% l'efficacité globale de la production laitière, grâce à des systèmes de croisement et de production intensive; et améliorer des techniques systématisées permettant l'utilisation plus économique des aliments dans la production laitière en fonction des diverses conditions géographiques et économiques.

3 Porcs

Accroître l'efficacité de la production porcine et améliorer la qualité de la viande et des produits du porc.

BUT 1: REPRODUCTION, NUTRITION ET CONDUITE. D'ici 1983, mettre au point de nouvelles données qui permettront d'accroître de 5% le rendement de porc par unité d'énergie alimentaire tout en améliorant la qualité de la viande, par des recherches sur l'amélioration génétique, la physiologie de la reproduction et la mise au point de meilleurs systèmes d'alimentation et de gestion.

4 Volailles

Accroître l'efficacité de la production des oeufs et améliorer la qualité des produits.

BUT 1: REPRODUCTION, NUTRITION ET CONDUITE. D'ici 1983, mettre au point de nouvelles données sur l'amélioration génétique, la nutrition et la conduite des pondeuses qui permettront d'accroître de 4% le poids des oeufs et de 10% la production de viande par unité d'énergie alimentaire, en plus de mettre au point de nouvelles données sur les facteurs déterminants de la qualité intérieure de l'oeuf et de sa coquille, par l'amélioration génétique et la sélection, et aussi par la diminution des troubles du métabolisme et la mise au point de meilleurs systèmes d'alimentation et de conduite des troupeaux.

5 Moutons

Améliorer l'efficacité de l'élevage ovin et la qualité des produits du mouton et de l'agneau.

BUT 1: REPRODUCTION, NUTRITION, PHYSIOLOGIE ET CONDUITE. D'ici 1983, grâce à l'amélioration des races et à une plus grande efficacité de la reproduction ainsi qu'à l'élaboration de meilleurs systèmes d'alimentation et de conduite des troupeaux, mettre au point de nouvelles données qui permettront d'accroître de 10% la production d'agneaux par année et de 5% le taux de croissance des agneaux.

6 Autres animaux et abeilles

Accroître l'efficacité de la production des autres animaux et des abeilles, et améliorer la qualité de leurs produits.

BUT 1: MALADIES, PHYSIOLOGIE, ALIMENTATION ET CONDUITE. D'ici 1982, grâce à la recherche extra-muros, accroître de 5% la productivité des animaux à fourrure en améliorant les produits alimentaires, en réduisant les pertes dues aux maladies et en accroissant les connaissances de la reproduction; et grâce à la recherche interne, mettre au point de nouvelles données qui permettront d'accroître de 2% la productivité des abeilles, en effectuant des recherches sur la chimie des phéromones, la génétique et la lutte contre les maladies, et en améliorant la conduite des ruchers au cours de l'hiver et d'autres modes de gestion.

RECHERCHE SUR LA PRODUCTION ET L'AMÉLIORATION DES CULTURES

1 Blé

Poursuivre des recherches pluridisciplinaires pour améliorer la production et la protection du blé.

BUT 1: PRODUCTION ET GESTION. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du blé, tout en maintenant ou en améliorant la qualité pour répondre aux besoins du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

2 Autres cultures céréalières

Poursuivre des recherches pluridisciplinaires pour améliorer la production de l'orge, de l'avoine, du maïs, du seigle et du sarrasin.

BUT 1: ORGE. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire d'orge, tout en maintenant la qualité pour satisfaire la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

BUT 2: AVOINE. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire de l'avoine, tout en maintenant la qualité pour répondre aux besoins du marché, par la création de variétés supérieures et l'amélioration des pratiques culturales.

BUT 3: MAÏS. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire du maïs-grain et du maïs d'ensilage, tout en maintenant la qualité pour satisfaire la demande du marché, et accroître de 1% la superficie cultivée de maïs, grâce à la création de variétés autofécondées supérieures, d'hybrides supérieurs de maïs-grain et de maïs d'ensilage, et à l'amélioration des pratiques culturales.

BUT 4: SEIGLE ET SARRASIN. D'ici 1981, mettre au point un cultivar de seigle d'hiver et un cultivar de sarrasin, et améliorer des pratiques culturales de façon à augmenter le rendement potentiel de 5% tout en maintenant ou en améliorant la qualité pour répondre aux besoins du marché.

3 Oléagineux

Mener des recherches pluridisciplinaires pour améliorer l'efficacité de la production du colza, de la moutarde, du tournesol, du soja et du lin.

BUT 1: COLZA ET MOUTARDE. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du colza et de la moutarde, et d'améliorer la qualité de la graine et de ses produits pour répondre aux besoins du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

BUT 2: TOURNESOL. D'ici 1981, mettre au point des données et des techniques nouvelles qui permettront d'accroître de 10% le rendement unitaire des graines de tournesol dans les zones de sol noir et de 10% la production de graines de tournesol dans les zones de sol brun, tout en maintenant ou en améliorant la qualité de la graine et de ses produits pour répondre aux besoins des marchés, par la création de variétés autofécondées supérieures et d'hybrides supérieurs, et l'amélioration des pratiques culturales.

BUT 3: SOJA. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du soja, et démontrer sa valeur comme culture possible dans de nouvelles régions, tout en maintenant ou en améliorant sa qualité pour répondre aux besoins du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

BUT 4: LIN. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du lin, tout en maintenant ou en améliorant la qualité pour répondre aux besoins du marché, par la création de variétés supérieures et l'amélioration des pratiques culturales.

4 Cultures fourragères

Poursuivre des recherches pluridisciplinaires pour augmenter l'efficacité des systèmes de production de cultures fourragères ainsi que la qualité de ces dernières.

BUT 1: LÉGUMINEUSES ET GRAMINÉES FOURRAGÈRES. D'ici 1984, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire en matière sèche digestible des légumineuses et des graminées fourragères, grâce à la création de variétés supérieures, à l'amélioration des pratiques culturales et à l'accroissement de la production de semences.

5 Horticulture

Améliorer, par le biais de la recherche pluridisciplinaire, l'efficacité des fruits de verger, des petits fruits, des légumes, des pommes de terre et des plantes ornementales.

BUT 1: FRUITS DE VERGER. D'ici 1980, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire des fruits de verger, tout en maintenant ou en améliorant les normes de qualité des produits frais et transformés, grâce à la création de meilleurs cultivars et à l'amélioration des pratiques culturales.

BUT 2: PETITS FRUITS. D'ici 1980, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement des petits fruits, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de cultivars supérieurs résistant mieux au froid et aux maladies, et grâce à l'amélioration des pratiques culturales.

BUT 3: LÉGUMES. D'ici 1980, mettre au point des données et des techniques nouvelles permettant d'augmenter de 5% le rendement unitaire des légumes, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de meilleurs cultivars et à l'amélioration des pratiques culturales.

BUT 4: POMMES DE TERRE. D'ici 1980, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire des pommes de terre, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de cultivars supérieurs et à l'amélioration des pratiques culturales et des moyens de lutte contre les ravageurs.

BUT 5: PLANTES ORNEMENTALES. D'ici 1980, créer et introduire six nouveaux cultivars améliorés de plantes de serre, de pépinière et de graminées à gazon correspondant à la demande de ce marché; accroître de 5% le rendement des plantes ornementales dans le secteur commercial, par l'amélioration des pratiques culturales; enfin, réduire de 10% la consommation d'énergie dans les serres.

6 Grandes cultures

Mener une recherche pluridisciplinaire pour améliorer l'efficacité de la production du tabac, des pois, des haricots, d'autres légumineuses et de nouvelles cultures.

BUT 1: TABAC. D'ici 1980, mettre au point des données et des techniques nouvelles permettant d'élargir les connaissances sur la qualité des tabacs et d'accroître de 10% le rendement unitaire des variétés de tabac améliorées en vue de répondre à la demande du marché, par la création de meilleurs cultivars, l'amélioration des pratiques culturales et l'application des connaissances acquises dans le domaine de la qualité du tabac.

BUT 2: POIS, HARICOTS ET AUTRES LÉGUMINEUSES. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire des pois, des haricots et d'autres légumineuses tout en maintenant ou en améliorant la qualité pour répondre à la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales et des techniques d'entreposage après récolte.

BUT 3: NOUVELLES CULTURES. D'ici 1981, déterminer les possibilités d'implantation dans le commerce de 10 nouvelles cultures par l'évaluation des conditions de production et de mise en marché, et décrire les méthodes de production, de protection et d'utilisation de cinq nouvelles cultures dont les possibilités ont déjà été reconnues.

RECHERCHE D'APPUI À LA PRODUCTION

1 Recherche et développement d'appui

Fournir de nouvelles données de la recherche sur les cultures, les animaux et les sols.

BUT 1: RUSTICITÉ. D'ici 1984, définir et décrire diverses activités physiologiques des végétaux par des études biochimiques et physiologiques, et montrer comment ces caractéristiques peuvent être utilisées pour améliorer l'efficacité des productions culturales.

BUT 2: FIXATION DE L'AZOTE. D'ici 1984, mettre au point des données sur les méthodes nouvelles ou améliorées de fixation de l'azote atmosphérique, par l'étude des hôtes, des bactéries et des fonctions biologiques.

BUT 3: CYTOGÉNÉTIQUE. Chez les espèces de céréales et de cruciféracées, élaborer des méthodes de production de matériaux haploïdes doublés aux fins de l'amélioration génétique; chez plusieurs espèces culturales, établir des cultures cellulaires et des protoplastes pour une meilleure sélection des mutants utiles, pour la création parasexuelle d'hybrides et pour la régénération de plantes entières; chez les espèces de céréales et de brome, élucider les relations cytogénétiques facilitant le transfert de certains gènes entre diverses espèces.

BUT 4: SERVICES DE RECHERCHE. Maintenir de façon permanente une collection canadienne des ressources phylogénétiques ainsi qu'un fichier central de données génétiques; produire des semences spéciales à l'intention des phytosélectionneurs et assurer leur distribution; assurer un service et de la recherche en microscopie électronique et en chimie analytique; fournir des services

d'illustration aux programmes de recherche et maintenir des systèmes nationaux d'information mécanographiée sur la recherche agricole et sur les pesticides.

BUT 5: INGÉNIERIE ET STATISTIQUE. Appuyer de façon permanente les programmes de recherche et de développement de la Direction générale et du Ministère par l'élaboration, l'analyse et l'interprétation des statistiques, et la conception d'instruments, d'appareils et d'équipement.

2 Protection

Mettre au point de nouvelles données de recherches applicables de façon générale à la protection des animaux et des cultures contre les maladies, les insectes et les mauvaises herbes.

BUT 1: LUTTE BIOLOGIQUE ET CHIMIQUE, ET ÉCOLOGIE DES MAUVAISES HERBES. D'ici 1984, mettre au point des données et des techniques nouvelles permettant de déterminer les possibilités de réussite de la lutte biologique contre 25 des plus importantes mauvaises herbes, par la sélection, l'élevage et l'évaluation d'agents biotiques appropriés; et mettre au point des méthodes de lutte efficaces et non dommageables à l'environnement, capables d'éliminer certaines mauvaises herbes au moyen d'herbicides, grâce à des études sur leur mode d'action, les façons de les appliquer et leur persistance dans l'environnement; et mettre au point des données techniques nouvelles permettant de réduire les baisses de rendement causées par les mauvaises herbes, grâce à l'étude écologique de 30 mauvaises herbes sélectionnées et à la collecte de données sur leur importance biologique, sur leur réaction aux herbicides et aux pratiques culturales, et sur leurs autres caractéristiques biologiques.

BUT 2: LUTTE INTÉGRÉE CONTRE LES INSECTES DU COLZA. D'ici 1984, mettre au point des données et des techniques nouvelles qui permettront l'élaboration d'un ou de plusieurs systèmes de lutte contre les insectes du colza, en menant des recherches sur ces insectes et leurs prédateurs, et en évaluant les rapports coût-bénéfice et risque-bénéfice ainsi que l'impact des méthodes de lutte sur la qualité de l'environnement.

BUT 3: MALADIES ET LUTTE CONTRE LES INSECTES. D'ici 1984, élargir les connaissances des modes d'action, de la dégradation et des effets secondaires de divers insecticides et fongicides, et rendre possible la lutte améliorée contre les insectes ravageurs et les maladies fongiques par les pesticides chimiques, tout en développant des agents chimiques plus efficaces.

BUT 4: LUTTE CONTRE LES VIRUS ET LES MYCOPLASMES. D'ici 1984, améliorer les méthodes de lutte contre les virus et les mycoplasmes des végétaux en menant des études plus poussées sur leur biochimie et leur ultrastructure, les rapports vecteur-hôte et les mécanismes de transport et d'infection à l'intérieur des plantes.

BUT 5: LUTTE CONTRE LES NÉMATODES. D'ici 1984, améliorer les méthodes de lutte contre les maladies causées par les nématodes en identifiant les espèces qui s'attaquent aux principales cultures, en étudiant les rapports hôte-parasite et en déterminant les méthodes d'utilisation les plus efficaces des nématicides dans la lutte intégrée contre les ravageurs.

BUT 6: PROTECTION DES ANIMAUX. D'ici 1984, mettre au point des méthodes pratiques, efficaces, économiques et écologiques pour assurer la protection des troupeaux contre les arthropodes et les parasites, et augmenter la productivité du bétail grâce à l'amélioration de la protection des troupeaux et de la lutte contre les parasites.

3 Biosystématique

Clarifier la taxonomie et assurer un service d'identification des plantes vasculaires, des insectes, des arachnides, des nématodes et des champignons du Canada.

BUT 1: PLANTES VASCULAIRES. D'ici 1981, résoudre les problèmes relatifs à la taxonomie de groupes sélectionnés de plantes vasculaires, en particulier celles qui intéressent le secteur agricole canadien, en effectuant des relevés floristiques et en constituant des répertoires de la flore pour les régions choisies, en montant et en conservant un herbier de plantes vasculaires ainsi qu'une collection de plantes vivantes, et en fournissant, à partir de ces travaux, un service efficace d'information et d'identification.

BUT 2: INSECTES, ARACHNIDES ET NÉMATODES. D'ici 1981, compléter la taxonomie de groupes sélectionnés d'insectes, d'arachnides et de nématodes, particulièrement ceux qui intéressent le secteur agricole canadien, en effectuant des relevés de la faune, en dressant des répertoires pour les régions choisies, en montant et en conservant une collection nationale de ces biotes et en fournissant, à partir de ces travaux, un service efficace d'identification et d'information.

BUT 3: CHAMPIGNONS. D'ici 1981, améliorer la taxonomie de groupes sélectionnés de champignons, surtout ceux qui intéressent le secteur agricole canadien, en effectuant des relevés mycologiques et en constituant des répertoires des champignons pour les régions choisies, en montant et en conservant un herbier national et une collection des cultures de champignons et en fournissant, à partir de ces travaux, un service efficace d'identification et d'information.

RECHERCHE SUR LES FACTEURS DE PRODUCTION AGRICOLE

1 Recherche sur la machinerie et les bâtiments

Mettre au point des données et des techniques nécessaires à l'amélioration et à une meilleure utilisation des bâtiments et de la machinerie agricoles.

BUT 1: TECHNOLOGIE DE LA MACHINERIE ET DES BÂTIMENTS. Appuyer de façon permanente les programmes de la Direction générale et du Ministère concernant la machinerie et les bâtiments agricoles en fournissant, perfectionnant et évaluant les techniques courantes et nouvelles.

RECHERCHE SUR LA TRANSFORMATION

1 Technologie de la transformation

Élaborer de nouvelles techniques de transformation alimentaire et améliorer l'efficacité des systèmes de transformation, en favorisant la recherche de base sur les modifications chimiques et physiques que subissent les aliments au cours de la transformation ainsi que l'évaluation par des projets-pilote, le cas échéant.

BUT 1: TRANSFORMATION ALIMENTAIRE. D'ici 1985, mettre au point ou améliorer des techniques et de l'équipement afin d'extraire et d'utiliser des composantes de produits agricoles sélectionnés, d'origine végétale ou animale, et afin de convertir des produits frais en aliments transformés qui se conservent bien et ont une apparence savoureuse.

BUT 2: QUALITÉ DES ALIMENTS. D'ici 1985, mettre au point des techniques nouvelles ou perfectionnées d'évaluation et d'amélioration de la qualité de divers produits alimentaires sélectionnés aux niveaux intermédiaire et final de leur transformation et rehausser la qualité des produits alimentaires finis par une meilleure connaissance des réactions qui surviennent au cours de la transformation.

2 Développement de nouveaux produits

Mettre au point et caractériser des ingrédients ou produits nouveaux et utiles en vue de les soumettre au secteur privé pour évaluation et fabrication, et mettre au point également la technologie nécessaire à leur production, y compris leur évaluation par des projets-pilotes, le cas échéant.

BUT 1: CRÉATION DE NOUVEAUX PRODUITS ET INGRÉDIENTS ALIMENTAIRES. D'ici 1985, mettre au point des méthodes et des procédés intéressant le secteur chargé de trouver de nouveaux produits et ingrédients alimentaires qui pourraient offrir de bonnes propriétés fonctionnelles et nutritionnelles, et une valeur commerciale.

RECHERCHE CONCERNANT LA DISTRIBUTION

1 Produits entreposés

Améliorer les techniques et l'efficacité de l'entreposage des fruits et des légumes frais hors des exploitations; dans les entrepôts, réduire les pertes de céréales et d'oléagineux par une lutte soutenue contre les insectes.

BUT 1: ENTREPOSAGE DES FRUITS ET DES LÉGUMES. D'ici 1985, mettre au point des données et des techniques nouvelles qui permettront une prolongation de 10% de la conservation en entrepôt des fruits et légumes frais, tout en maintenant ou en améliorant leur qualité, grâce à des études physiologiques et à l'élaboration de meilleures conditions d'entreposage.

BUT 2: ENTREPOSAGE DES CÉRÉALES ET DES OLÉAGINEUX. D'ici 1985, élaborer des méthodes et faire les recommandations permettant de réduire de 10% les pertes que causent les insectes, les acariens et les champignons aux céréales, aux oléagineux et à leurs produits en entreposage, grâce à des études sur les populations de parasites et des recherches sur les moyens de lutte.

RECHERCHE SUR LA SALUBRITÉ DES ALIMENTS ET LA NUTRITION

1 Salubrité

Augmenter la protection du consommateur par des recherches visant à diminuer les facteurs antinutritionnels et les contaminants microbiologiques et chimiques dans les produits agricoles et les aliments.

BUT 1: ÉLÉMENTS TOXIQUES ET CONTAMINANTS. D'ici 1985, définir les dangers possibles de certains éléments nocifs que renferment les aliments de consommation animale et humaine, grâce à des recherches sur leur présence dans les aliments et leurs interactions dans le circuit alimentaire, et élaborer des méthodes de contrôle pour leur prévention ou leur élimination.

2 Nutrition

Contribuer à l'amélioration du régime alimentaire général du consommateur canadien.

BUT 1: COMPOSITION ET VALEUR NUTRITIVE DES ALIMENTS. D'ici 1985, mettre au point des données et des techniques nouvelles permettant de rehausser la valeur nutritive des aliments de consommation humaine, par le contrôle de la composition des sources alimentaires animales et végétales, par la formulation des produits alimentaires qui en sont dérivés et par l'évaluation de la disponibilité de divers éléments nutritifs dans les aliments.

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