Agriculture Canada

RESEARCH BRANCH REPORT

1985

RAPPORT DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

·1986

Canada

One hundred years of progress

The year 1986 is the centennial of the Research Branch, Agriculture Canada.

On 2 June 1886, *The Experimental Farm Station Act* received Royal Assent. The passage of this legislation marked the creation of the first five experimental farms located at Nappan, Nova Scotia; Ottawa, Ontario; Brandon, Manitoba; Indian Head, Saskatchewan (then called the North-West Territories); and Agassiz, British Columbia. From this beginning has grown the current system of over forty research establishments that stretch from St. John's West, Newfoundland, to Saanichton, British Columbia.

The original experimental farms were established to serve the farming community and assist the Canadian agricultural industry during its early development. Today, the Research Branch continues to search for new technology that will ensure the development and maintenance of a competitive agri-food industry.

Research programs focus on soil management, crop and animal productivity, protection and resource utilization, biotechnology, and food processing and quality.

Cent ans de progrès

En 1986, la Direction générale de la recherche d'Agriculture Canada célèbre ses cent ans d'existence.

C'est, en effet, le 2 juin 1886 que la loi appelée *Acte des stations agronomiques* reçut la sanction royale. De son adoption découla la mise sur pied des cinq premières fermes expérimentales situées à: Nappan, en Nouvelle-Écosse; Ottawa, en Ontario; Brandon, au Manitoba; Indian Head, en Saskatchewan (alors englobée dans les Territoires du Nord-Ouest); et Agassiz, en Colombie-Britannique. C'étaient là les débuts du réseau actuel de plus de quarante établissements de recherches disséminés entre St-John, à Terre-Neuve, et Saanichton, en Colombie-Britannique.

Les premières stations agronomiques avaient été fondées pour desservir la communauté des agriculteurs et venir en aide au secteur agricole canadien encore débutant. De nos jours, la Direction générale de la recherche poursuit la même tâche en travaillant aux découvertes technologiques dont dépendent le développement et le maintien d'un secteur agro-alimentaire compétitif.

Les programmes de recherches s'intéressent surtout aux modes d'exploitation du sol, à la production animale et végétale, à la protection des richesses naturelles et à leur gestion, aux biotechnologies et enfin à la transformation et à la qualité des aliments.

Research Branch Report

1985

Rapport de la Direction générale de la recherche

RESEARCH BRANCH
DIRECTION GÉNÉRALE DE LA RECHERCHE

AGRICULTURE CANADA

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FOREWORD

The *Research Branch Report*, which is published yearly, provides a summary of research results achieved during the year throughout the branch. During 1985, the regions and institutes of the branch effectively contributed to departmental objectives and strategies aimed at enhancing growth, stability, and competitiveness in the agri-food sector. Results are reported in both scientific and extension-type papers. Those for 1985 are listed at the end of each station's report. Information is passed on through various provincial committees and technology transfer mechanisms to the producers and food processors.

The five regions of the Research Branch, namely Atlantic, Quebec, Ontario, Prairie, and Pacific, include 29 major establishments, 13 experimental farms, and a number of smaller units. Each one carries out research contributing to national and regional objectives while developing technology pertinent to the specific area where it is located. The Institutes Directorate in Ottawa, made up of five research institutes and Research Program Service, combines research on national programs with special services to regional establishments and the public. The Program Coordination Directorate, located at Branch Headquarters in Ottawa, coordinates research programs at the national level and develops policies consistent with furthering the objectives of the branch and the department.

Research programs in the branch are developed in response to the needs of the agri-food industry as determined through the mechanism of the Canadian Agricultural Services Coordinating Committee and consultations at all levels of the agri-food sector.

Research programs encompass all components of the industry, including natural resources, animal and crop production, protection, food processing, nutrition, and food safety.

To support these programs, basic research is conducted on such high-priority areas as biotechnology and toxic chemicals. Biotechnology programs accelerate conventional agricultural research through the application of genetic engineering and associated techniques for increased agri-food production. Biotechnological techniques are valuable because they are energy-saving, economical, and environmentally clean. Research in toxic chemicals is currently focusing on detecting their presence in primary agricultural products, determining their effects on animal and human health, and finding ways to reduce or eliminate them from food products.

In 1985, the Research Branch had a budget of $263 million and a staff of 3632, of which 948 were professionals.

The Research Branch cooperates with other branches of Agriculture Canada, with other federal departments, and with various agencies in activities related to the agri-food sector. In 1985 the department began to restructure its activities comprehensively toward market-oriented commodity-based development strategies. The Research Branch has actively participated in this process.

The Research Branch has ongoing science and technology exchanges with several countries, including seven with whom Agriculture Canada has memoranda of understanding and another nine with whom there are other formal arrangements for exchange. Scientific and technical information and personnel are provided to development assistance projects overseas, including the management and staffing of long-term development projects sponsored by the Canadian International Development Agency (CIDA).

This report documents the continuous effort by Research Branch staff to deliver a broad and effective research program that benefits all sectors of the agri-food industry.

E.J. LeRoux
Assistant Deputy Minister, Research

AVANT-PROPOS

Le *Rapport de la Direction générale de la recherche*, publié annuellement, présente un résumé des résultats de recherches obtenus au cours de l'année par la Direction générale. En 1985, les régions et les instituts de la Direction générale ont efficacement contribué à la réalisation des objectifs et des stratégies du Ministère destinés à favoriser la croissance, la stabilité et la compétitivité du secteur agro-alimentaire. Les résultats sont signalés dans des documents scientifiques et de vulgarisation. Ceux de 1985 sont énumérés à la fin du rapport de chaque station. L'information est transmise par divers comités provinciaux et mécanismes de transfert de technologie aux producteurs et à l'industrie alimentaire.

Les cinq régions de la Direction générale de la recherche, en l'occurence les provinces de l'Atlantique, le Québec, l'Ontario, les Prairies et la Région du Pacifique, comptent 29 établissements principaux, 13 fermes expérimentales et un certain nombre de plus petits centres. Chacun exécute des recherches qui contribuent à la réalisation des objectifs nationaux et régionaux tout en mettant au point de la technologie adaptée à la région particulière où il est situé. La Direction des instituts à Ottawa, composée de cinq instituts et d'un Service aux programmes de recherche, combine la recherche sur les programmes nationaux à des services spéciaux offerts aux établissements régionaux et au grand public. La Direction de la coordination des programmes, logée dans les bureaux de l'Administration centrale de la Direction générale à Ottawa, coordonne les programmes de recherche à l'échelle nationale et établit des politiques conformes à la poursuite des objectifs de la Direction générale et du Ministère.

Les programmes de recherches de la Direction générale visent à satisfaire les besoins du secteur agro-alimentaire déterminés par le Comité de coordination des services agricoles canadien (CCSAC) et par voie de consultation à tous les niveaux du secteur agro-alimentaire.

Les programmes de recherches touchent à tous les aspects du secteur, notamment les ressources naturelles, les productions animale et végétale, la protection, la transformation des aliments, la nutrition et l'innocuité des aliments.

Pour épauler l'exécution de ces programmes, des recherches fondamentales sont menées dans des domaines hautement prioritaires comme la biotechnologie et les produits chimiques toxiques. Les programmes sur la biotechnologie ont pour effet d'accélérer les recherches agricoles classiques par l'application du génie génétique et des techniques qui y sont reliées à l'accroissement de la production agro-alimentaire. Les techniques biotechnologiques comportent plusieurs avantages: elles consomment peu d'énergie, sont économiques et ne causent pas de dommages à l'environnement. La recherche sur les produits chimiques toxiques met actuellement l'accent sur la détection de leur présence dans les produits agricoles primaires, sur la détermination de leurs effets sur la santé humaine et animale, et sur les moyens d'en réduire la teneur ou de les éliminer dans les produits alimentaires.

En 1985, la Direction générale disposait d'un budget de 263 millions de dollars et d'un effectif de 3 632 employés dont 948 professionnels.

La Direction générale collabore avec d'autres directions générales du Ministère, avec d'autres ministères fédéraux et avec divers organismes à la tenue d'activités reliées au secteur agro-alimentaire. En 1985, le Ministère a entamé une restructuration en profondeur de ses activités en fonction de stratégies de développement par secteur de production, axées sur les marchés. La Direction générale a activement participé à ce processus.

Elle procède aussi régulièrement à des échanges en sciences et en technologie avec plusieurs pays, dont sept ont signé des protocoles d'entente avec le Ministère et neuf ont conclu d'autres accords formels d'échanges. La Direction générale fournit de l'information et du personnel scientifiques et techniques pour la réalisation de projets d'aide au développement outre-mer, et assure la gestion et la dotation en personnel de projets de développement à long terme parrainés par l'Agence canadienne de développement internationale (ACDI).

Le présent rapport témoigne des efforts permanents déployés par le personnel de la Direction générale pour exécuter efficacement un vaste programme de recherches qui bénéficie à tous les segments du secteur agro-alimentaire.

E.J. LeRoux
Le Sous-ministre adjoint à la Recherche

E.J. LeRoux

W. Baier

R.L. Halstead

W.B. Collins

J.-J. Jasmin

J.J. Cartier

W.L. Pelton

S.C.Thompson

J.E. Andrews

L.R. Radburn

J.E. Renaud

J.R. Lessard

Headquarters
Administration centrale

BRANCH EXECUTIVE
HAUTE DIRECTION

Assistant Deputy Minister, Research — E.J. LeRoux, B.A., M.Sc., Ph.D.
Sous-ministre adjoint à la Recherche

Directors General *Directeurs généraux*

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Atlantic Region, Acting *Région de l'Atlantique, intérimaire*	W.B. Collins, B.Sc.(Agr.), M.Sc., Ph.D.
Quebec Region *Région du Québec*	J.-J. Jasmin, B.Sc.(Agr.), M.Sc.
Ontario Region *Région de l'Ontario*	J.J. Cartier, B.A., B.Sc., Ph.D.
Prairie Region *Région des Prairies*	W.L. Pelton, B.S.A., M.S.A., Ph.D.
Pacific Region *Région du Pacifique*	S.C. Thompson, B.Sc., M.S.A., Ph.D.

Special Advisers *Conseillers spéciaux*

Senior Adviser, special projects *Conseiller principal aux projets spéciaux*	J.E. Andrews, B.S.A., M.S.A., Ph.D.
Director, Administration Division *Directeur de l'Administration*	L.R. Radburn, A.C.B.A., R.I.A.
Branch Financial Manager *Gestionnaire financier de la Direction générale*	J.E. Renaud, C.D.
Executive Assistant *Adjoint exécutif*	J.R. Lessard, B.A., B.Sc., M.S., Ph.D.

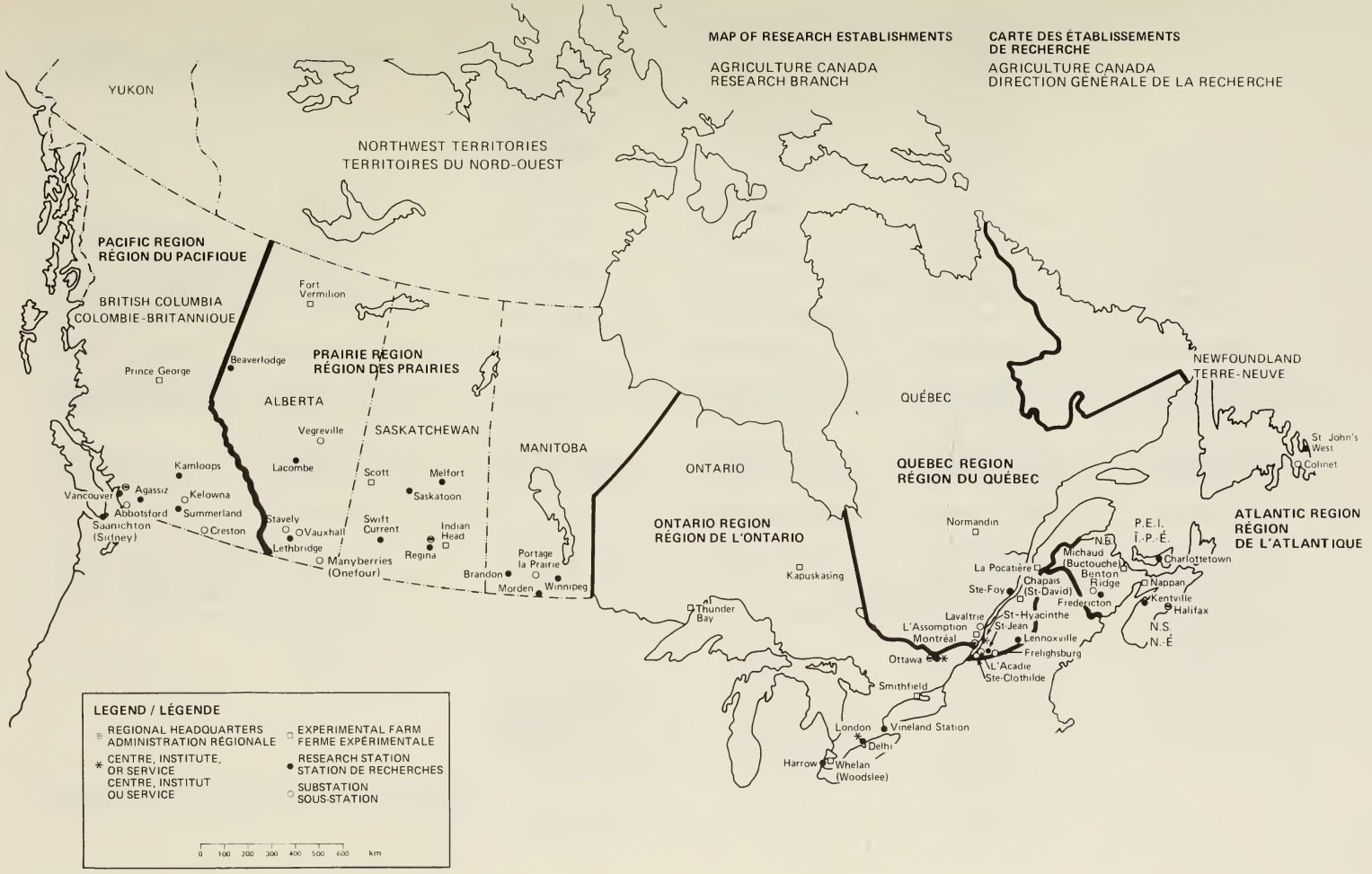
ADMINISTRATION DIVISION
DIVISION DE L'ADMINISTRATION

Director *Directeur*	L.R. Radburn
Chief, Administration Section *Chef de la Section de l'administration*	I.M. Wood
Chief, Personnel Section *Chef de la Section du personnel*	G.J. Redmond

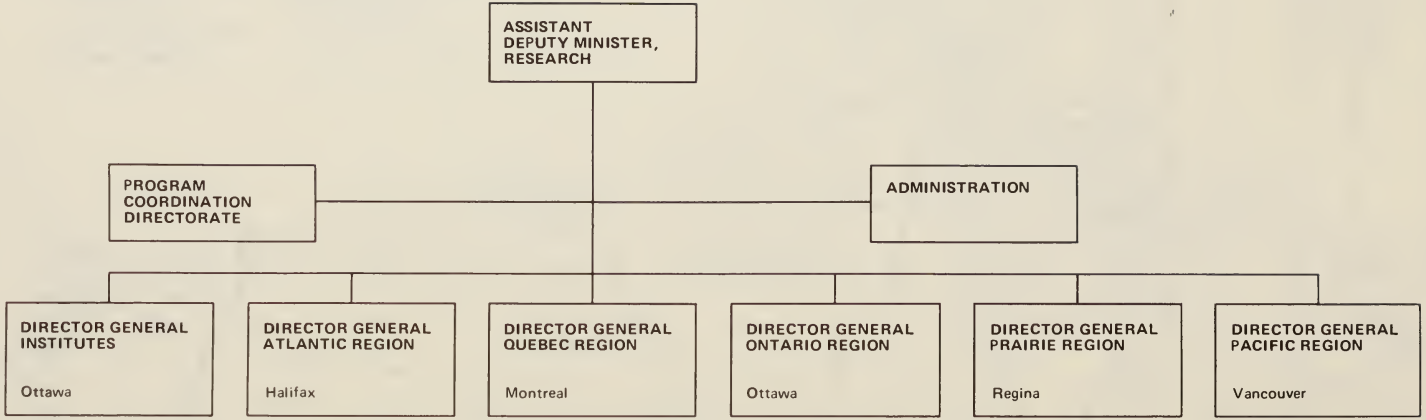
BRANCH FINANCIAL MANAGEMENT
GESTION FINANCIÈRE DE LA DIRECTION GÉNÉRALE

Manager *Gestionnaire*	J.E. Renaud,[1] C.D.
Chief, Financial planning *Chef de la Planification financière*	K. Archer,[1] R.I.A.
Chief, Financial analysis *Chef de l'Analyse financière*	A.L. Dignard[1]
Chief, Financial planning and analysis (Institutes and Ontario) *Chef de la Planification et de l'Analyse financières (Instituts et Ontario)*	J. B. Moran[1]

[1]Seconded from Finance and Administration Branch *Détaché de la Direction générale des finances et de l'administration.*


MAP OF RESEARCH ESTABLISHMENTS
AGRICULTURE CANADA
RESEARCH BRANCH
CARTE DES ÉTABLISSEMENTS DE RECHERCHE
AGRICULTURE CANADA
DIRECTION GÉNÉRALE DE LA RECHERCHE
YUKON
NORTHWEST TERRITORIES
TERRITOIRES DU NORD-OUEST
PACIFIC REGION
RÉGION DU PACIFIQUE
BRITISH COLUMBIA
COLOMBIE-BRITANNIQUE
PRAIRIE REGION
RÉGION DES PRAIRIES
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUÉBEC
NEWFOUNDLAND
TERRE-NEUVE
QUEBEC REGION
RÉGION DU QUÉBEC
ONTARIO REGION
RÉGION DE L'ONTARIO
ATLANTIC REGION
RÉGION DE L'ATLANTIQUE
Fort Vermilion
Beaverlodge
Prince George
Vegreville
Lacombe
Kamloops
Vancouver
Agassiz
Kelowna
Abbotsford
Summerland
Saanichton (Sidney)
Creston
Stavely
Vauxhall
Lethbridge
Manyberries (Onefour)
Scott
Saskatoon
Melfort
Swift Current
Regina
Indian Head
Portage la Prairie
Brandon
Morden
Winnipeg
Thunder Bay
Kapuskasing
Normandin
La Pocatière
Ste-Foy
Lavaltrie
L'Assomption
Montréal
Ottawa
Smithfield
London
Delhi
Vineland Station
Harrow
Whelan (Woodslee)
St-Hyacinthe
St-Jean
Lennoxville
Frelighsburg
L'Acadie
Ste-Clothilde
Chapais (St-David)
Michaud (Buctouche)
Bronton Ridge
Fredericton
N.B.
P.E.I. Î.-P.-É.
Charlottetown
Nappan
Kentville
Halifax
N.S. N.-É.
St. John's West
Colinet
LEGEND / LÉGENDE
REGIONAL HEADQUARTERS ADMINISTRATION RÉGIONALE
CENTRE, INSTITUTE, OR SERVICE CENTRE, INSTITUT OU SERVICE
EXPERIMENTAL FARM FERME EXPÉRIMENTALE
RESEARCH STATION STATION DE RECHERCHES
SUBSTATION SOUS-STATION
0 100 200 300 400 500 600 km

ORGANIZATION OF THE RESEARCH BRANCH



Research Institutes

Biosystematics
Chemistry and Biology
Engineering and Statistical
Food
Land Resource

Research Program Service

Research Stations

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

Research Centre

Food, Saint-Hyacinthe, Que.

Research Stations

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

Research Centres

Animal, Ottawa, Ont.
London, Ont.

Research Stations

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

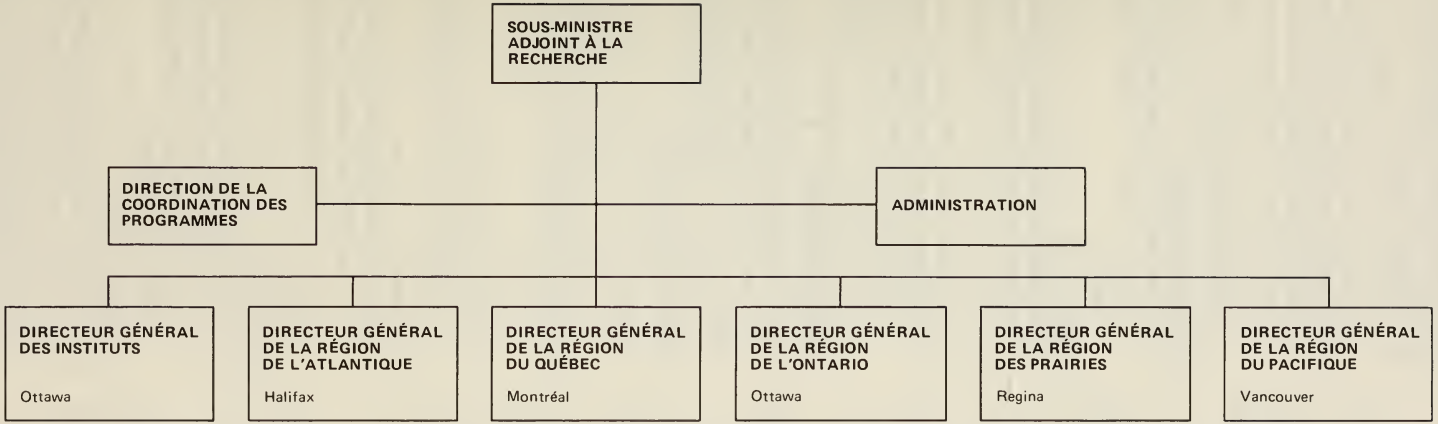
Research Stations

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, Alta.
Fort Vermilion, Alta.
Lacombe, Alta.
Vegreville, Alta.
Lethbridge, Alta.
Manyberries (Onefour), Alta.
Stavely, Alta.
Vauxhall, Alta.

Research Stations

Agassiz, B.C.
Abbotsford, B.C.
Kamloops, B.C.
Prince George, B.C.
Saanichton Research and Plant Quarantine Station (Sidney), B.C.
Summerland, B.C.
Creston, B.C.
Kelowna, B.C.
Vancouver, B.C.

ORGANISATION DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE



Instituts de recherches

Aliments
Biosystématique
Chimie et biologie
Technique et statistique
Terres

Service aux programmes de recherche

Stations de recherches

Saint-Jean (T.-N.)
  Colinet (T.-N.)
Charlottetown (Î.-P.-É.)
Kentville (N.-É.)
  Nappan (N.-É.)
Frédéricton (N.-B.)
  Benton Ridge (N.-B.)
  Michaud (Buctouche) (N.-B.)

Centre de recherches

Aliments (Saint-Hyacinthe) (Québec)

Stations de recherches

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

Centres de recherches

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

Stations de recherches

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

Stations de recherches

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.)
  Manyberries (Onefour) (Alb.)
  Stavely (Alb.)
  Vauxhall (Alb.)

Stations de recherches

Agassiz (C.-B.)
  Abbotsford (C.-B.)
Kamloops (C.-B.)
  Prince George (C.-B.)
  Station de recherches et de quarantaine des plantes de Saanichton (Sidney) (C.-B.)
Summerland (C.-B.)
  Creston (C.-B.)
  Kelowna (C.-B.)
Vancouver (C.-B.)

PROGRAM STRUCTURE OF THE RESEARCH BRANCH

Departmental objective

Agriculture Canada's objective is to promote the growth, stability, and competitiveness of the agri-food sector, by making available policies, programs, and services that are most appropriately provided by the federal government, so that the sector makes its maximum contribution to the economy.

Branch objective

The Research Branch's objective for the scientific research and development planning element is to maintain and improve the productivity of the agri-food sector through developing and transferring new knowledge and technology.

Objectives for branch planning sub-elements and sub-sub-elements

Management and administration. To provide the managerial, financial, personnel, and administrative services required for efficient management of the Research Branch.

1. Planning and program management
   To provide branch planning and program coordination in support of senior branch management.
2. Administrative services
   To provide support for branch management in financial, personnel, and any other administrative areas necessary for the efficient functioning of the branch.

Resource and support research. To produce scientific and technical information and to develop technology that will assist the agri-food sector in managing and conserving the natural resources necessary for agricultural production, while increasing the level and efficiency of production, and that will assist other researchers in developing applied technology.

1. Land
   To provide accurate information about the quantity, quality, and location of Canada's land resource and to better understand the properties of soils, which affect agricultural productivity.
2. Water and climate
   To improve water management on Canadian soils in order to increase productivity and to monitor and preserve environmental quality within the constraints imposed by Canada's northern climate.
3. Energy and engineering
   To develop and adapt engineering technology that will optimize energy utilization and efficiency of production, storage, processing, and distribution of agricultural products.
4. Biological resources
   To provide accurate information about the quantity, quality, and location of Canada's biological resources (including vascular plants, insects, arachnids, nematodes, fungi, and bacteria) and to provide identification services that can be used as required to ensure agricultural productivity.
5. Biotechnology
   To assess, develop, and utilize technology in support of basic and applied agricultural research.
6. Protection
   To provide new, general, and basic research information on the protection of animals and crops from diseases, insects, and weeds.
7. Scientific support services
   To provide for all scientific researchers the statistical, graphic arts, publishing, and other general support services necessary to maintain the quality and quantity of output of research findings.

Animal productivity research. To produce scientific and technical information and develop new technology that will assist the primary producer in increasing the quality and efficiency of the production of animals.

1. Beef
   To improve the efficiency of beef production and the quality of beef products in support of regional, domestic, and export market development.
2. Dairy
   To improve the efficiency of milk production for domestic and export market development.
3. Swine
   To improve the efficiency of pork production and the quality of pork and pork products in support of domestic and export market development.
4. Poultry
   To improve the efficiency of production of eggs and poultry meat and the quality of poultry products in support of domestic and export market development.
5. Other animals
   To increase the efficiency of production and quality of products from sheep, honey bees, fur bearers, and any other animals deemed to be of agricultural importance in support of domestic and export market development.

Crop productivity research. To produce scientific and technical information and develop new technology that will assist the primary producer in increasing the quality and efficiency of the production of crops.

1. Cereals
   To increase the production efficiency, quality, and protection of cereal crops for domestic and export markets.
2. Oilseeds
   To increase the efficiency of production adaptability and the quality of oilseed crops and their products for domestic and export markets.
3. Forages
   To increase the efficiency of production adaptability and the quality of domestic forage crops in support of livestock production.
4. Field crops
   To increase the production efficiency, quality, and protection of field crops such as tobacco, field peas, buckwheat, and field beans.
5. Vegetables
   To increase the efficiency of production, protection, adaptability, and quality of vegetables for the domestic market, and of potatoes and seed potatoes for export.
6. Tree fruits and berries
   To increase the efficiency of production, protection, adaptability, and quality of tree fruits and berries for domestic and export markets.
7. Ornamentals
   To develop, test, and release high-quality ornamental plants that are adapted to Canada's climatic regions.

Food research. To produce scientific and technical information and develop technology that will assist the agri-food processing sector in increasing the efficiency and effectiveness of crop and animal commodity processing, while ensuring the safety and nutritional value of food.

1. Crop processing and products
   To develop new food-processing technology, to improve the efficiency and effectiveness of food-processing systems, and to develop and characterize new products and ingredients in the processing of agricultural crops.
2. Livestock processing and products
   To develop new food-processing technology, to improve the efficiency and effectiveness of food-processing systems, and to develop and characterize new products and ingredients in the processing of animal and dairy products.
3. Food safety and nutrition
   To increase consumer safety from antinutritional and toxic constituents in food and to improve the nutritive value of processed foods, where practical, in order to improve the level of nutrition of Canadians.

STRUCTURE DU PROGRAMME DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

Objectif du Ministère

L'objectif d'Agriculture Canada est de promouvoir la croissance, la stabilité et la compétitivité du secteur agro-alimentaire au moyen de politiques, de programmes et de services fournis par le gouvernement fédéral, de façon à assurer une contribution optimale de ce secteur à l'économie.

Objectifs de la Direction générale

L'élément planification de la recherche scientifique et du développement de la Direction générale de la recherche a pour objectif d'améliorer la productivité du secteur agro-alimentaire en mettant au point de nouvelles technologies et en diffusant les connaissances.

Objectifs des sous-divisions et des sub-sous-divisions de la planification

Gestion et administration. Fournir les services nécessaires dans les domaines de la gestion, des finances, du personnel et de l'administration afin d'assurer une gestion efficace de la Direction générale.

1. Planification et gestion des programmes
   Assurer la planification et la coordination des programmes de la Direction générale afin d'appuyer la haute direction.
2. Services administratifs
   Fournir un soutien à la haute direction dans les domaines des finances, du personnel et tout autre domaine administratif pour assurer le bon fonctionnement de la Direction générale.

Recherche sur les ressources et recherche de soutien. Mettre à la disposition du secteur agro-alimentaire des informations scientifiques et techniques et développer des technologies qui l'aideront à gérer et à conserver les ressources naturelles nécessaires à la production agricole tout en augmentant leur utilisation efficace: ces mêmes ressources doivent aider les chercheurs à mettre au point des technologies appliquées.

1. Terres
   Fournir des informations précises sur la quantité, la qualité et l'emplacement des ressources en terres du Canada et parvenir à une meilleure connaissance des propriétés des sols, qui influent sur la productivité agricole.
2. Eau et climat
   Améliorer la gestion des eaux sur les sols du Canada afin d'accroître la productivité et de contrôler et conserver la qualité de l'environnement, en tenant compte des contraintes imposées par le climat boréal du Canada.
3. Énergie et recherches techniques
   Développer et adapter une technologie pour optimiser le rendement énergétique et l'efficacité de la production, du stockage, de la transformation et de la distribution des produits agricoles.
4. Ressources biologiques
   Fournir des informations précises sur la quantité, la qualité et l'emplacement des ressources biologiques du Canada (notamment les plantes vasculaires, insectes, arachnides, nématodes, champignons et bactéries) et offrir des services d'identification sur demande pour assurer la productivité agricole.
5. Biotechnologie
   Évaluer, développer et appliquer une technologie à l'appui de la recherche agricole fondamentale et appliquée.
6. Protection
   Fournir les résultats généraux et fondamentaux sur la recherche dans le domaine de la protection des animaux et des récoltes contre les maladies, les insectes et les mauvaises herbes.
7. Services de soutien scientifique
   Fournir à tous les chercheurs des statistiques, des publications et tout autre service d'aide générale nécessaire au maintien de la qualité de la recherche et à l'accroissement de la productivité des opérations.

Recherche sur la production animale. Produire l'information scientifique et technique et élaborer une nouvelle technologie afin d'aider le producteur primaire à augmenter la qualité et l'efficacité de la production animale.

1. Bovins de boucherie
   Accroître l'efficacité de la production bovine et améliorer la qualité des produits pour les marchés régional, national et d'exportation.
2. Bovins laitiers
   Accroître l'efficacité de la production laitière pour les marchés national et d'exportation.
3. Porcs
   Accroître l'efficacité de la production porcine et améliorer la qualité des produits pour les marchés national et d'exportation.
4. Volaille
   Accroître l'efficacité de la production des oeufs et de la volaille et améliorer la qualité des produits avicoles pour les marchés national et d'exportation.
5. Autres
   Accroître l'efficacité de la production ovine, apicole, d'animaux à fourrure et de tous les autres animaux jugés importants pour l'agriculture, pour les marchés national et d'exportation.

Recherche sur les productions végétales. Produire de l'information scientifique et technique et élaborer une nouvelle technologie afin d'aider le producteur primaire à augmenter la qualité et l'efficacité de la production animale.

1. Céréales
   Accroître l'efficacité, la qualité et la protection des cultures cerealières pour les marchés national et d'exportation.
2. Oléagineux
   Accroître l'adaptabilité sur le plan productif et la qualité des oléagineux et de leurs produits pour les marchés national et d'exportation.
3. Fourrages
   Accroître l'adaptabilité sur le plan productif et la qualité des cultures fourragères national afin d'aider à la production du bétail.
4. Grandes cultures
   Accroître l'efficacité de la production, la qualité et la protection des grandes cultures comme le tabac, le pois sec, le sarrasin et le haricot sec.
5. Légumes
   Accroître l'efficacité de la production, la protection, l'adaptabilité et la qualité des légumes pour le marché national, et des pommes de terre et des pommes de terre de semence pour l'exportation.
6. Arbres fruitiers et baies
   Accroître l'efficacité de la production, la protection, l'adaptabilité et la qualité des arbres fruitiers et des baies afin d'augmenter les marchés national et d'exportation.
7. Plantes d'ornement
   Développer, tester et distribuer des plantes d'ornement de grande qualité qui soient adaptées aux différentes régions climatiques du Canada.

Recherches alimentaires. Fournir l'information scientifique et technique et élaborer la technologie à l'appui du secteur de la transformation agro-alimentaire afin d'accroître l'efficacité et la rentabilité de la transformation des produits animaux et végétaux tout en assurant la salubrité et la valeur nutritive des aliments produits.

1. Transformation alimentaire et aliments
   Élaborer de nouvelles techniques de transformation alimentaire des produits végétaux, accroître l'efficacité et la rentabilité du système et élaborer et caractériser de nouveaux produits et ingrédients.
2. Transformation du bétail et produits alimentaires
   Élaborer de nouvelles techniques de transformation alimentaire des produits animaux, accroître l'efficacité et la rentabilité du système et élaborer et caractériser de nouveaux produits et ingrédients.
3. Salubrité des aliments et nutrition
   Accroître la protection des consommateurs contre les constituants alimentaires toxiques et néfastes sur le plan nutritif et rehausser si possible, la valeur nutritive des aliments transformés afin d'assurer une meilleure nutrition aux Canadiens.

Program Coordination Directorate
Direction de la coordination des programmes


W. Baier


R. Bouchard


W.J. Saidak


D.F. Wood


C.B. Willis


D.F. Kirkland


R. Trottier


J. Nowland

Acting Director General ***Directeur général intérimaire***

W. Baier, Diplomlandwirt, Dr.Agr., M.Sc.

Research Coordinators ***Coordonnateurs des recherches***

Animal production *Production des animaux*	R. Bouchard, B.A., B.S.A., M.Sc., Ph.D.
Crops production (grains and oilseeds) *Production végétale (céréales et oléagineux)*	W.J. Saidak, B.S.A., M.S., Ph.D., F.W.S.S.A.
Food and nutrition, acting *Aliments et nutrition, intérimaire*	D.F. Wood, B.Sc., M.Sc., Ph.D.
Crop production (horticulture and special crops) *Production végétale (horticulture et cultures spéciales)*	C.B. Willis, B.Sc.(Agr.), Ph.D., F.A.I.C.
International R & D, acting *R & D international, intérimaire*	D.F. Kirkland
Protection *Protection*	R. Trottier, B.Sc., M.Sc., Ph.D.
Natural Resources *Ressources naturelles*	J. Nowland, B.A., M.Sc.

PREFACE

The Program Coordination Directorate (PCD) provides the Research Branch with a national capability for coordinating agricultural research in Canada. The directorate is an essential component of Research Branch management. It ensures that research programs achieve maximum contribution to the department's scientific endeavors in support of the agri-food industry. It is the only group without regional affiliation, with specific responsibility for the national branch strategy as a whole.

PCD provides expertise in agricultural research at Research Branch Headquarters in Ottawa, supporting the Assistant Deputy Minister, Research, in his roles as both branch head and corporate manager. Through consultation and advice PCD assists in the management of research programs and in the development and implementation of branch and departmental policies. It is also called upon to assist in the analysis of government policies that have an impact upon the branch and the department. In performing these advisory duties, PCD is responsible for preparing briefings, position papers, and correspondence relating to any of these topics.

PCD plans national programs through the consolidation of regional operational plans. The directorate also reviews the effectiveness of programs in meeting objectives and determines the impact of programs on the agri-food sector. It coordinates at the national level the scientifically based activities that result in the monitoring and delivery of programs at the regional level. It is the principal contact on matters concerning research and development (R&D) with central agencies, other countries, departments, provinces, universities, and industry. It effects liaison between the Research Branch and other branches, departments, and agencies leading to collaborative action on national (e.g. Economic Regional Development Agreement) and international (e.g. CIDA) matters. It is responsible for the organization of the activities of the Canadian Agricultural Services Coordinating Committee (CASCC) and the Canadian Agricultural Research Council (CARC). Under the Research Branch's human resources development plan, the directorate provides training for potential managers.

Currently, PCD consists of the director general and seven coordinators, all of whom are senior professionals with international recognition in their specific disciplines. The group also includes two special advisers and one special assistant (CASCC and CARC), who provide support on a permanent basis. In addition, six professionals are seconded to the directorate as special advisers.

The current divisions of responsibility within the group are: crop and animal production, protection, natural resources, food and nutrition, and international R&D.

W. Baier
Acting Director General

PRÉFACE

La Direction de la coordination des programmes constitue, pour la Direction générale de la recherche, un organe national de coordination de la recherche agricole au Canada. Elle représente aussi un élément clé de la fonction de gestion à la Direction générale, laquelle voit à ce que les programmes de recherches contribuent le plus possible à l'aboutissement des efforts scientifiques déployés par le Ministère pour le bénéfice du secteur agro-alimentaire. Seul groupe sans affiliation régionale, elle a pour responsabilité spécifique de mener à bien la stratégie nationale de la Direction générale.

La Direction offre des compétences techniques en recherche agricole à l'Administration centrale de la Direction générale à Ottawa, aidant de ce fait le Sous-ministre adjoint à la Recherche à remplir son double rôle de chef de la Direction générale et de cadre ministériel. Par la consultation, elle contribue à la gestion des programmes de recherches, ainsi qu'à l'élaboration et à l'application des politiques de la Direction générale et du Ministère. Elle est également appelée à participer à l'analyse des politiques gouvernementales qui touchent la Direction générale et le Ministère. À titre de service consultatif, la Direction doit préparer des notes de documentation, des documents de travail et de la correspondance portant sur n'importe lequel de ces sujets.

Les responsabilités de la Direction touchent également à la planification des programmes en fonction d'une vue d'ensemble et d'une intégration des plans opérationnels régionaux. Elle contrôle aussi l'efficacité avec laquelle les programmes permettent d'atteindre les objectifs fixés et détermine leur incidence sur le secteur agro-alimentaire. Elle coordonne, à l'échelle nationale, les activités scientifiques touchant à la surveillance et à l'exécution de programmes à l'échelle régionale. En matière de recherche et de développement, elle sert d'organe de liaison principal avec les organismes centraux, d'autres pays et ministères, les provinces, les universités et le secteur. Elle assure également la liaison entre la Direction générale de la recherche et d'autres directions générales, ministères et organismes, ce qui permet une concertation des efforts à l'égard des questions de portée nationale (p.ex., EDER) et internationale (p.ex., ACDI). Elle est responsable de l'organisation des activités du Comité de coordination des services agricoles canadiens (CCSAC) et du Conseil de recherche agricole du Canada (CRAC). Dans le cadre du Programme de perfectionnement des ressources humaines de la Direction générale, la Direction dispense de la formation aux futurs gestionnaires.

Actuellement, la Direction se compose du directeur général et de sept coordonnateurs qui sont tous des professionnels cadres reconnus internationalement dans leur discipline respective. Le groupe comprend également deux conseillers spéciaux et un adjoint spécial (CCSAC et CRAC) qui apportent constamment leur concours. En outre, six professionnels sont détachés à la Direction à titre de conseilleurs spéciaux.

Les champs d'activités du groupe sont les suivants: productions animale et végétale, protection, ressources naturelles, alimentation et nutrition, ainsi que recherche et développement à l'échelle internationale.

W. Baier
Directeur général intérimaire

Program Coordination Directorate, Ottawa, Ontario

PROFESSIONAL STAFF

W. Baier, Diplomlandwirt, Dr.Agr., M.Sc.	Acting Director General

Research Coordinators

R. Bouchard, B.A., B.S.A., M.Sc., Ph.D.	Animal production
D.F. Kirkland	International R&D, acting
J. Nowland,[1] B.A., M.Sc.	Natural resources
W.J. Saidak, B.S.A., M.S., Ph.D., F.W.S.S.A.	Crop production—grains and oilseeds
R. Trottier, B.Sc., M.Sc., Ph.D.	Protection
C.B. Willis,[2] B.Sc.(Agr.), Ph.D., F.A.I.C.	Crop production—horticulture and special crops
D.F. Wood,[3] B.Sc., M.Sc., Ph.D.	Food and nutrition, acting

Special Advisers

D.P. Gray,[4] B.Sc., D.V.M., M.V.Sc.	Animal health and diseases
M.K. John,[5] B.Sc.(Agr.), M.S., Ph.D.	Resources

Secondees/Trainees

G.W. Andrews,[6] B.Sc.F., M.Sc.	Planning and policy
D.J.E. Demars,[7] B.Sc., M.Sc., Ph.D.	Human resources planning and industry relations
B.N.A. Hudson,[8] B.Sc., Ph.D.	Protection
K.W. Lievers,[9] B.Sc., M.Sc.	Program analysis
J.A. Perrin,[10] B.Sc.	Operational processes
D.R. Phillips,[11] B.Sc., M.Sc., Ph.D.	International R&D

Special Assistant, Committees and Special Projects

E. Hunter	CASCC and CARC

Departures

R.L. Halstead, B.S.A., Ph.D. Appointed acting director general, Institutes Directorate	Director General
J.R. Aitken, B.S.A., M.Sc., Ph.D. Retired 30 October 1985	Contracts Analyst
C.J. Bishop, B.Sc., A.M., Ph.D., D.Sc., F.R.S.C., F.A.S.H.S., F.A.I.C. Retired 5 July 1985	Production
J.R. Lessard, B.A., B.Sc., M.S., Ph.D. Appointed acting executive assistant, Research Branch Executive	Animals
J. Millette, B.Sc., M.Sc., Ph.D. On 2-year assignment, India Dryland Project, Hyderabad, India, August 1985–August 1987	International R&D
R.M. Prentice, B.Sc., M.Sc. Retired 4 January 1985	Protection
J. Mulders, B.A., B.Sc., M.Sc. Retired 27 December 1985	Production
G.L. Rousselle, B.A., B.Sc.(Agr.), M.Sc., Ph.D.; Appointed superintendent, Senator Hervé J. Michaud Experimental Farm, Bouctouche, N.B.	Horticulture

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[1]Appointed 11 December 1985.
[2]Appointed 28 November 1985.
[3]Seconded from Food Research Institute, Ottawa, Ont.
[4]Appointed 4 April 1985.
[5]Appointed 1 March 1985.
[6]Seconded from Finance and Administration Branch.
[7]Seconded from Research Branch Executive.
[8]Seconded from Biosystematics Research Institute, Ottawa, Ont.
[9]Seconded from Engineering and Statistical Research Institute, Ottawa, Ont.
[10]Seconded from Research Program Service, Ottawa, Ont.
[11]Seconded from Research Station, Harrow, Ont.

INTRODUCTION

1985 is the first year in which the activities and achievements of the Program Coordination Directorate (PCD) have been recorded in the *Research Branch Report*.

Over the year the directorate has fulfilled its role as described in the "Preface" and has also met a number of new demands arising from major government policies. These included the economic statement of 1984, which introduced budget reductions and required the identification of Research Branch services suitable for cost recovery. The PCD acted to ensure that reductions in resources did not seriously curtail the capacity of the branch to maintain a viable level of research. Branch activities were reviewed at national and regional levels in order that low-priority programs could be identified from which resources could be reallocated.

PCD also played a major role in the initial meetings with members of the Ministerial Task Force on Program Review and in responding subsequently to recommendations for the reorientation of departmental programs toward market-oriented, commodity-based development strategies. PCD personnel, in cooperation with personnel from other branches, developed commodity strategy outlines for the department. Actions were recommended for addressing priority constraints and opportunities and for developing the various commodities, thus increasing market penetration. A new role is thus emerging for PCD in response to this reorientation of strategies within the department.

W. Baier
Acting Director General

POLICY, PLANNING, AND CONTROL

Corporate plan

The corporate plan for scientific research and development was prepared in response to the departmental strategic priorities. The development of a "national strategy for agricultural research and development" was proposed, which includes a vision of the future, research implications, and required management initiatives.

Response to the Ministerial Task Force

The Program Coordination Directorate played a major role in providing information to members of the study team on agricultural program review. The information included an overview of Research Branch operations, an outline of major program elements, and a listing of major clients.

The recommendations of the Ministerial Task Force relating to agricultural programs were reflected in the *Record of Decision* dated 20 May 1985. In June six departmental task forces were established, each including Research Branch representatives, to develop a detailed implementation plan.

In August 1985 the Program Coordination Directorate organized a Research Branch action plan process session, which formulated initial branch positions on the six dimensions of the strategic plan. Following this meeting, PCD established six parallel working groups to provide input to the departmental task forces. The report of the working groups elaborated specific action recommended by the action plan session and developed branch positions on issues raised by the Ministerial Task Force. This report was well received by the branch representatives.

Program specialists' meeting

The program specialists' meeting, held 7–8 August 1985, provided an excellent opportunity for regional representatives to meet with members of the directorate on issues of mutual concern, with emphasis on operational planning. It was evident that the focus of these meetings had changed from how information is reported (the process) to what should be reported.

Topics for discussion included the quarterly reports against goals, the management information system, international research and development (R&D), program reviews, economic regional development agreements, and cost recovery. The need for improved program coordination was identified and it was proposed that advisory committees be formed to assist in program coordination across the branch. It was also proposed that guidelines on priority setting and project selection be developed, based on practices already in place across the branch. The meeting supported the continuation and updating of the project inventory system.

Operational plan

The Program Coordination Directorate provided input to decisions on corporate planning processes through attendance at the Agriculture Canada regular operational planning (ACROP)

meetings and liaison with planning officers in the Finance and Administration Branch. These consultations ensured that the unique needs of the Research Branch were considered when operational planning policies and regulations were developed at the corporate level.

In preparation for the 1986–1990 planning process, guidelines and instructions for operational planning at the regional and establishment level were developed and distributed in cooperation with Branch Financial Management. Establishments proceeded with their long-range planning during the summer and early fall.

A new orientation for operational planning began to take shape, however, late in the year. Toward the end of 1985, a plan was prepared that was intended to be a bridge between the former planning process and the new shift to market-oriented commodity-based development strategies. This plan reflects both the research imperatives and new management initiatives and addresses departmental priorities as well as government priorities in general. Branch goals specific to the 1986–1987 planning period were also developed and modified in consultation with the regions. Regional planning would then follow in early 1986.

Operational reporting and control

Operational control model—development and testing. As part of the activities to complete the action plan for improved management practices and controls (IMPAC), which was established in response to requirements of the comptroller general, an operational control model was developed and tested. Atlantic Region Headquarters and the Fredericton Research Station, N.B., were the pilot areas. The model focused on measuring the productivity of resources and the rate of resource consumption.

This model was superceded by a broadened branch-wide project entitled "Decision Information Systems Project," which is to provide a solid base for more efficient and effective information systems as well as operational control. This project will include the development of business and information models and an inventory of current data bases and systems, cognizant of similar approaches being taken in other branches. The Program Coordination Directorate is playing an active part in this project through membership on the working group. A multi-year action plan will be prepared by 31 May 1986, with full implementation to be completed by 1990.

Electronic Data Processing (EDP). The Program Coordination Directorate provides leadership for branch EDP, which has become a widespread element of research operations. The advisory role of the Branch Information Systems Committee (BISC) has broadened to include management and operational information needs and systems, as well as EDP. BISC was instrumental in gaining a branch decision to upgrade the major Agrinet computer for the Research Branch, providing nearly four times the computing power. BISC also spearheaded the preparation of the information systems plan for the branch during the operational planning exercise. This branch plan is an element of the departmental information and technology systems plan (ITSP), submitted to Treasury Board each February.

The Research Branch continues to represent the department on the Interdepartmental Advisory Committee at the Department of Communications Workplace Automation Research Centre at Laval, Que. Submissions made in 1985 outlined several areas where Agriculture Canada and its clients could benefit from the application of emerging technologies like computer vision, expert systems, and computerized translation.

Reporting to Treasury Board and Parliament. The Program Coordination Directorate prepared the Research Branch sections in departmental reports to Treasury Board and Parliament, such as the *Multi-year Operational Plan* (MYOP), the *Main Estimates Part III* (ME), and the *Annual Report of the Minister*. These reports provide an opportunity for the branch to outline clearly its longer-range concerns, opportunities, and additional resource needs (MYOP), to document its planned expenditures for the coming year (ME), and to describe its achievements of the previous year (*Annual Report*).

Quarterly reporting. In support of the management accountability projects for operational information systems and performance measures (MAP-8), the Deputy Minister instituted in 1983 a quarterly report against goals for branch heads. This report would be used to inform the Deputy Minister and the branch heads of progress toward goals, and to provide a basis for periodic review and discussions with each branch head. A similar process for operational reporting was subsequently implemented at all management levels in the branch. The Program Coordination Directorate provided leadership in developing this process, and in 1985 the reporting system was firmly in place. The Research Branch quarterly reports have been well received at the corporate level and have provided excellent documentation for use in preparing briefings, reports, and other specialized material.

Research Highlights. PCD, in cooperation with the Communications Branch, assembled a

wide variety of press clippings on achievements and technology transfer in the Research Branch. This looseleaf volume has served as an immediate resource document for preparing reports and speeches and provides a quick overview of branch activities for visitors.

Progress in Research. The 1986 Centennial issue of *Progress in Research* was compiled by PCD from a large number of regional and establishment contributions. This documentation of outstanding achievements in the Research Branch over the past 100 years will serve as a lasting tribute to agricultural research in the department.

Directors' work-planning meeting

A directors' work-planning meeting, organized by the Program Coordination Directorate, was held in Ottawa on 20 November 1985. It followed a meeting of the Departmental Management Council, which served to update all managers on the activities in response to the Ministerial Task Force on Program Review and the related Cabinet decision. The implications of the proposals outlined at the management council in the six areas, i.e., commodity-based market-oriented development strategies, client consultation, corporate decision-making, legislative framework, fiscal framework, and human resources management, were discussed, along with the action that the Research Branch should take to respond to the proposed strategies. Other sessions dealt with management, program coordination, and current issues of significance to the Research Branch.

Input to policy, planning, and program development

An audit report of the branch crop production development research (CPDR) program was received, comments were solicited, and an implementation plan was prepared in response to the seven recommendations. The audit found that the CPDR program was soundly conceived and cost effective and that it should continue to be supported by the federal government. The audit recommended the need for policies on contracting-in, stronger priority-setting mechanisms, greater economics support, effective national coordination of research, and greater recognition and reward for technology transfer.

Directorate personnel provided significant input to the initial identification and outlines for market-oriented commodity-based development strategies for a number of sectors including cereals and oilseeds, horticultural crops, and special crops. Input to these strategies is ongoing.

Interbranch and interdepartmental activities

PCD is chairing an interbranch committee on Canamais, which is developing a release policy for corn inbreds developed by the Research Branch. The policy will provide for fair and equitable release of inbreds to seed firms operating in Canada, provide for the collection of royalties, and protect these inbreds in foreign countries.

The directorate represented the branch on the Interbranch Steering Committee for Commodity Strategies. Based on this steering committee's decision, directorate personnel, in cooperation with personnel from other branches, developed commodity strategies for the department in which action was recommended for addressing priority constraints and opportunities that would support development of specific commodities and increase access to markets. Research, regulatory and marketing constraints, and opportunities were addressed in strategies for apples, blueberries, storable vegetables, pulse crops, cut flowers, and grapes and wine.

PCD has performed leadership roles on the Canada Committee on Crop Production Services and on expert committees on weeds, horticulture, and plant gene resources.

In addition to strategic initiatives within the department, directorate personnel provided significant input into the development of an implementation action plan in response to "A Strategy for Research and Development in Horticulture" in Canada, approved by CASCC.

Extramural activities

Consultation and advice on crop production were provided through representation on committees and advisory boards, such as the Eastern Grain Standards Committee, which allowed the concerns of branch scientists to be considered in the setting of standards for grain produced in eastern Canada; and Canada Grains Council, which did a study of agricultural research in Canada.

The directorate represented the branch on the Steering Committee for Seed Potato Management Review and on the advisory board of the New Crop Development Fund, which allocates funds to organizations attempting to initiate or expand production of new crops.

Communication between the Research Branch and the seed industry is maintained through PCD membership in the SeCan Association and the Canadian Seed Grower's Association.

Directorate personnel, together with representatives of other branches of Agriculture Canada, met with personnel from a number of industries

(such as processing, floriculture, and nursery) to discuss the needs and priorities of industry as well as the services offered by government.

The Canadian section of the publication *Horticultural Research International* was updated in 1985. This publication is a directory of horticultural research institutes and their activities in numerous countries throughout the world.

Directorate personnel continued cooperation with the Canadian Horticultural Council in the publication of a report that includes summaries of horticultural research carried out at all federal and provincial government establishments and at universities in Canada.

Canada continued to support the International Board for Plant Genetic Resources (IPBGR). The Program Coordination Directorate has represented Canada on the board for the past 6 years. The board's function is to promote and coordinate an international network of genetic resource centers to further the collection, conservation, documentation, evaluation, and use of plant germ plasm. Canada carries the responsibility for storing the international base collections of oats, barley, oilseed *Brassica* spp., and millets, and works closely with the IBPGR and the U.S. National Plant Germplasm Committee.

ANIMAL PRODUCTION

Input to policy, planning, and program development

An evaluation of the animal productivity research program was conducted by the Audit and Evaluation Branch. The findings were consistent with the recommendation from the Ministerial Task Force and from the external review committees. The evaluation recommended that a benefit–cost analysis be undertaken to determine the performance of the program during the past 15–20 years and indicated that the needs of the client are being well served by this program.

Dairy and swine programs were reviewed by external committees made up of representatives from universities, industry, and the provincial governments. These established the base for national coordination of the programs. Implementation plans were prepared by PCD. Program reviews of poultry and sheep research were deferred pending the development of market-oriented commodity-based strategies. The current plan is to review these programs during 1986.

As input to the Ministerial Task Force, a plan was proposed for the consolidation and streamlining of the animal productivity program in fewer establishments and for the establishment of centers of excellence based on commodities.

Interbranch and interdepartmental activities

PCD assisted the Marketing and Economics Branch to develop strategies on dairy, pork, and turkey marketing. The results will assist the department in the development of market-oriented commodity-based strategies and should assist the Research Branch in targeting animal programs and projects.

Extramural activities

PCD has played a major role in ensuring continued cooperation and consultation between the Research Branch and the Dairy Farmers of Canada, the Canadian Pork Council, the Canadian Cattlemen's Association, and the Canadian Sheep Council.

NATURAL RESOURCES

Input to policy, planning, and program development

PCD contributions to the departmental plan for resource sustainability and enhancement emphasized due regard for the technical constraints on producers, as well as the processes and roles in program delivery. The importance of cooperative producer-centered programming and provincial extension was stressed, with appropriate emphasis on long-term stability of the resource base and the natural environment, in addition to short-term economic feasibility of conservation measures.

Contributions to strategic planning included injection of a resource base and research viewpoint into the formulation of plans to implement the recommendations of the Ministerial Task Force on Program Review. An independent external viewpoint was provided to the action plan on regulation and inspection programs.

New research needed in natural resources was recently identified by both client groups and specialists. They used the national committees under the Canadian Agricultural Services Coordinating Committee (CASCC), a major review of Atlantic Region programs, briefs to parliamentary committees, and a number of regional conferences as sources of information for recommendations. These submissions were evaluated by PCD and led to significant reallocation of resources from lower priorities, although completion has been delayed by fiscal restraints.

Interbranch and interdepartmental activities

Positions on natural resources issues were developed as a basis for advice for branch and

department action. Prominent issues in 1985 included the development of departmental and national strategies for soil and water, the implementation of a $30 million federal–provincial agreement on a soil and water environmental enhancement program (SWEEP) for southwest Ontario, and the development of a strategy for the reorientation of Agriculture Canada to a development approach. National issues dealing with the conflict between land drainage for agriculture and environmental goals and the impact on agriculture of recommendations of the Pearse inquiry on federal water policy were also studied and advice was provided. Regional issues dealing with the feasibility of further irrigation development in western Canada and the need to reduce agricultural nonpoint sources of pollution in the Great Lakes were addressed. PCD provided input to the development of a project sponsored by the Organization for Economic Cooperation and Development (OECD) to reconcile agriculture and environmental policies.

The positions of the department on several of these issues were raised for discussion on the interdepartmental committees for land, water, space research, and long-range transport of air pollutants (LRTAP). The agricultural viewpoint was thus assured circulation and benefited from detached cross-sector discussion.

A symposium presentation was made by PCD on behalf of the department on "Land Resources for Feeding a Hungry World."

Support to CASCC

In addition to the normal consultations under CASCC and its research recommendations, a secretarial and leadership function was provided by PCD to the Canada Committee on Land Resource Services. This included an update of the *1981 Strategy for Land Resource Research*, outlining positions of provinces and federal agencies. It will be published in 1986 under the title *Land—A Fragile Resource: New Goals for Agricultural Land Research* and should influence the setting of research priorities, as did the earlier report.

Extramural activities

Canadian space program. The Research Branch was represented by the Program Coordination Directorate on the Interdepartmental Committee on Space, which is attempting to develop a balanced Canadian space program. The department has developed specific plans in the area of remote sensing and crop information systems. Funding is under Cabinet consideration.

Acid rain. As a member of the Interdepartmental Committee on Acid Rain and two of its subcommittees, the directorate participated in numerous government activities involving assessment of the problem and the development of policies.

Technology centers. The directorate has been involved in interdepartmental consultations and studies resulting in a Cabinet decision on a new policy on technology centers. Detailed plans are yet to be developed on the implementation of the policy.

Climate. The directorate has been concerned with the impact of climatic change on agriculture and took part in developing interdepartmental programs to study the various aspects of the issue.

Science policy. PCD has provided senior management with advice and analyses concerning scientific issues affecting the department. The directorate represented the department in many science-related activities and maintained liaison with central agencies and other science departments.

Memorandum of understanding with the National Research Council (NRC). Details are being worked out to formalize the working arrangement with NRC for cooperative research on agricultural-related areas.

ANIMAL AND CROP PROTECTION

Input to policy, planning, and program development

A work-planning meeting on pest management, organized by PCD personnel, was held on 7–8 May 1985. Participants at the meeting included representatives of the agri-food industry from the federal and provincial governments, universities, and the private sector. More than 40 papers provided before the meeting were used as background material in the preparation of a comprehensive discussion paper entitled "Towards an IPM Strategy for Canada." It summarized discussions that took place at the meeting and gave recommendations for follow-up action.

PCD is chairing a branch steering committee on integrated pest management (IPM), which has developed an action plan to establish multidisciplinary working groups that will accelerate the development of IPM systems based on commodity–pest complexes and regional priorities.

Interbranch and interdepartmental activities

PCD personnel provided significant input in response to the need for a corporate plan on management of toxic chemicals. Specifically,

proposals were made to further support research aimed at developing alternative control methods to chemical pesticides. Furthermore, PCD provided input into enhancing the development of the departmental minor use of pesticides program and the Agriculture Canada pesticide information system.

The directorate provided input into the Audit and Evaluation Branch's plant health and input assurance evaluation study and into Agriculture Canada's plant pest emergency system.

Support to CASCC

PCD provided leadership for the Expert Committee on Insect Pests of Animals, which proposed a review of biting fly research in Canada, and also for the Expert Committee on Vertebrate Pests.

Extramural activities

In its role of providing liaison for the Commonwealth Agricultural Bureaux (CAB), the directorate provided leadership for the Canadian delegation at the 5-year review conference of CAB, and coordinated biological control research in cooperation with the Commonwealth Institute of Biological Control.

In cooperation with the provinces of Saskatchewan and Ontario and with the United States authorities, PCD was instrumental in establishing research projects to determine the impact of acarine mites on honey bees under Canadian climatic conditions, a subject that was identified as top priority by the Canadian Honey Council.

PCD represented the branch at international meetings in Washington, Tampa, and London, on matters relating to integrated pest management, biological control, and apiculture research.

FOOD AND NUTRITION

Input to policy, planning, and program development

A work-planning meeting on meat quality was organized in collaboration with research scientists at Lacombe Research Station. In addition, input was given to the national swine program review.

An evaluation of the food research program was conducted by the Audit and Evaluation Branch and PCD was involved at the evaluation review stage. Action has been initiated on some of the recommendations from this review.

Input has been provided to a number of working groups preparing policy and research plans relating to food irradiation, nutrition, meat, and canola.

Interbranch and interdepartmental activities

Input was provided to the Marketing and Economics Branch for the development of a strategy for grape and wine commodities.

PCD has been actively involved in the promotion of the new Saint-Hyacinthe Food Research Centre, which is to be completed in 1986 at a cost of $36.7 million. The centre will be industry-oriented and priority will be given to the use of the facilities by industrial R&D personnel and for projects with high value-added potential.

Committee functions have been performed relating to CODEX alimentaries; food irradiation labeling; nutrition labeling; pale, soft, and exudative pork; and a number of other food-related subjects.

Extramural activities

Technical expertise was provided to the Department of External Affairs on a mission to southeast Asia to promote Canadian irradiation and technology. Assistance was provided to both the beef and pork industries for the collection of up-to-date nutrient data.

INTERNATIONAL RESEARCH AND DEVELOPMENT

Research Branch scientists participate in a wide range of international science and technology exchanges with agricultural research institutes around the world. The branch also supports departmental objectives in the development, maintenance, and expansion of export markets through the provision of technical expertise to other branches and outside agencies. In addition, the branch contributes to technological advancement in less-developed countries by encouraging its scientists to participate in development assistance programs and by training foreign scientists in Canada. Canadian agricultural research managers also keep in touch with their colleagues in other industrialized nations through international consultations, such as the Tetrapartite Meeting of National Research Directors involving the United Kingdom, United States, France, and Canada.

All these activities are coordinated across the branch by the international research and development component of the Program Coordination Directorate. During 1985, bilateral and multilateral relations were coordinated with some 55 countries and international agencies in order to enhance our domestic research capability and to ensure that Canadian government policies on agricultural science and technology are supported and encouraged internationally.

Many of the branch's international bilateral exchanges come within the framework of seven departmental memoranda of understanding with ministries of agriculture in other countries (Brazil, China, Israel, Mexico, Romania, Yugoslavia, and the U.S.S.R.) and several formal agreements for science and technology exchanges between the Government of Canada and governments of other countries (Belgium, France, Federal Republic of Germany, Japan, Switzerland, and the United Kingdom). During 1985, the directorate became heavily involved with compiling and documenting research proposals and in negotiating cooperative research programs with China and the U.S.S.R. Other coordination activities included monitoring international program development and implementation under all bilateral agreements, and reporting to the Branch Management Committee on a regular basis.

The interests of the branch concerning multilateral policies were presented by the directorate at interbranch and interdepartmental committees for international agencies such as the Food and Agriculture Organization (FAO), OECD, and Consultative Group on International Agricultural Research (CGIAR). Branch involvement in official development assistance programs was also coordinated by the directorate. In 1985, the branch, under the authority of the Canadian International Development Agency (CIDA), established five new projects in Brazil and supplied scientific expertise to CIDA and the International Development Research Centre (IDRC) for a wide range of foreign assignments.

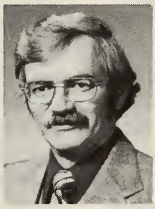
The directorate assisted branch scientists in obtaining special funding for international exchanges through application to sources such as the Export Expansion Fund and the Catalytic Seed Fund.

The branch has provided specialists to solve technical problems related to international marketing and for promotional activities such as technical seminars and trade expositions (e.g., Ag China 85). These arrangements were coordinated through the services of the Program Coordination Directorate.

Institutes Directorate
Direction des Instituts

R.L. Halstead

E. Larmond



D.G. Proctor

Acting Director General *Directeur général intérimaire*	R.L. Halstead, B.S.A., Ph.D.
Program Specialist *Spécialiste en programmes*	E. Larmond, B.Sc.
Chief, Administration *Chef de l'administration*	D.G. Proctor

PREFACE

The Institutes Directorate, located at the Central Experimental Farm in Ottawa, consists of the Biosystematics Research Institute (BRI), Chemistry and Biology Research Institute (CBRI), Engineering and Statistical Research Institute (ESRI), Food Research Institute (FRI), Land Resource Research Institute (LRRI), and Research Program Service (RPS). In 1985 the institutes' programs were conducted by a staff of 580 with a budget of $35 million. All the institutes combine active research on national programs with service to regional stations or to the public in specialized areas of their research. Significant research accomplishments are highlighted in the reports of the individual establishments.

The Biosystematics Research Institute provides Agriculture Canada and other departments, agencies, and their clients with a unique center of systematic expertise for dealing with economic and social problems relating to insects, mites, spiders, plant parasitic nematodes, weeds, crop plants, native plants, plant parasitic and biodegrading fungi, and nonmedical bacteria. As the only Canadian organization with comprehensive collections, systematic research, and identification expertise, BRI continues to provide all systematic services to support production and resource protection for two major Canadian industries, agriculture and forestry. Research activities have been progressively realigned in response to demands in areas such as integrated pest management, environmental protection, and biotechnology.

The program of the Chemistry and Biology Research Institute concentrates on biotechnology, preservation of natural resources, environmental protection, and food safety. Some of the applications in these areas are soil conservation, nitrogen fixation, mycotoxin research, and stress physiology. It also provides services in analytical chemistry and electron microscopy to other branch establishments.

The Engineering and Statistical Research Institute provides the Research Branch with a center of expertise where engineers and statisticians carry out research and analyses to improve agricultural and food production and inspection systems and to support research by other disciplines.

The aim of the Food Research Institute is to assist the Canadian food industry become more efficient, productive, and competitive by developing new processes and prototype ingredients and by improving the quality, safety, and nutritive value of food. The research programs on processing technology, dairy technology, structure and sensory evaluation of food, and food safety and nutrition are geared to the needs of the food industry and the concerns of the consumer.

The activities of the Land Resource Research Institute include research, development, and services related to Canada's land resources. The institute provides leadership and is responsible for the following national programs: soil inventory, Canada soil inventory system, soil taxonomy and interpretation, soil degradation, land evaluation, crop information system, and agroclimatic resources.

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

In February, Dr. J.W. Morrison, director general, retired from the Public Service and Dr. R.L. Halstead assumed the responsibilities of director general of the Institutes Directorate. Mr. Yves Bélanger 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 enquiries to Institutes Directorate, Research Branch, Agriculture Canada, Room 2077, K.W. Neatby Building, Ottawa, Ont. K1A 0C6.

R.L. Halstead
Acting Director General

PRÉFACE

La Direction des instituts, située à la Ferme expérimentale centrale d'Ottawa, comprend l'Institut de recherches biosystématiques (IRB), l'Institut de recherches chimiques et biologiques (IRCB), l'Institut de recherches techniques et statistiques (IRTS), l'Institut de recherches sur les aliments (IRA), l'Institut de recherches sur les terres (IRT) et le Service aux programmes de recherche (SPR). En 1985, les effectifs de 580 employés ont réalisé les divers programmes des instituts grâce à un budget de 35 millions de dollars. Tous les instituts exercent à la fois des activités de recherches dans le cadre des programmes nationaux et offrent des services dans leurs spécialités respectives aux stations régionales ou au grand public. Les rapports de chaque établissement font état des réalisations importantes en matière de recherche.

L'IRB constitue pour Agriculture Canada, d'autres ministères et organismes et leurs clients, un centre unique de connaissances spécialisées dans l'étude des problèmes économiques et sociaux reliés aux insectes, aux acariens, aux araignées, aux nématodes parasites des plantes, aux mauvaises herbes, aux plantes cultivées, aux plantes indigènes, aux champignons parasites des plantes et biodégradants, et aux bactéries dépourvues d'intérêt médical. Grâce à ses collections complètes, à son service d'identification et à sa capacité de recherches systématiques, l'IRB est en mesure de dispenser aux deux grands secteurs canadiens que sont l'agriculture et les forêts tous les services pertinents nécessaires dans le cadre de la production et de la protection des ressources.

Les activités de recherches ont été progressivement réorientées face à la demande dans des domaines comme la lutte antiparasitaire intégrée, la protection de l'environnement et la biotechnologie.

L'IRCB met l'accent sur la biotechnologie, la conservation des ressources naturelles, la protection de l'environnement et la salubrité des aliments. La conservation des sols, la fixation de l'azote, les mycotoxines et la physiologie du stress retiennent surtout l'attention. L'Institut offre en outre des services de chimie analytique et de microscopie électronique aux autres établissements de la Direction générale.

L'IRTS constitue pour la Direction générale un centre de connaissances spécialisées où des ingénieurs et des statisticiens effectuent des recherches et des analyses pour améliorer la production agro-alimentaire et le système d'inspection, et pour appuyer la recherche effectuée par d'autres secteurs.

L'IRA a pour mandat d'aider l'industrie alimentaire canadienne à devenir plus efficace, plus productive et plus concurrentielle en mettant au point de nouveaux procédés et ingrédients, ainsi qu'en augmentant la qualité, la salubrité et la valeur nutritive des aliments. Les programmes de recherches sur la technologie de la transformation, la technologie laitière, l'évaluation structurale et sensorielle des aliments, la salubrité des aliments et la nutrition tiennent compte des besoins de l'industrie alimentaire et des préoccupations des consommateurs.

L'IRT s'occupe de recherche et de développement et offre des services reliés aux ressources en terre du Canada. Il joue un rôle de chef de file et est chargé de l'exécution des programmes nationaux dans les domaines de la prospection pédologique, du système canadien d'inventaire des sols, de la taxonomie et de l'interprétation des sols, de la dégradation des sols, de l'évaluation des terres, du système d'information sur les cultures et des ressources agro-climatiques.

Le SPR offre divers services spécialisés aux établissements de la Direction générale de la recherche et aux chercheurs en agriculture aux échelons universitaire, provincial et fédéral.

En février, M. J.W. Morrison, directeur général, a pris sa retraite et M. R.L. Halstead a accédé au poste de directeur général de la Direction des instituts. M. Yves Bélanger a été nommé directeur du SPR.

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

R.L. Halstead
Directeur général intérimaire

Biosystematics Research Institute, Ottawa, Ontario

PROFESSIONAL STAFF

G.A. Mulligan, B.Sc.	Director
I.M. Smith, B.Sc., Ph.D.	Assistant Director
E. Gavora,[1] I.N.G., B.L.S.	Librarian, Botany
M.-J. Boisvenue,[1] B.Sc., M.Bibl.	Librarian, Entomology
S. Allyson, B.Sc., M.Sc.	Manager, National Identification Service, Zoology
P.M. LeClair	Manager, National Identification Service, Botany
A. Giroux	Administrative Officer

Arachnida and Diptera

C.D. Dondale, B.Sc., M.Sc., Ph.D.	Head of Section; Araneae (spiders), Opiliones (harvestmen)
V.M. Behan-Pelletier, B.Sc., M.Sc., Ph.D.	Oribatei (oribatid mites); Unit Curator of Arachnida
A. Borkent, B.Sc., M.Sc., Ph.D.	Program Leader, Diptera; Cecidomyiidae (gall midges), Ceratopogonidae (biting midges)
E.E. Lindquist, B.Sc., M.Sc., Ph.D.	Acari (mites and ticks)
D.R. Oliver, B.A., M.A., Ph.D.	Chironomidae (chironomid midges)
I.M. Smith, B.Sc., Ph.D.	Eriophyoidea (rust and gall mites), Hydrachnida (water mites)
H.J. Teskey, B.Sc., M.S.A., Ph.D.	Unit Curator of Diptera; Tabanidae (horse flies and deer flies)
J.R. Vockeroth, B.A., M.A., D.Phil.	Syrphidae (flower flies), Scatophagidae (dung flies)
D.M. Wood, B.A., M.A., Ph.D.	Tachinidae (parasitic flies), Culicidae (mosquitoes)

Coleoptera, Lepidoptera, and Trichoptera

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

Hemiptera, Hymenoptera, and Nematoda

R.V. Anderson, B.A., M.S., Ph.D.	Head of Section; Unit Curator of Nematoda Hoplolaimidae (spiral nematodes), Tylenchorhynchidae (stylet nematodes), Aphelenchoidea (foliar nematodes)
J.R. Barron, B.Sc., M.Sc., Ph.D.	Ichneumonidae
B.A. Ebsary, B.Sc., M.Sc., Ph.D.	Criconematidae (ring nematodes), Hemicycliophoridae (sheath nematodes)
R.G. Foottit, B.S.A., M.Sc., Ph.D.	Unit Curator of Hemiptera and Miscellaneous Insect Orders; Aphids, scales, and thrips
G.A.P. Gibson, B.Sc., M.Sc.	Chalcidoidea (chalcid wasps)
H. Goulet, B.A., B.Sc., M.Sc., Ph.D.	Symphyta (sawflies)
K.G.A. Hamilton, B.S.A., M.Sc., Ph.D.	Cicadellidae (leafhoppers), Cercopidae (spittlebugs)
L. Masner, B.Sc., M.Sc., Ph.D.	Proctotrupoidea (proctotrupid wasps), Sphecoidea (digger wasps), Evanioidea (ensign wasps); Unit Curator of Hymenoptera
W.R.M. Mason, B.Sc., Ph.D.	Braconidae (braconid wasps)
M.J. Sharkey, B.Sc., M.Sc., Ph.D.	Program Leader, Hymenoptera; Braconidae (braconid wasps)
C.M. Yoshimoto,[2] B.A., M.Sc., Ph.D.	Chalcidoidea (chalcid wasps), Cynipoidea (gall wasps)

Mycology

G.A. Neish, B.Sc., Ph.D.	Head of Section; Mycotoxin fungi
D.J.S. Barr, B.Sc., M.Sc., Ph.D.	Zoosporic parasites of vegetable crops
J.D. Bissett, B.Sc., Ph.D.	Conidial parasites of forage crops
M.P. Corlett, B.A., M.A., Ph.D.	Ascocarpic parasites of fruit crops
Y. Dalpé, B.Sc., M.Sc., D.Sc.	Mycorrhizae
J.H. Ginns, B.Sc., M.Sc., Ph.D.	Basidiocarpic tree wood rots
S.A. Needham, B.A., B.Sc.	Curator of the National Culture Collection of Fungi and Nonmedical Bacteria
J.A. Parmelee, B.Sc., M.A., Ph.D.	Obligate parasites of plants (rusts, smuts, mildews); Curator of National Mycological Herbarium
S.A. Redhead, B.Sc., M.Sc., Ph.D.	Mushrooms
R.A. Shoemaker, B.S.A., M.S.A., Ph.D.	Ascocarpic parasites of cereals

Vascular Plants

B.R. Baum, M.Sc., Ph.D., F.R.S.C.	Head of Section; Cultivated crops, *Hordeum*
G. Baillargeon, B.S.A., M.Sc.	Cultivated crops, *Brassica*
I.J. Bassett, B.A.	Hay-fever plants, palynology, weeds
P.M. Catling, B.Sc., Ph.D.	Sedges, aquatic plants
J. Cayouette, M.Th., M.Sc., Ph.D.	Grass flora of Canada
C.W. Crompton, M.Sc.	Weed biology—taxonomy and palynology
W.J. Cody, B.A.	Curator of Agriculture Canada Vascular Plant Herbarium; Canadian flora, ferns
G.A. Mulligan, B.Sc.	Weeds, Cruciferae
E. Small, B.A., B.Sc., M.Sc., Ph.D.	Cultivated crops, *Medicago*
A.E. Stahevitch, B.Sc., M.Sc., Ph.D.	Weeds, cytotaxonomy
S.I. Warwick, B.Sc., Ph.D.	Weeds, genecology

Departures

R. Matsuda, B.A., Ph.D., D.Sc. Retired	Comparative morphology and evolution
J.F. McAlpine, B.S.A., M.Sc., Ph.D. Retired	Lonchaeidae (lance flies), Chamaemyiidae (silver flies)
B.N.A. Hudson, B.Sc., Ph.D. Seconded to Program Coordination Directorate	Chemical taxonomy of insects, polymorphic enzymes
G.P. Holland, B.A., M.A., D.Sc. Died 9 November 1985	Honorary Research Associate

HONORARY RESEARCH ASSOCIATES

E.C. Becker, B.Sc., M.Sc., Ph.D.	Elateridae (click beetles, wireworms)
S.J. Hughes, B.Sc., M.Sc., D.Sc., F.R.S.C.	Conidial molds of wood and insects
L.A. Kelton, B.S.A., M.Sc., Ph.D.	Miridae (plant bugs), Anthocoridae (flower bugs)
R. Matsuda, B.A., Ph.D., D.Sc.	Comparative morphology and evolution
J.F. McAlpine, B.S.A., M.Sc., Ph.D.	Lonchaeidae (lance flies), Chamaemyiidae (silver flies)
W.C. McGuffin, B.A., M.A., Ph.D.	Geometridae (geometer moths, loopers)
D.B.O. Savile, B.S.A., M.Sc., Ph.D., D.Sc., F.R.S.C.	Plant rusts
G.E. Shewell, B.Sc., M.Sc.	Lauxaniidae (lauxaniid flies), Calliphoridae (blow flies)

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]Seconded from Canadian Forestry Service Branch, Agriculture Canada.

INTRODUCTION

The Biosystematics Research Institute (BRI) provides Agriculture Canada, other departments and agencies, and their clients with a unique center of systematic expertise for dealing with economic and social problems relating to insects, mites, spiders, plant parasitic nematodes, weeds, crop plants, native plants, plant parasitic and biodegrading fungi, and nonmedical bacteria. It provides Canadians with an expert team of scientists and technicians that maintains and updates an information system ensuring that the identities of any of these organisms can be determined accurately, and that appropriate data on their biology and impact are quickly available. It is a vehicle for the flow of biosystematic information nationally and between Canada and other countries. The following broad aims guide the Biosystematics Research Institute in its operations: to conduct research to discriminate and correctly name organisms that occur in Canada or are otherwise of importance to Canadians; to contribute to science and its uses by developing natural classifications and interpreting evolutionary relationships; to develop and maintain the national collections of living or preserved organisms from Canada and elsewhere to provide a reference base for biosystematic research on diversity and distribution, and for identification purposes; to provide a national identification service for clients, publish guides to help others make identifications, and supply relevant information; to provide inventories and floristic and faunistic studies for selected regions, habitats, or host groups to permit effective assessment and monitoring of environments, their quality, and their changes; to provide leadership and cooperation in the development of biosystematics in Canada by making expertise available for training and other educational purposes.

A publication titled *Systematics in Agriculture Canada at Ottawa 1886–1986/La recherche en systématique à Agriculture Canada, Ottawa, de 1886 à 1986* is available.

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

G.A. Mulligan
Director

COLLECTION DEVELOPMENT AND MAINTENANCE

The holdings of the Canadian National Collection of Insects, Arachnids, and Nematodes increased by 457 300 specimens during 1985, of which 198 400 specimens were curated. Major contributions were made by members of the institute collecting throughout Canada, northern United States, Costa Rica, and Nepal. During the summer of 1985, five institute scientists collected insects and arachnids in parts of western Canada and the Pacific Northwest, and scientists from the Coleoptera Unit conducted an intensive survey of the beetle fauna of Rondeau Park in southern Ontario. As part of ongoing research on the fauna of the Canadian Arctic and subarctic and their relationship with the fauna of adjacent areas, two institute scientists collected extensively in the Ogilvie Mountains, Yukon, and one scientist surveyed the insect fauna of the James Bay region of northern Quebec. A total of 19 600 specimens were purchased and 35 222 specimens were donated to the national collection in 1985, consisting of material from Canada, Alaska, southern United States, Mexico, and Chile, and a major collection of 100 holotypes, 25 paratypes, and 1720 named specimens of European Tachinidae. As a result of an exchange program established between the Coleoptera Unit and the Hungarian National Museum, the national collection received 655 species of Old World Curculionoidea. Requests for loaning of material from scientists throughout the world amounted to 209 loans of approximately 80 400 specimens. Many scientists and students from various parts of the world, including the United States, Australia, Japan, Czechoslovakia, Germany, England, and Finland, visited the Canadian national collection in 1985 to study and curate specific groups. The CanaColl Endowment Fund and the CanaColl Development Fund supported 12 visiting scientists who curated specimens of Hymenoptera, Coleoptera, and Diptera. As a result of these experts visiting the national collection, over 100 000 specimens of Ichneumonidae were curated; the holdings Empididae (Diptera), *Apamea* (Noctuidae, Lepidoptera), and Rhagidiidae (Acari) were curated and expanded; and the national collection of long-tongued bees is now the second-largest in North America. Preparation of

insect and arachnid specimens was carried out with the assistance of two persons employed under the training of handicapped program and six persons employed on the homebound handicapped program. This help allowed material to be prepared that could not have been done otherwise with our present staff. Growth of the national collection involved acquisition and curation of material required both for current research activities of institute scientists and for increasing representation of other groups of importance to Canadians.

New accessions for the Vascular Plant Herbarium numbered 9168 specimens bringing the total number of specimens in the collection to 772 248. About 3000 plant collections were made by staff members in the various Canadian provinces, the Mediterranean region, and Baja California. A total of 1829 specimens were received on exchange from Canadian and foreign correspondents and 145 specimens were received as gifts. We received 7671 specimens in 85 loans from cooperating Canadian and foreign institutions and sent out 8246 specimens to 50 herbaria in Canada and abroad. Numerous visitors came to examine specimens in our herbarium in relation to their taxonomic, phytogeographic, and identification problems.

During 1985, the National Mycological Herbarium and the Vascular Plant Herbarium began their conversion from standard metal cabinets to a state-of-the-art, fully electrically operated compactor system for the storage of specimens. To accommodate this change some structural modifications were required to the Saunders Building. In addition, both of the herbaria were moved temporarily to storage facilities off the Central Experimental Farm campus. When the conversion is completed early in 1986, the housing capacity for specimens in the William Saunders Building will be doubled in the same floor area.

There were 2949 specimens added to the National Mycological Herbarium in 1985 and holdings now total 248 332 specimens. We received 258 specimens as gifts and sent 191 gifts to other institutions. As exchange material, we received 692 specimens. Some 379 specimens were sent on loan to 37 institutions and 38 institutions sent 449 specimens on loan to us based on our 65 requests.

The Canadian Collection of Fungus Cultures (CCFC) increased its accessioned holdings from 8828 to 9007. This increase was due mainly to material received through the National Identification Service, cultures received from other establishments, or isolations made by staff members. During 1985, 447 cultures were sent out in response to requests from scientists in Canada and throughout the world. This year the number of requests from abroad almost trebled at 300. This was due to the ever-increasing interest by researchers in the potential applications for fungal metabolites to food production and industrial technology (alternate energy sources). Twenty-five requests were received to deposit individual collections, ranging from 10 to 150 species, during 1985. Also, the CCFC requested 44 cultures for BRI projects from other major collections. Information on the entire collection was updated and listed in the World Data Centre's *Directory of Culture Collections* and in the new Canadian *Directory of Culture Collections*.

NATIONAL IDENTIFICATION SERVICE

A total of 1171 shipments of insects, mites, spiders, and nematodes were received by the National Identification Service, section Zoology, and 69 634 specimens were identified. The principal clients were Agriculture Canada (31%) and Canadian universities (19%). The remaining clients were other federal and provincial departments and agencies, the general public, and industry. Some of the Canadian research supported by the Zoology section of the National Identification Service included wheat blossom mite studies; insect pests of oilseed crops; canola insect survey; insect pests of sunflowers and their parasites; grass and legume forage crops survey; ecology and control of forage alfalfa insects; control of insect pests of legume crops; ecology of cutworms; biological control of weeds; ecology of stored grain insects; survey of stored-products mites; thrips vector of tomato spotted wilt virus; pest management of pome fruit pests; management of insects and related pests associated with apple; integrated control of orchard mites; insect pests of berry crops; survey of destructive and useful arthropods on strawberries; the cone and seed insects studies; control of red pine seed and cone insects; pine wood nematode survey; forest insect and disease survey; and nursery pest management. Adults and immature stages of Diptera were identified as part of forensic evidence obtained in two police investigations. Identifications were used to try and establish time of death.

During 1985, 13 393 collections of vascular plants were identified. Major users of the service were universities (34%) and Agriculture Canada (17%). Assistance was provided in the identification of weeds and native plants, as well as edible and poisonous plants. The identifications pro-

vided to agriculture research stations, universities, and other departments related to host plants of insect pests and plant pathogens, weed control practices in forest tree nurseries, biological control studies, the interception of imported plant materials used in commercial products and as food, the identification of pollen in honey samples for western producers, vegetation studies of acid rain national early-warning-system plots in the maritimes, northern wells pipeline monitoring, studies investigating waterfowl habitats, and an ecological study of permafrost–vegetation relationships. An increased number of inquiries were received from poison control centers for the identification of plants suspected of poisonings, and from Ontario Ministry of Agriculture and Food for the identification of crop weeds. Inquiries were received from the Forensic Laboratory of the Royal Canadian Mounted Police and from municipal police forces for identification of plant material used as exhibits in court cases.

A total of 3417 collections and cultures of fungi were identified during 1985. Principal users of the service were the general public (25%), Agriculture Canada (23%), and provincial departments (15%). An increased number of inquiries were received from poison control centers and hospitals for the identification of mushrooms suspected of poisonings. Assistance was provided on the identification of poisonous and edible fungi, mycotoxic fungi, molds isolated from building material, fungi used as biological control agents, contaminants of food, and diseases of crops, fruit trees, and ornamentals. Agriculture research stations, other departments, and universities from across the country received assistance in the identification of fungi relating to storage problems of wheat, cabbage, and carrots; postharvest decay of apples; mycotoxin problems with haylage and in cereal crops; fungi associated with seedling damping-off and the decay of budworm-killed balsam fir; entomopathogenic fungi in an insect-rearing laboratory; vomitoxin milling experiments; root diseases of pulse crops, vegetables, and cereals; crown rot of cucumbers and tomatoes; a mildew study of spring wheat; fungal decay of hydro poles; seedling blight of canola; snow mold on strawberries; various diseases of potatoes; molds on building materials suspected of causing health problems; and disease surveys from several provinces. Staff members again provided assistance to western research stations and growers in the screening of leafcutter bee cocoons for the presence of chalkbrood. Information was also provided to the Toronto Police Department in a court case involving the growing of hallucinogenic mushrooms.

RESEARCH AND TECHNOLOGY TRANSFER

Insects, mites, spiders, and nematodes

Hemiptera. Research on members of the aphid genus *Cinara* attacking pine, using an electronic digitizing system for collecting morphometric data from microscope images, facilitated the discovery of additional species complexes. These findings have now more than doubled the known number of species. Nearing completion is a handbook on the 185 genera of aphids in Canada, for which 80% of the text and illustrations have been prepared. A significant identification was the first finding of the western flower thrip, *Frankliniella occidentalis* (Pergande), attacking greenhouse crops in southern Ontario. Subsequent identifications of this important vector of plant diseases, previously known only in western Canada, has shown that it is now spreading in greenhouses throughout eastern Canada, including the Maritimes. Published systematic studies on leafhoppers in Canada established eight new species. Most significant was the resolution of a species complex, which made it possible to identify for the first time a cryptic, introduced European pest of economic importance. A major handbook of the leafhoppers in Canada and the northern United States is in preparation and will include 266 species of 49 genera and most pests of trees. Chapters completed incorporate synopses of the evolutionary history, biogeography, life history, behavior, parasitism, and morphology of these pests. Analyses of climatic and distributional data suggest that primitive leafhoppers evolved with flowering plants, whereas modern genera evolved with boreal fauna and by isolation of neotropical from old-world faunas. Modern leafhoppers are limited mainly in ranges by host-plant distribution, aridity, length of growing season, snow cover, and duration of high summer. Analysis of leafhoppers from grasslands at Windsor, Ont., and Great Cloche Island confirms that these relict grasslands do not represent modern introduction of western grasses. A catalog of the world fauna of leafhoppers described or revised since 1955 has been prepared on file cards, listing about 8000 new names, 2000 new combinations, 900 new synonymies, and 44 new homonyms.

Hymenoptera. Research concentrated on systematics, morphology, phylogenetic relationships, natural classifications, and identification of parasites of biocontrol application. Comparative morphological studies of the prothorax and mesothorax of Hymenoptera helped standardize inconsistent terminology and presented new evi-

dence for correct higher classification of the order based on inferred relationships between taxa. A new species of the parasitic wasp, *Bassus arthurellus* Sharkey, was described, making the name available for studies currently underway on the natural control of pests of sunflower. The genus *Bassus* was resurrected and split from its sister genus *Agathis*, based on shared derived characters. The 11 world families of the wasps in the superfamily Proctotrupoidea were reviewed, their phylogenetic relationships discussed, and character states tabulated and analyzed. A new family, Peradoniidae, comprising two new species was proposed and placed in a new diagnostic key to the proctotrupoid families. The first annual workshop on identification of Hymenoptera was held in Ottawa. Eighteen participants from forestry, agriculture, universities, and the private sector were present, representing institutes and research stations across Canada. In conjunction with this workshop, a comprehensive manual of the Hymenoptera of Canada was prepared to aid workers in identification. Also, an invited 1-week workshop on the parasitic Hymenoptera attacking leafmining pests was given at the University of Florida. Coordinated curatorship efforts resulted in a substantial increase in the holdings and value of the Hymenoptera collection. Added to the collection were over 268 000 named specimens from Canada and many parts of the world. Published was a catalog of the primary types of Braconidae housed in the Canadian national collections.

Diptera. A search extending over several decades for the early larval stages of a primitive black fly, *Parasimulium stonei* Peterson, met with success. The larvae were found in remote mountainous localities in northern California and Oregon, and a description was submitted for publication. Their structure suggests that the genus *Parasimulium* occupies a significant position close to the base of black fly phylogeny. In the cecidomyiid gall midges, a highly specialized symbiotic relationship was discovered to exist between the adults of certain species and a fungus. The midges carry the fungal spores in a pocket on the abdomen and are believed to transmit them to a wide array of plant hosts ranging from grasses to composits. A project to revise the ceratopogonid (no-see-um) genus *Serromyia* was initiated; four new North American species were uncovered to date. Chironomid midges, which are one of the dominant insect groups in the Arctic region, are being investigated on a Holarctic basis. In a collaborative effort involving British, Scandinavian, and U.S. specialists, a key to the adult males of more than 80 genera was prepared and submitted for external review. In addition, an annotated list of 12 species of Chironomidae inhabiting Kongsoya, one of the arctic Spitzbergen islands, was prepared for publication; this resulted from receipt of a large collection of these insects received from the scientific leader of the Swedish 1980 Ymer Expedition to Kongsoya. One new genus of Chironomidae and eight of Lauxaniidae were described from the New World.

Coleoptera. A number of contributions were received for publication in the BRI handbook series. Preliminary or final drafts were received for the carrion beetles, jewel beetles, hister beetles, and scarab beetles. The first part of a three-volume work on the weevils of Canada and a bibliography of the bark and ambrosia beetles of the world containing 15 000 references was completed. A large manuscript describing the damage, geographic distribution, and biology of the destructive beetles of Canada (exclusive of the forest industry) was submitted for publication. Work is progressing on schedule for important books on the stored-products beetles of Canada, the beetles of arctic North America, a checklist of the beetles of Canada, and a handbook of the water scavenger beetles of Canada. Individual research publications included larval studies of 34 species of the ground beetle tribe Pterostichini, a description of *Atranus pubescens* (Dejean), and larvae of the leaf beetle genus *Cryptocephalus*. Studies of adults included publications revising the leaf beetle genus *Ophraella*, a revision of the 41 species of the water scavenger beetle subfamily Helophorinae, a review of the six species of the ground beetle subgenus *Pseudoferonina*, and a review of the New World species of the genus *Peplomicrus*. Four papers were accepted for publication or were published describing new species of the bark beetle genus *Pityophthorus*, two papers treated systematic problems in the family Alleculidae, one including a key to the North American genera of the family, and three papers were accepted dealing with systematic problems of the rove beetles.

Lepidoptera–Trichoptera. A key to the species of *Choristoneura* (spruce budworms) of Canada was published and the following papers were submitted for publication: a paper on caddisfly genera, "Considérations diverses sur quelques genres Leptocerins (Trichoptera, Leptoceridae);" part four of the geometrid subfamily Ennominae for the series *The Geometridae of Canada*; and three papers on the cutworms of northern Canada (a revision of the genus *Trichosilia*, a revision of the *Lasionycta leucocycla* species complex, and a paper on the identity of *Autographa ottolenguii* and the occurrence of a Siberian species, *Auto-*

grapha buraetica, in northern Canada). A monographic treatment of arctic Lepidoptera is on schedule.

Mites. Two major chapters were published as part of a new book entitled *Spider Mites: Their Biology, Natural Enemies and Control*. The book was published by Elsevier in the Netherlands and brings together the latest views of more than 50 specialists in many countries. One contribution deals in depth with anatomy, and the other with classification; both are strongly evolutionary in approach. Owing to the recent appearance in North America of the honey bee tracheal mite, *Acarapis woodi* (Rennie), and the potentially even more serious problem of *Varroa* mites to the honey industry, invitational lectures were given on these mites at the summer program of acarology at the Ohio State University (in addition to the regular course presentations) and at the annual meeting of the Ontario Beekeepers' Association. Topics included the biology, origin, and spread of the mites, their threat to the industry, and sampling and possible control methods. These mites have threatened honey production in parts of the United States and are now literally at the New York–Ontario border. Other lectures were presented at the Acarology Laboratory of the Faculty of Science, Universidad Nacional Autonoma de México; the talks dealt with the life history and classification of parasitic aquatic mites. This served to broaden the contacts between Canada and Mexico, and provided opportunities for technology transfer and professional encouragement. A manuscript entitled *Water Mites of Peatlands and Marshes in Canada* was submitted for publication as part of a memoir on the fauna of wetlands. A major paper, coauthored with Dr. R.A. Norton of the State University of New York, Syracuse, explores the systematic relationships of the oribatid genus *Propelops* and the family Unduloribatidae in North America. This is part of a project that is intended to culminate in a comprehensive illustrated key to the oribatid genera of this continent.

Spiders. Eighteen North American wolf spider species belonging to 11 species groups of the genus *Pardosa* were revised, and two manuscripts were submitted for publication. One of the species is new to science, and three new synonyms are proposed. This essentially completes revision of the genus *Pardosa* in America north of Mexico; a few difficult species from the Rocky Mountains remain to be revised. A new classification of the Lycosidae, or wolf spiders, was prepared for publication. The traditional subfamilies Lycosinae and Pardosinae are retained, the recently proposed Venoniinae is modified to include the genus *Pirata* and its relatives, and two new subfamilies are proposed for groups of New World genera.

Nematoda. Of major impact to the wood products industry in Canada was the identification of the pine wood nematode, *Bursaphelenchus xylophilus* (Steiner & Buhrer, 1934) Nickle, 1970, in southern Ontario. The species was found in large numbers in a dying red pine in each of three tree nurseries. Sexes were successfully mated with those of a known species from the United States, confirming the taxonomic affinities of the species. Cooperative work is planned with Plant Health Division, Forestry Insect and Disease Survey, Forestry Branch, and with Simon Fraser University to resolve problems in the identity, distribution, pathology, and genetics of this major pest and a closely related species in Canada. Results to date from extensive surveys by forestry in eastern Canada revealed a great diversity in other species associated with conifer wood. Represented are 23 genera of insect parasites and associates, most of which are previously unknown to occur in Canada. Published were nine new species of plant and free-living nematodes in Canada, a new genus, and a catalog of 4990 types of 396 species housed in the Canadian national collections. Studies completed on the stunt nematodes added an undescribed species to those known to occur in Canada and new diagnostic characters that facilitate their identification. In preparation for technology transfer are bulletins of the distribution of obligate plant-parasitic nematodes in Canada, the root-knot and cyst nematodes, and a checklist of the world plant, terrestrial, and freshwater nematodes.

Vascular plants

A summary of biological information was submitted for publication on two species of prickly nightshades: *Solanum carolinense* L. (horse-nettle) and *S. rostratum* Dunal (buffalobur). Horsenettle, a troublesome perennial weed in southern Ontario, is also an important host for insects and diseases of crop plants and is considered poisonous to livestock. Buffalobur, an annual, is also reported to be poisonous to livestock. Work continued on the mapping, illustrations, and text for the *Flora of the Yukon*. It is scheduled for completion in 1987. A monographic study of the genus *Sinapis* is near completion. Study of the wild material collected in Algeria has led to the recognition of a new species and to the reinstatement of two others; on the other hand, two Egyptian species have been found conspecific with *S. arvensis* L. and are now regarded as subspecies. An invited paper entitled *International Registra-*

tion of Cultivars with Emphasis on Barley: Procedures and Methods of Producing a Register was presented at the International Symposium on Taxonomy of Cultivated Plants in Wageningen, Netherlands, in August 1985. The paper will be published in the proceedings of the symposium. In a cooperative project the nomenclature of *Aegilops*, *Triticum*, and *Secale* and their hybrids has been clarified. A field trip to California, Arizona, and Baja California (Mexico) was conducted in May–June 1985 to collect germ plasm of various indigenous *Hordeum* species, and to study the species in the field. The *Hordeum pusillum* Nutt. group containing two species native to South America and two to North America were studied by morphometric analysis and numerical taxonomy. The characterization of species of *Hordeum* by using starch granules by means of techniques of image analysis is in progress. A paper was submitted comparing life history features and genetic variation as determined electrophoretically in nine recently introduced Canadian populations of the weed silky bent grass. These were compared with six native European populations. The results indicated considerable variability in the Canadian introductions, i.e. no bottleneck effects were apparent in this colonization event. A paper was submitted comparing rhizome depth and winterhardiness of rhizomes of two contrasting biotypes of a new problem weed in Ontario, Johnson grass. The overwintering success of one of the biotypes can be attributed to greater rhizome production at greater depths rather than inherent difference in rhizome tolerance to cold. Electrophoretic and growth trial studies were conducted on seven populations of giant foxtail from the northeastern part of North America. In contrast to striking differences in many life-history features, the populations showed little allozyme variation. Allozyme studies on 110 accessions of proso millet, including 39 weed and crop–weed accessions from North America and Europe and 71 crop accessions from two-world seed banks indicated very little variation in this crop–weed complex. The newly evolved weed strains of the species represent recent adaptive divergence in response to anthropomorphic selection. A paper was accepted which utilized electrophoretic techniques to test the validity of two conflicting taxonomic treatments of the annual North American members of the genus *Zizania* (wild rice). Allozyme data supported Dore's (1969) recognition of two species, *Z. aquatica* L. and *Z. palustris* L. Diagnostic enzyme markers were found for each species and have served as a useful taxonomic tool in identifying problem populations and in verifying F_1 hybrid production in artificial crosses. The results confirmed that the three commercial cultivars of wild rice have been developed from *Z. palustris* var. *interior* (Fassett) Dore. Two papers were accepted for publication which examined speciation events in the composite genus *Layia*. A paper was published reviewing the biology of a newly introduced weed of winter cereals in Ontario, silky bent grass. A paper was published that examined variation and climatic adaptation in northern populations of jimson weed. A paper was accepted for publication, which examined life history and allozyme variation in 39 populations of velvet leaf from northeastern North America. A systematic study examining hybridization and introgression among two thistle species, *Carduus nutans* L. and *C. acanthoides* L. in Grey County, Ont., was initiated. Taxonomic work on the alfalfa genus *Medicago* continued, with the goal of clarifying poorly understood groups in order to prepare a comprehensive revision. Studies of chloroplast DNA, seed ultrastructure, and biogeography proved useful in clarifying the evolution and taxonomy of the genus. Two invited review papers were prepared, and in these a new taxonomic system was proposed, expanding the genus *Medicago* to include about 90 species. Very small epidermal glands have proven to be of considerable importance in protecting wild alfalfa against insects, and in view of the potential economic importance of this for breeding resistant alfalfa, this aspect was intensively studied, with three papers prepared, describing the taxonomic importance of the glands in wild alfalfa (the *Medicago sativa* L. complex), in the closely allied *M. papillosa* Boiss. complex, and in seedlings of *Medicago* and allied genera. A 6-week collecting trip in Israel, Greece, Italy, and Spain resulted in the acquisition of over 400 stocks of seeds for research and for deposition in the germ plasm holdings of the department. A plan for studying the grass flora of Canada was submitted. An identification guide will be published, and studies on certain genus and species groups will be undertaken. Classification of the literature has started. To date over 1000 entries have been classified, and some 2000 distribution cards on more than 500 taxons of grass in Canada have been prepared. Some work is being done on the complex *Poa eminens* C. Presl–*labradorica* Steudel. Three articles on the chromosomes of *Carex maritimes* of the sections *Phacocystis* and *Cryptocarpae* (species and hybrids) have been accepted for publication or published. A study on *Carex lyngbyei* Hornem. in eastern North America was submitted for publication. It revealed that the species should be eradicated from the region. Crops are being examined for four other species and six different hybrids. Studies on the flora in

New Quebec, in cooperation with the Northern Studies Center at Laval University, Quebec City, have led to the preparation of three papers, which should be ready in 1986: flora of Lake Chavigny, of Raglan Mine, and the Manitounuk. An article dealing with new flora taxonomies in the region has been submitted and a study on the distribution of *Carex lapponica* O.F. Lang is almost ready.

A manuscript, *Preliminary Inventory of Canadian Weeds*, containing approximately 500 major Canadian weeds was completed and submitted for publication. It includes geographical distributions, life histories, bibliographical data, current scientific names and synonyms, the English and French sanctioned names, and other common names. Cytological studies carried out on 75 accessions of *Artemisia* species indicated that Canadian populations exhibit considerable dysploidy. *Hypericum spaerocarpum* Michx. from southwestern Ontario was recognized as new to Canada. Variants of this taxon occur weedy in the midwestern United States. Studies are being conducted on the species in Ottawa. A weed survey in western Canada was conducted in Alberta and British Columbia; in addition, honey producers and packers were visited in the vicinity of Edmonton and the laboratory at Calgary to discuss methods of honey palynology. An account of the vascular aquatic weeds of Alberta was prepared and two additional sections on aquatic plants were completed for the *Atlas of the Rare Vascular Plants of Ontario*, in cooperation with the National Museum. Identification and status were clarified in a group of prairie rushes (*Juncus* spp.) important as forage. A paper was completed on the sedge *Carex praegracilis* W. Boott, which is important in maintaining roadside vegetation cover because of its high salt tolerance. Other papers on sedges included one on additions to the sedge flora of Manitoba and another concerning the taxonomy of *Carex* sect. Paludosae, which includes the sedges that frequently dominate swamps and sloughs across Canada. A book entitled *Ontario Orchids* was modified for publication by Agriculture Canada. The book includes notes on the identification, ecology, and distibution of all 60 species found in Ontario ranging from weedy species of lawns to the very rare species protected under the *Ontario Endangered Species Act*. Two other papers were completed on the relationship between ecology, taxonomy, and breeding systems in the Orchidaceae.

Fungi

The *Compendium of Plant Disease and Decay Fungi in Canada*, an up-to-date reference book for plant pathologists, plant breeders, ecologists, and mycologists, is in press. The book contains about 30 000 entries and treats nearly 5700 names of disease and decay causing fungi in Canada. In addition, a floristic study of the parasitic fungi in the Yukon Territory was completed. It lists 283 fungal species, of which 31 species are new records for the Yukon. *Puccinia claytoniae* Thum., on *Claytonia arctica* Adams, was redescribed to include an aecial morph not previously known. The rust was described originally from a specimen collected on Wrangel Island in the Bering Sea but its geographic range probably extends into North America. Also, nine autoecious species of *Puccinia* on *Polemoniaceae* in North America were described and illustrated. Two varieties are described as new, each with geographically limited distributions, and two species are recognized as distinct, having been earlier regarded as synonyms of a third species, *Puccinia plumbaria* Peck. Descriptions of four cereal rusts, the leaf rusts of oats, barley, rye, and wheat, have been prepared and are in press. In collaborative mycotoxin research with Agriculture Canada scientists from other establishments, and with American and Canadian researchers, a new method for preparing deoxynivalenol (vomitoxin) from *Gibberella zeae* (rotted corn) was published; a study of the toxigenic potential of southeast Asian *Fusarium* species was completed; the first report of zearalenone production by *Fusarium crookwellense* Burgess et al. was published; a new method for the production and purification of moniliformin produced by *Fusarium* sect. *Liseola* Wollenw. et al. isolates was developed; and new data on the occurrence and toxigenic potential of *Fusarium* sect. *Sporotrichiella* Wollenw. isolates were obtained, which helped to explain the origin of the trichothecenes discovered in eastern Ontario corn in 1984. A *Canadex* bulletin was prepared on the epidemiology and control of histoplasmosis in Canada. Histoplasmosis is an opportunistic fungal disease in man and animals, endemic in central Canada, and most often associated with farming and construction occupations. Assistance was rendered to investigators and Crown prosecutors in Quebec and Ontario in two cases involving an imported illicit hallucinogenic mushroom, *Psilocybe cubensis* (Earle) Singer. Subsequently, expert opinion from a BRI scientist was sought in court in both cases. Mycological expertise also was provided for a project by Health and Welfare Canada, Health Protection Branch, establishing reference standards of allergenic potency for selected highly allergenic fungi. The Health and Welfare project is part of a larger World Health Organization project to establish reference standards for all types of al-

lergenic substances. Identifications of fungi from urea–formaldehyde foam insulation (UFI) samples submitted over a 6-year period by Consumer and Corporate Affairs, the National Research Council, Health and Welfare, the Ontario Ministry of Health, and private consultants were completed. A publication on these results will comment on the potential pathogenicity, toxicity, and allergenic status of fungi associated with UFI in Canadian residences.

A working collection of Endogonaceae in the National Mycological Herbarium, which did not exist 4 years ago, now includes more than 200 specimens representing 5 genera and 28 species. A project on the production of mycorrhizal apple trees has necessitated an inventory of Endogonaceae from orchard soil and permitted the evaluation of a taxonomic approach essential for the effective use of mycorrhizal fungi in the field. A similar inventory is being carried out in alfalfa and soya bean fields in eastern Canada. Previously unknown sporocarpic morphs of two species in the Endogonaceae, *Glomus etunicatum* Becker & Gerdemann and *Glomus clarum* Nicolson & Schenck, were redescribed, seven species belonging to the genera *Glomus* and *Aculospora* were observed for the first time in soil samples from Canada, and a new species of *Glomus* is being described. The culture collection of ectomycorrhizal basidiomycetes is growing and now comprises nearly 120 species in 26 genera. A major study comparing cultures of the North American species of *Hericium*, a genus of wood-rotting species, was published. It will aid in the identification of isolates from infected trees. The publication included an extensive analysis of the mating system of each species. The latter resulted in a clearer circumscription of the species. A new mushroom genus, *Ossicaulis*, was proposed for a fungus associated with a crumbly brown heart rot of living sugar maples in eastern Canada. *Ossicaulis lignatilis* (Pers.:Fr.) Redhead & Ginns had escaped earlier detection in eastern Canada because it normally sporulates inside hollow trunks, and as a result it had never been fully characterized in culture. A second new genus, *Neolentinus*, was erected for *N. kauffmanii* (Smith) Redhead & Ginns, a species causing a brown pocket rot of Sitka spruce along the Pacific coast, *N. lepideus* (Fr.) Redhead & Ginns, causal agent of a dry rot of structural timbers and railway ties across Canada, and for other related species, after the discovery of correlations between anatomical structures in the basidiomata, the physiology in culture, decay type, and the types of mating systems. A third new generic name, *Heliocybe*, was proposed for a genus allied to *Neolentinus*. This refined classification will aid the identification of unnamed basidiomycetes isolated from wood decay samples. These studies also support the recent controversial transfer of the commercially grown Shiitake to the genus *Lentinula* by D.N. Pegler, Kew Gardens. As part of this continuing modernization of the classification of agarics in Canada, two new genera, *Mythicomyces* and *Stagnicola*, were established for unusual species bridging the families Cortinariaceae and Strophariaceae. In addition, two new species, *Rhodocybe carlottae* Redhead & Baroni and *Clitopilus fuscogelatinosus* Redhead & Baroni, were documented from maritime regions of Canada. Type specimens for several species names in *Omphalia* and *Pleurotus* described by C.H. Peck around the turn of the century were examined and all the names redisposed. These names had been maintained in current literature based on incomplete or incorrect data and the purported existence of species with such features had interfered with the delimitation of well-defined species. The agaric genus *Phaeocollybia*, long suspected of being mycorrhizal, was shown to be parasitic on the roots of spruce. Two species were reported from eastern Canada. Descriptions of *Didymella bryoniae* (Auersw.) Rehm, which causes gummy stem blight of glasshouse cucumbers, and of *Pithoascus intermedius* (Emmons & Dodge) v. Arx, isolated from seeds of lowbush blueberry, were completed and are in press. A description of *Petriella sordida* (Zukal) Barron & Gilman, isolated from seeds and soil, was completed. A manuscript discussing the past and present status of the genus *Hormotheca* was prepared and is in press. A monograph of the Canadian and extralimital species of *Wettsteinina* is nearing completion. Twenty-two species have been accepted and described in *Wettsteinina*. Twelve of these are considered new. Details are also given for ten excluded species and two other species transferred to the genus *Nodulosphaeria*. The presence of a cap-like opening in the ascomata of many species of *Wettsteinina* is proving to be a significant taxonomic character, as is the unusual formation of the secondary septa in the ascospores. The genus *Phaeosphaeria* is also being monographed; over 60 species are being described and illustrated. An examination of the holotypes of most of the 84 species of the foliicolous parasites described in *Schiffnerula* and *Clypeolella* was completed. The synanamorph components and the continuous series of teleomorph morphology indicate that the two genera must be combined. A new anamorphic species, *Questeriella quercina* Hughes, in this group of fungi was described. About 30 species in the foliicolous genus *Meliolina* are being distinguished. These occur on old-world myrtaceous

hosts with one species on *Memecylon* (Melastomataceae). Only about seven species have been recognized in the past. A defoliating leaf spot hyphomycete on red alder along the Pacific coast, and a related species on big leaf maple in the same area, were shown to be generically misplaced because of a misinterpretation of the function of the propagules. *Mycopappus* form gen. nov. was described for both species. Two similar-looking leaf spot fungi, previously confused with *Mycopappus alni* (Dearn. & Barth.) Redhead & White by plant pathologists, were transferred to the primarily aquatic hyphomycete genus *Anguillospora*. This is the first indication that *Anguillospora* species may be plant pathogens. *Discochora* was proposed as the earliest available name for holomorphs with *Phyllosticta* anamorphs, replacing *Guignardia* auct. in this context. The latter generic name had been incorrectly applied to teleomorphs of *Phyllosticta* for over 90 years. A new species, *Discochora yuccae* Bissett, was described, and 11 new combinations were made in *Discochora* for leaf spot fungi on Liliales and other hosts. Ultrastructural studies on zoospores of the *Rhizophlyctis–Karlingia* complex showed that there are distinctive generic groupings; two research papers were published.

Ten Canadian species were fully illustrated and described for *Fungi Canadenses*. These include descriptions of four rust fungi, *Puccinia gentianae* (Str.) Rohling, *P. haleniae* Arth. & Holw., *Uredo bergingiana* (Tranz.) Parmelee, and *Uromyces eugentianae* Cumm., all occurring on species of Gentianaceae; two mycorrhizal Endogonaceae, *Glomus aggregatum* Schenck & Smith, present in the rhizosphere of various herbacious plants, and *Glomus mosseae* (Nicol. & Gerd.) Gerdemann & Trappe, present in the rhizosphere of some agriculturally important legumes such as soyabean, alfalfa, and kidney bean; *Venturia asperata* Samuels & Sivanesan, causing a leaf spot on *Malus*; *Omphalina brevibasidiata* (Singer) Singer, an agaric occurring on *Sphagnum*; *Typhula thaxteri* (Burt) Berthier on woody debris; and *Helicoma morganii* Linder, a hyphomycete occurring under the bark on the wood and cambium of *Populus*.

An international conference on molecular systematics and cellular evolution was organized at Carleton University by staff. The proceedings have been published in *Biosystems*. A complex paper on the coevolution of the grasses (Poaceae) and the grass rust fungi, being prepared for an international symposium on the grasses, is approaching completion. The paper throws light on the age and evolution of the bamboos, the oldest grasses, and clarifies the taxonomic disposition of several other grasses.

VISITING SCIENTISTS

Many scientists visited the institute during 1985: Peter Cranston, British Museum (Natural History), London, England, postdoctorate fellow, arctic chironomid midges; Miroslav Zacharda, Czechoslovakian Academy of Sciences, soil mites; Marcel Reeves, University of New Hampshire, Durham, oribatid mites; Toyohei Saigusa, Kyushu University, Fukuoka, Japan, empid flies; Roy Norton, State University of New York, Syracuse, oribatid mites; Ye Yuanbei, Sericultural Research Institute, Zhenjiang City, The People's Republic of China, spiders; Wang Mingzu, Wuhan University, The People's Republic of China, plant nematodes; J. Webster, Simon Fraser University, nematode genetics; G. Scudder, University of British Columbia, mirids; M. Schauff, United States National Museum, Washington, mymarids; M. Sandborne, Carleton University, ichneumonid wasps; J. Pinto, University of California, Riverside, trichogrammatids; J. Noyes, British Museum (N.H.), London, England, encyrtids; P. Hanson, University of Oregon, Corvallis, ormyrids; E. Grissel, United States National Museum, Washington, torymids; I. Gauld, British Museum (N.H.), London, England, ichneumonid wasps; P. Feldstein, University of Quebec, Montreal, nematodes; R. Brooks, University of Kansas, Lawrence, long tongued bees; G. Thorn, University of Guelph, basidiomycetes; L. Innes and C. Dupont, Province of Quebec, Quebec, forest tree parasites; J. Jazivik and L. Czerwinski, Ontario, maple, forest tree diseases; D. Myren, Forest Insect Disease Survey, Sault Ste. Marie, herbarium procedures; C. Manville, Academy of Natural Sciences, Philadelphia, gasteromycetes; V. Demoulin, University of Liege, Belgium, gasteromycetes; G. Kay, Harvard University, herbarium; D. McLaughlin, University of Saint Paul, Minneapolis, tremellales; W. Burk, University of North Carolina, Chapel Hill, gasteromycetes; G. Lindell, Forest Products Laboratory, Madison, Wis., basidomycetes; L. Schalkwyk, Edmonton, fleshy fungi; A. Rossman, National Fungus Collections, Beltsville, herbarium; K. Katsuya, University of Tsukuba, Sakuramura, Japan, rusts; K. Seifert, Centraalbureau voor Schimmelcultures, Holland, hyphomycetes; K. Nelson and A. Asselin, University of Guelph, *Fusarium*; K. Egger, Laval University, Quebec, mycorrhizae; Mike Ivie, Montana State University, beetles; Gayle Nelson, College of Osteopathic Medicine of the Pacific, buprestid beetles; Joan Chapin, Louisiana State University, and Natalia Vandenberg, University of California, Berkeley, ladybird beetles; John Lawrence, Commonwealth Scientific and Indus-

trial Research Organization, Canberra, Australia, beetles; Clarke Scholtz, University of Pretoria, South Africa, scarab beetles; Margaret Thayer and A.E. Newton, Jr., Field Museum, Chicago, rove beetles; G.A. Lohse, Hamburg, West Germany, rove beetles; Don Chandler, University of New Hampshire, pselaphid beetles; Scott Elias, University of Colorado, fossil beetles; Jack Schuster, Universidad del Valle, Guatemala, passalid beetles; Jan Klimaszewski, Macdonald College, rove beetles; Kauri Mikkola, University of Helsinki, Finland, noctuid moths; Bernard Landry, Macdonald College, pterophorid moths; Luis Handfield, Montreal, noctuid moths; T. McCabe, Albany, New York, noctuid moths; Nils Kristenssen, Copenhagen, Denmark, Microlepidoptera; Richard Cayouette, Levis, Que., flora of the Saguenay; Martin Dubé, University of Ottawa, *Festuca*; Pierre Grondin, Quebec, flora of the Minganne; Pierre Morisset, Laval University, Quebec, *Empetrum*; Jocelyn Weber, University of Toronto, *Carex*; A.G. Schwarz, University of Saskatchewan, Saskatoon, Graminea; Kay MacInnes, Indian and Northern Affairs, Yellowknife, northern floristics; Vernon Harms, University of Saskatchewan, Saskatoon, Saskatchewan flora; J. Morton, University of Waterloo, Manitoulin Island flora; K. Reading, Toronto, Keewatin flora; C. Kennedy, Yukon Renewable Resources, Whitehorse, Yukon flora; Albert Legault, Sherbrooke University, herbarium; K.F. Sayers, University of Guelph, conservation; Gilles Vincent, Montreal Botanical Garden, floristics; Tom Shay, University of Manitoba, Winnipeg, anthropology; Helene Joly, Gifs/Yvette, France, gene bank.

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Research

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INTRODUCTION

The Chemistry and Biology Research Institute (CBRI) is engaged in various research programs of national importance to Canadian agriculture. The institute supports fundamental and applied research and focuses on improved crop production, plant and environmental protection, preservation of natural resources, and food safety. These objectives are being addressed through multidisciplinary in-house research and close collaboration with other branch establishments and government departments, universities, and the private sector. Biotechnology remains the main thrust of the research activities.

The research programs are concerned with the improvement of the nitrogen-fixing capability of forage legumes through molecular genetics; the study of fungal physiology of *Fusarium* species and the understanding of the basic chemistry and the biosynthesis of toxic fungal metabolites; the understanding of the mechanisms of cold acclimation and freezing injury as well as overwintering and ice encasement damage in relation to the development of stress-resistant cultivars; the nature and distribution of pesticide residues, their potential release, and their bioavailability; the genetic manipulation of soil bacteria for improved pesticide degradation; the epidemiology and transmission of virus and mycoplasma diseases of plants; and the improvement of soil conservation through efficient use of nitrogen, preservation of organic matter, and increased understanding of the mineralogy of Canadian soils. The Electron Microscope Centre, the Analytical Chemistry Service, and the Mineral Analyses Service continued to provide services and to improve methodologies in response to the needs of the institute and other departmental establishments.

Notable achievements in 1985 include the identification of at least three separate regions in the *Rhizobium meliloti* genome, which contain genes essential for symbiotic nitrogen fixation; the measurement of energy levels in cells and plant crowns during ice encasement and freezing; establishment of the metabolic factors that govern the production of mycotoxin by *Fusarium*; demonstration that the ability of viroid-like ribonucleic acid (RNA) of lucerne transient streak virus to interact with genomes of other viruses is selective and depends on mutual genetic homology; determination of various enzymes present in aster yellows mycoplasma; development of procedures for specific isolation of *Pseudomonas* species, which degrade the herbicide atrazine and utilize their metabolites for growth; development of supercritical gas extraction methods for efficient isolation of specific organic components from soils.

During the past year several collaborative research projects were continued with Canadian universities, industries, and European research organizations. The institute has also supported a number of postdoctorate fellows and hosted visiting scientists.

This report records only the highlights of our accomplishments for 1985. Reprints of research publications and copies of this report are available upon request from the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J.-M. Deschênes
Acting Director

SYMBIOTIC NITROGEN FIXATION

Rhizobium ecology

An assessment of the influence of *Medicago sativa* cultivar, inoculant strain, and field site on the composition of indigenous populations of *Rhizobium meliloti* was completed. Fifty-five unique indigenous phage types (IPTs) of *R. meliloti* were identified at one site and 65 at the second location. At one site, the nodule population was dominated by two IPTs, seven others occurred consistently but at lower frequency, and the remainder were found infrequently. No IPTs predominated at the second location although nine occurred more frequently than the others. Indigenous *R. meliloti* predominated in inoculated plots at both sites; inoculant recovery varied between 10% and 38% in each of 2 years. The frequency of ITPs was influenced by a *M. sativa* cultivar, inoculation, and sample year. A cultivar × inoculation interaction on the frequency suggests that the inoculant differentially affected nodule occupancy of *M. sativa* cultivars by members of the indigenous *R. meliloti* population.

Recognition and physiology

Lectins are believed to play a role in *Rhizobium*–host recognition; thus the binding of the glycoproteins to sugars on the cell wall of *Rhizobium* is of obvious interest. The binding of soybean lectin to a series of galactosamines re-

vealed that this lectin contained four high-affinity binding sites and four low-affinity binding sites.

Differences in the side chains of exopolysaccharides produced by arctic rhizobia under various environmental conditions were observed using the technique of ^{13}C nuclear magnetic resonance (NMR). The nature of these side chains differs from those found in other rhizobia and are currently being characterized.

Studies on the mechanism of nitrogenase revealed that binding of adenosine triphosphate (ATP) to the molybdenum iron nitrogenase protein as measured by flow dialysis was an important step in energy transduction.

High levels of carbon dioxide in the atmosphere retarded growth and nitrogen fixation in *M. sativa* with nodulated roots. It was also shown that plants grown under equal intensities of photosynthetically active radiation and at a single phytochrome ratio but with three times more energy in blue light than the control did not show any enhancement during the period of accelerated vegetative growth. Similar results were obtained for plants grown in light enriched with red or far-red wavelengths.

Molecular genetics

Analysis of Tn5 mutants of *Rhizobium meliloti* has resulted in the identification of three new regions in the genome that contains genes essential for symbiotic nitrogen fixation. These deoxyribonucleic acid (DNA) regions do not overlap and are not continuous with the known nod–nif–fix region on the megaplasmid.

An insertion element present as four copies in wild type *R. meliloti* JJ1-C10 was shown to cause mutations by the generation of additional copies in another target region. This insertion element is identical to ISRm1, which was found in *R. meliloti* strain 1021. ISRm1 from JJ1-C10 has been mapped and its transposition site specificity characterized. The target site affected in the nodulation-defective mutants was the 3′ end of the nod C gene. The insertion element does not transpose into the nitrogen fixation genes in strain JJ1-C10 as it does in strain 1021, indicating that its site selection is host dependent. Thus the presence of ISRm1 in *R. meliloti* does not necessarily decrease the stability of the nitrogen fixation phenotype.

The acquisition of rifampin resistance in a mutant of *R. meliloti* strain IZ450 was correlated with a significant loss of nodulating competitiveness on *M. sativa*. Rifampin resistance was shown to be due to an altered ribonucleic acid (RNA) polymerase. Twelve independent rifampin mutants of *R. meliloti* strain IZ450 and three rifampin mutants of each of four additional *R. meliloti* strains all showed significant losses in nodulating competitiveness. These results suggest that in *R. meliloti* the acquisition of rifampin resistance is correlated with a loss in nodulating competitiveness.

STRESS PHYSIOLOGY

Biotechnology

Suspension culture cells of *Brassica napus* were hardened to cold stress by exposure to 25°C for 1 week in the presence of abscisic acid (ABA). Attempts to similarly acclimate isolated cells of winter rye at 25°C with ABA or at 2°C were only minimally successful. Further experiments with *B. napus* suspension cells have shown specific synthesis of new messenger RNA and proteins by the incorporation of [^{35}S]methionine during a critical hardening period.

Video photomicrography and transmission electron microscopy of isolated cells of *B. napus* and winter rye during plasmolysis showed that endoplasmic reticulum vesicles coalesce with and supplement the plasma lemma when membrane strands are formed between the protoplast and cell wall adhesions. On deplasmolysis, the strands are reabsorbed into the plasma membrane in cells from cold-hardened tissue, but are excluded from the membrane in cells that have not been cold hardened. This membrane deletion commonly causes lysis in nonhardened cells during expansion after plasmolysis or freezing stress.

Total energy levels (the adenylates ATP, ADP, and AMP) declined during ice encasement of isolated cells and plant crowns of winter wheat, but the adenylate energy charge (AEC) remained high. Similarly during freezing of cells, the adenylates declined but AEC levels remained high. Therefore, loss of ATP was not the initial cause of cell or tissue damage in either ice encasement or freezing stress. Calcium protected cells against the damage of ice encasement and reduced losses of ATP but did not influence AEC. Preflooding of whole plants of winter wheat increased their subsequent survival of ice encasement. This was associated with higher levels of ATP and AEC because of a higher glycolytic rate in the preflooded plants.

Proteins

Changes in proteins of winter rye seedlings located by two-dimensional electrophoresis during cold hardening and desiccation stress were most abundant in the soluble fraction and in subcellular fractions containing the etioplasts. Rela-

tively few changes were observed in a total membrane or in the mitochondrial fraction.

Sodium dodecyl sulfate–polyacrylamide gel electrophoresis demonstrated that highly virulent isolates of the fungus *Phytophthora megasperma* had similar protein patterns, but that they differed markedly from those of the mildly pathogenic isolates of the same species. *P. megasperma* is an economically significant root-rot disease of alfalfa.

Field trials and screening

Survival of winter cereals in eastern Ontario was generally good in the winter of 1984–1985, with little differential kill between adapted cultivars in test plots. September plantings of recently released cultivars gave slightly higher survival than October plantings at two locations. However, the later plantings had markedly higher survival rates after the imposition of an ice encasement stress in February. This test totally killed a September planting of 75 lines of winter cereals. These same lines were tested in controlled environments for freezing resistance and ice tolerance, and useful strain separation was obtained. In a single experiment, 186 winter wheat lines from the Ottawa Research Station breeding program were tested for coldhardiness by a new technique to reduce plant handling to a minimum. Seeds were germinated in growth pouches, and plants were cold-hardened, frozen, allowed to recover, and recorded without further transfer.

Diseases

The spring survey of winter wheat fields in Ontario indicated that loss in plant stand resulting from snow mold infection was 12–15%. Three *Typhula* species and *Gerlachia nivalis* were the snow mold pathogens responsible for the crop loss. Sclerotia of *Typhula* species were susceptible to attack by a number of other fungi and bacteria. For the first time, sporophores of the *Typhula* were observed under natural conditions on wheat. The occurrence of *T. phacorhiza* sporophores unequivocally established this species as a new pathogen of winter wheat in Ontario. Commercially available surfactants (oils and waxes) showed little or no inhibition of snow mold infection on winter wheat.

Barley yellow dwarf virus (BYDV) reduced coldhardiness of winter wheat, more so in Fredrick, a cultivar susceptible to BYDV, than in Caldwell, a virus-tolerant cultivar. Two strains of the virus classified as mild and severe by symptom expression reduced coldhardiness to the same degree.

MYCOTOXINS

Biosynthetic studies

Two 10-L fermentor growths enriched with [^{13}C]acetate were carried out, resulting in the isolation of highly enriched sample of 3-acetyl deoxynivalenol (ADON) and other important metabolites, such as culmorin, apotrichothecene, sambucinol, and dihydroxy calonectrin, in gram and sub-gram amounts. These compounds were purified for use in future metabolic studies with plant cell cultures. Other enrichment studies with [^{13}C]acetates (^{13}C-1, ^{13}C-2, ^{13}C-1,2, and ^{13}C–^{18}O) were also completed. ^{18}O enrichment occurred only in the acetoxy moiety, which is consistent with our knowledge of trichothecene biosynthesis. Preliminary experiments with other ^{13}C-labeled precursors, e.g. mevalonate, showed poor incorporation, giving only inconclusive data. Future work with the labeled compounds thus obtained will necessitate the use of cell free or protoplast systems. Initial studies with *Myrothecium* showed a high incorporation of [^{13}C]acetates in both rings and side chains of the macrocyclic trichothecene metabolites.

Degradation and decontamination studies with deoxynivalenol (DON)

The treatment of contaminated corn with aqueous bisulfite is known to result in a significant reduction in the level of DON. The reaction between DON and bisulfite has been studied and the product characterized as the 10-sulfonate derivative of DON, addition having occurred at the double bond and not at the keto moiety. Preliminary results indicated that bisulfite adduct is not as toxic as DON to pigs. However, the use of bisulfite-treated contaminated flour for baking resulted in the reappearance of DON in the product, which is thought to be caused by alkalinity of the dough.

DON is degraded by a variety of bases on aqueous solution. It undergoes subsequent rearrangement to give three novel compounds. The compounds were characterized by their spectroscopic properties (ultraviolet, nuclear magnetic resonance, and mass spectroscopy). A mechanism for the rearrangement of DON in base was proposed.

Microbiology

The charge ratio (ATP:ADPT AMP) and anabolic and catabolic charge ratios (function of NAD, NADH, NADPH) were investigated in the 12-h period after induction of trichothecene synthesis in *F. culmorum*. Analytical procedures for the rapid quantification of the above bio-

chemicals by high-performance liquid chromatography were developed. Measurements taken during optimum toxin-producing circumstances, as well as suboptimal conditions, were carried out in a 15-L fermentor. Data from the optimum fermentation conditions indicated that the charge ratio declines from 3.6 to 1 at the onset of toxin synthesis and the NADH:NAD ratio increases while the NADPH:NADP ratio decreases. These ratios were different for nonoptimal conditions for mycotoxin synthesis.

A final fermentation method for trichothecene production with *F. sporotrichioides* from Saskatchewan was developed yielding T-2 toxin at rates of about 400 $mg.L^{-1}$ and quantities of minor metabolites. Several medium-scale fermentations were done and some minor metabolites have been characterized.

A preliminary field experiment was carried out. It involved inoculating a toxigenic strain of *F. moniliforme* in ears of field corn (in conjunction with Health and Welfare and Animal Research Centre) and the corn samples were found to contain 240 ppb of the carcinogenic toxin fusarin C.

Analysis

A number of capillary column gas chromatographic–mass spectroscopic procedures were developed in connection with the analysis of fungal secondary metabolites. Identification of the secondary metabolites produced by isolates of *Fusarium culmorum, F. graminearum,* and *F. sporotrichioides* in various liquid culture media gave a means of establishing the genetic response of each isolate. Samples were analyzed for their fungal content using ergosterol as a marker. The procedure involved formation of the heptafluorobutryl derivative and analysis in the multiple ion detection mode resulted in a sensitivity of 20 pg (least detectable amount). A fast, simplified procedure using high-performance liquid chromatography for the simultaneous analysis of DON and nivalenol was developed with a sensitivity of 0.05 and 0.02 ppm, respectively.

PLANT PATHOLOGY

Peach X-disease

Various herbaceous plants were experimentally infected through vector leafhoppers *Paraphlepsius irroratus* with peach-X mycoplasma (PXM) and the concentration of PXM-antigens in them was determined by enzyme-linked immunosorbent assay (ELISA). Celery plants contained the highest concentration of PXM, followed closely by carrot, and then with decreasing concentration in sweet clover, cinquefoil, chrysanthemum, and white clover. These results provided information about the relative importance of herbaceous hosts that may serve as reservoirs of peach X-disease. Thirty-two additional plant species in seven families were tested for their susceptibility to PXM, and of these 15 developed the disease symptoms. In other studies, a mycoplasma was transmitted by the leafhoppers *P. irroratus* and *Scaphytopius acutus* from wild chokecherry showing typical peach X-disease symptoms to celery and clover plants. Transmission tests indicated that this isolate of the mycoplasma is much less efficiently transmitted by the leafhoppers than is PXM from southwestern Ontario.

Experiments on correlation between immunosorbent electron microscopy (ISEM) and transmission tests showed that all exposed leafhoppers that transmitted PXM to healthy plants (46%) were also scored positive by ISEM. However, 30% of the leafhoppers that were exposed to diseased plants did not transmit PXM to healthy plants but showed the presence of PXM by ISEM test. About 24% of the exposed leafhoppers were scored negative by both tests.

Aster yellows disease

Studies on the localization and distribution of various enzymes in purified aster yellows mycoplasma (AYM) showed that NADH oxidase and ATPase were confined to the membrane fraction and NADPH oxidase to the cytoplasmic fraction of the AYM-cells. *para*-Nitrophenyl phosphatase and ribonuclease were associated mainly with the membranes, whereas deoxyribonuclease was with the cytoplasmic fractions. This is the first report on the distribution of enzymes in a nonculturable mycoplasma parasitic to plants.

Cereal viruses

An antiserum developed against purified cock's-foot mild mosaic virus (CMMV) was used to demonstrate that the Canadian strain (CMMV-C) was serologically indistinguishable from the German strain. CMMV-C was moderately related to the French strain of CMMV, and to phleum mottle, holcus transitory mottle, and brome stem leaf viruses, and distantly related to panicum mosaic virus. CMMV-C sedimented as a single component at 108 S and had an extinction coefficient of 5.8 and buoyant density of 1.3600 g/mL. The viral genome had two species of RNA, 1.5×10^6 and 0.5×10^6 d. The single species of coat protein had a molecular weight of 27 000 d, with a high content of the amino acids serine, alanine, and glycine.

Forage legume viruses

The viroid-like (VL) RNA of lucerne transient streak virus (LTSV) was shown to interact with the genome of turnip rosette virus (TRosV) as it replicated under the direction of TRosV-RNA and encapsulated in TRosV virions. The interaction between the VL-RNA and southern bean mosaic virus (SBMV) appears to be host specific, as the VL-RNA replicated in *Trifolium incarnatum* and *Trigonella* but not in *Phaseolus vulgaris*—a host of SBMV but not of LTSV.

ENVIRONMENTAL CHEMISTRY

Bound atrazine residues in soil

Atrazine, uniformly [^{14}C]ring-labeled, was applied to mineral soil under field conditions. Nine years after application of the herbicide, soil samples were collected for analysis. The soil contained about 50% ^{14}C residues in the bound (nonextractable) form. The bound ^{14}C residues were distributed among the various soil humic fractions. In addition to the parent herbicide a considerable portion of these residues was composed of hydroxy analogues of atrazine and their dealkylated products.

Bioavailability of bound ^{14}C residues in rats

Corn plants grown to the silage stage were treated with [^{14}C]ring-labeled and unlabeled atrazine. The aerial portion of the plants was exhaustively extracted with solvents, and the extracted material containing bound ^{14}C residues was fed to rats. For comparison, extracted material from control plants fortified with [^{14}C]atrazine was also fed to rats. After 4 days, 88% of the dose was excreted in the feces and 10% in the urine from rats fed plant material containing bound ^{14}C residues. In contrast, only 32% of the dose was eliminated in the feces and 60% was voided via the urine when the corn material fortified with [^{14}C]atrazine was fed to rats. Atrazine added to the corn material before feeding was metabolized effectively when consumed by rats. The data demonstrated that bound residues in corn plant treated with atrazine have a low degree of bioavailability in rats.

Biodegradation of pesticides

A modified soil-enrichment procedure was developed for the specific isolation of the *Pseudomonas* species that degraded the herbicide atrazine and utilized the atrazine metabolites for growth. This was achieved by incorporating specific inhibitors of fungi, gram-positive bacteria, actinomycetes, and enteric gram-negative microbial species during soil enrichment culture with atrazine. Eighty percent of the isolates belonged to the genus *Pseudomonas*. They were tentatively assigned to three different species of *Pseudomonas*: *P. putida, P. fluorescens,* and *P. stutzeri*. Atrazine was degraded by all three species of *Pseudomonas*. The rate of degradation was slightly higher with *P. putida* and *P. fluorescens* than with *P. stutzeri*. A lag period in the biodegradation of atrazine indicated the necessity for bacterial-population build-up to produce sufficient amounts of utilizable metabolites. Degradation was faster when cell multiplication was achieved by the addition of other readily utilizable carbon sources, e.g. glucose and glycerol. The utilization of atrazine as a carbon source by the bacteria was shown by the increase in bacterial cell numbers with time. Unlike the degradation of atrazine by soil fungi, the predominent metabolic products by the *Pseudomonas* was deisopropylatrazine. Only trace amounts of deethylatrazine, the major product with fungi, were found. Further degradation of *N*-dealkylated atrazine metabolites showed that two of the three species of isolated *Pseudomonas* carried out effective (25–50%) dehalogenation of these metabolites. This is the first demonstration of bacterial dechlorination of atrazine metabolites. All the isolates were examined by various methods for the presence of plasmids. However, no plasmids could be detected in the species.

SOIL CHEMISTRY AND MINERALOGY

Soil carbohydrates

Time and increasing temperature showed an increase in unsaturated character and carbon content, paralleled by a decrease in carboxyl, amide carboxyl, and nitrogen content of melanoidins, the nitrogenous polymers of the Maillard reaction. Longer reaction times and higher temperatures yielded polymers with more pyrolle or indole nitrogen.

Studies on the biodegradation of melanoidins by soil microorganisms under laboratory conditions showed, like soil humus, that they are inherently biorecalcitrant. Temperature of synthesis of these polymers seemed to be the most important factor. After a 25-day incubation period, the number of bacteria and actinomycetes, in accord with the O_2 update data, were twice as numerous in samples containing melanoidins synthesized at 22°C, than at 68° and 100°C. *Penicillium, Cladosporium,* and *Paecilomyces* were the dominant fungi that degraded melanoidins syn-

thesized at 22°C, while only *Penicillium* species degraded those synthesized at 68° and 100°C.

Chemistry and soil organic matter

Three soils and two humic materials were extracted by supercritical gas extraction with *n*-pentane. Compounds identified in the extracts included *n*-alkanes (ranging from *n*-C_{12} to *n*-C_{32}), with *n*-C_{26} and *n*-C_{24} in prominence, and smaller amounts of cyclic alkanes (C_{19}–C_{31}). The major components, however, were *n*-fatty acids (*n*-C_7 to *n*-C_{29}), accompanied by lesser amounts of branched fatty acids (C_{12}–C_{19}), unsaturated fatty acids (*n*-C_{16}, *N*-C_{18}, and *n*-C_{18}), hydroxy fatty acids (C_{12}–C_{16}), and alkanoic α,ω-diacids (C_{15}–C_{25}). Even-to-odd carbon ratios suggested microbial origins for the *n*-alkanes and *n*-fatty acids. Total alkanes extracted from the soils and humic materials ranged from 4.3 to 8.9 and 32.5 to 201.4 mg/kg, respectively, whereas yields of alkanoic acids varied from 94.5 to 208.9 mg/kg of soil and from 740.1 to 1576.6 mg/kg of humic material. Other extractants investigated included ethanol and mixtures of water with ethanol and acetone. Supercritical gas extraction is a mild and efficient procedure for the extraction of specific organic components from soils and humic materials and is a valuable aid for the identification of significant soil organic matter components.

Soil nitrogen transformation

A rice rhizosphere isolate, *Pseudomonas* species strain H8, is a N_2-fixing bacterium capable of autotrophic growth. Physiological examination revealed that it can grow anaerobically in the presence of N oxides and release gaseous N in process. Such N transformation, termed denitrification, is responsible for a major N loss from soils and thus lowers the efficiency of fertilizer use. Autotrophic denitrification of nitrate by H8 with H_2 and CO_2 was also demonstrated. Although denitrification supports anaerobic growth and helps to remove nitrate as an inhibitor of N_2 fixation, the possibility remains that H8 may remove a significant amount of inorganic N from soils via denitrification compared with the N gained by soils via N_2 fixation.

Effect of acid emissions on soils

Physical and chemical analyses of soils from the Sudbury area were carried out on samples collected from four transects (NNE, E, SSE, WSW). The soils on the NNE transect were highly weathered, as evidenced by the highest level of amorphous materials in the clay and silt fractions and the smallest quantities of heavy metals such as Cr, Mn, Fe, Co, Ni, Cu, Zn, and Pb. It was concluded that the effects of acidification caused by local emissions on nearby soils decreased in the following order: NNE > WSW > SSE > E.

Role of extraneous cations in aluminum hydrolysis

The presence of trace to minor amounts of extraneous cations such as Na and K was very important for the hydrolysis of aluminum in the presence of sulfate anions. The hydrolysis at 50°C produced alunite, bioehmite, gibbsite, and basaluminite as solid-phase products in the presence of extraneous cations whereas no precipitates were formed in their absence. This suggests that the extraneous cations stimulate hydrolysis and subsequent crystallization.

Dynamics of blocked exchangeable cation sites of soil minerals

Under acidic conditions, the cation exchange capacity (CEC) of soils may be reduced through adsorption of hydrated aluminum cations between the layers of expandable clay minerals. In laboratory, sulfate anions can be incorporated with hydrated aluminum cations to form an aluminum hydroxy sulfate complex that is stable with respect to the interlayered aluminum hydroxy complex. The results indicate that sulfate anions can remove the interlayer complex that blocks exchangeable cation sites of expandable clay minerals. These results were further tested by equilibrating clays and soils with $CaSO_4$ solution. The equilibrium successfully increased CEC of aluminum hydroxysmectite from 31 mequiv/100 g to 79 mequiv/100 g. Similar results were obtained with some acid soils.

Acid sulfate weathering in soils

Mineral weathering in some acid sulfate soils resulted in the decomposition of smectite into amorphous components. The crystallinity of smectite decreased toward the surface horizons where this mineral was virtually undetectable. This reduction in smectite crystallinity was associated with an increase in extractable amorphous component. The natrojarosite was converted into poorly crystalline and noncrystalline iron oxides.

Mineral alterations associated with manure applications

Six years of liquid manure applications produced the collapse of vermiculite to form a pedogenic mica-like mineral. This change was the result of K and NH_4 fixation. An awareness of such an effect is important in making mineralogical interpretations.

Pedogenic imogolite and soil environments

Effects of soil temperature and vegetation were investigated on Podzolic soils with similar parent material, topography, and age along northern and southern transects in Quebec. The major differences in properties of pedons between the two transects were a lower total organic carbon content in B horizons and higher ratios of inorganic to organic amorphous Al and Fe in the horizons in the northern pedons than in the southern pedons. These differences may well be attributed to the differences in vegetative cover, soil temperature, and biological activities between the two transects. Pedogenic imogolite was detected in all B horizons and some C horizons of the pedons of the northern transect but in none of the pedons of the southern transect. The high organic carbon content in the pedons of the southern transect is believed to delay the formation of imogolite.

The dominance of inorganic forms of amorphous Al and Fe in the B horizons of the northern transect supports the hypothesis that much of the Al and some of the Fe are translocated without complexing with organic matter and deposited as inorganic complexes with Si, leading to the formation of imogolite. The hypothesis that the movement of inorganic Al–Si complex occurs at an early stage of podzolization and that the occurrence of pedogenic imogolite is not restricted to Podzolic soils was verified by detecting the presence of imogolite in relatively young sandy pedons in a podzolic environment.

MINERAL ANALYSES SERVICE

Mineral Analyses Service provided 2430 X-ray diffraction diagrams, 232 infrared spectra, 29 Mossbauer spectra, and 6 thermograms and assisted 42 scientists from branch establishments, other government agencies, and universities in characterizing mineral components of soils and sediments. Research projects supported by the service include mineralogical characterization of Canadian soils from various areas; mineral deterioration in acid soil environments; clay mineralogy of acid sulfate soils; organomineral complexes of tar sands from Alberta; aluminum chemistry related to soil acidification; photoreduction of water in the presence of clay surfaces; crystal chemistry of chlorites in relation to their susceptibility to weathering; distinction between soil vermiculites and soil smectites; K-deficiency problems in southern Ontario orchards; methodology development for mineral characterization and quantification; chemistry of soil humic compounds and soil carbohydrates. These services contributed to more than 30 research publications, reports, abstracts, and oral presentations to conferences.

A fully automated Scintag X-ray diffractometer was recently upgraded by acquiring a new PAD IV module. This acquisition has improved the versatility of data processing and increased the recording rate of diffractograms by at least twofold.

ANALYTICAL CHEMISTRY SERVICE

Analytical Chemistry Service provided branch establishments with chemical analyses in support of research projects in a broad variety of disciplines. A wide range of agricultural research materials was analyzed for constituents such as dietary fiber; fat; cellulose; lignin; ash; macro; minor, and trace elements of nutritional and toxicological relevance; nitrogen; proteins; amino acids; carbohydrates; and organic functional groups. Some 38 000 determinations were provided to professionals and technical staff of 15 branch establishments and three outside agencies.

Development was completed, in cooperation with the United States Department of Agriculture and other laboratories, of two agricultural biological reference materials for chemical analysis quality control purposes. These are being made available to the international analytical community by the Office of Standard Reference Materials, the United States National Bureau of Standards, Washington, DC, as maize (*Zea mays*) stalk, reference material 8412; and maize kernel, reference material 8413. Reports of investigation were prepared to document material preparation and provide recommended and informational concentration values for a number of chemical elements of agricultural, nutritional, and toxicological pertinence. Small quantities of the maize stalk powder are available from the Chemistry and Biology Research Institute for departmental laboratories as reference material 132F.

ELECTRON MICROSCOPE CENTRE

Over 80 professional and technical staff of establishments on the Central Experimental Farm, one off-campus station, and nine outside agencies (universities, other government departments, hospitals, and industrial research laboratories) made use of the facilities of the Electron

Microscope Centre. Special projects were undertaken for the Harrow Research Station, the Prince Edward Island Potato Marketing Board, the Canadian Red Cross, and the Civic Hospital.

Research carried out at the center was reported in 22 research papers and in numerous reports concerned with methodology development; biosystematics and phylogeny of insects, nematodes, and fungi; ultrastructure of fungal zoospores; taxonomy of the genus *Medicago*; gene mapping of *Rhizobium meliloti*; detection of mineral components in soils; micromorphology of soils; cereal quality by image analysis; detection of plant pathogenic mycoplasmas; differentiation of neurons; artery suture comparison; ultrastructure of blood platelets; structure–function relationships of coagulation proteins; microstructure of cheeses, yogurt, and milk proteins; and confirmation of virus-free potato. These publications and reports are reported in the individual listings of institutes and stations.

Users were trained in the use of the ISI-DS-130 scanning electron microscope, the T-N 5500 X-ray spectrometer system, the SEM-IPS image analysis system, and the Balzers freeze-etch unit. A cold stage was installed on the AMR 1000A scanning electron microscope for viewing specimens in the frozen-hydrated state at –180°C, thus avoiding all artifacts of freeze-drying or critical-point drying. Users were also trained in the use of this cold stage. The image analysis system will play an important role at the center. A link between SEM-IPS and the VAX system will provide direct access to various packages for data processing.

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W.S. Reid, B.Sc.(Agr.), M.Sc. Seconded to an assignment with the Canadian International Development Agency, Hyderabad, India, July 1985	Mechanization

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INTRODUCTION

1985 was an important milestone for the Engineering and Statistical Research Institute (ESRI) since it is now a quarter of a century that engineering and statistical research organizations have been in place on the Central Experimental Farm in Ottawa, separately or as combined to form the institute in 1978. Also, preparations were under way to participate in the Centennial celebrations of the Research Branch that exists as a result of the *Experimental Farm Station Act* of 1886. These preparations included the publication of a history of statistical research (1984) and a history of engineering research (1985). Other important reports prepared were a listing of the 1100 projects undertaken and the 960 miscellaneous and 730 scientific publications of the institute since 1960; and a listing of the 505 engineering research and development contracts undertaken by the branch since 1973 and the resulting reports. These two reports provide a complete summary of the engineering and statistical work accomplished over the past 25 years and serve as useful reference information.

Major changes were made in the energy program, largely as a result of a reduction of the contracting-out budget from $8 to $2 million annually. Also, the results of some 300 contracted-out projects are now available, providing solutions to previous technological problems and information to support future planning. A major finding is that much of the renewable energy technology has limited application in agriculture, largely because of economic considerations. Many of the renewable options have been explored and good technology has been developed; but its adoption cannot be recommended because it is not profitable for the farmer under present economic conditions. The reduced requirement for managing contracted-out energy work permitted a reallocation of human resources to in-house work on energy and the integration of this work with the traditional processing, mechanization, and structural research aims of improving the efficiency of crop, animal, and food production. The immediate result has been a strengthening of the food process engineering research program and the introduction of greenhouses as a new area covered by the Canada Plan Service. Future energy research will focus on energy conservation in the primary production sector where results to date indicate that significant economic benefits can accrue. Several important in-house projects are now under way in this area.

The strengthened food process engineering program now encompasses all of the institute's expertise in this discipline. The high level of effort maintained on technology transfer continues to pay off with industry adopting the results of the research.

Good progress is being made in the development of equipment and instruments for research and experimental operations across the branch. The development and capabilities of such equipment has accelerated and expanded as a result of the availability of microcomputing systems at relatively low cost. This work is having a profound effect on the efficiency of biological research and opening new avenues of research. Early results of the program on automating the inspection and grading of agricultural products are demonstrating clearly that such activities can be placed on an objective basis to supplement or even replace the human judgment normally used to assess quality against regulatory standards.

The Canada Plan Service continued its successful operation, serving as a model of the integration of research, development, design, and technology transfer that provides extension services and Canadian farmers with economic functional building designs. Greater emphasis was placed on developing new structural design methodology and its validation by full-scale testing, particularly for key components such as trusses and nailed joint connections.

Mechanization work was again focused on horticultural crop production, with progress being made on such specific items as cucumber and strawberry harvesting. Other technology developed continues to be picked up by manufacturers and marketed.

The statistical research program had an extensive impact on the efficiency of the research programs and projects of the branch in providing services in statistical design. A dramatic increase has occurred in the use of ESRI's statistical computer program library (50 000 accesses per year). This is a result of improved computer facilities and communications implemented in recent years and the training provided to staff across the branch by the statisticians. The acquisition of a minicomputer by ESRI has increased the efficiency of the statisticians and expanded their capability to collaborate with and support researchers in all the disciplines. Important changes in methodology were introduced into the branch's breeding programs, for example the nearest-neighbor technique in cereal breeding.

An important step to improve the workshop facilities was taken with the acquisition of numerically controlled machine tools for quickly fabricating and modifying the parts required for machines and instruments. Preventative and emergency maintenance services were successfully maintained for a huge catalog of research equipment on the Central Experimental Farm.

The agricultural engineering research and development bibliographic data base continued to expand. It now provides an efficient tool for obtaining reference material on specific topics and can quickly generate reports on such information. The organization of the system and its keywording system were published. Unfortunately it has so far proved impossible to make the system publicly accessible.

Expertise of the staff was further expanded through postgraduate training for several professionals.

The following report describes some of the achievements resulting from the institute's activities in 1985. Additional and more specific details can be gained by reviewing the list of publications given in the report. More information about past and current work can be obtained upon request.

Peter W. Voisey
Director

ENERGY

A modular wet grain storage system using plastic bags is giving promising results for barley, wheat, and corn, thereby eliminating the need for drying. Further automation of the system is warranted as a viable alternative for storing grain without incurring drying costs. Electrocution as the primary means of weed control in row crops was reviewed. The technical aspects were reported and the power required was identified as the main constraint to further exploitation of this technology.

Computer programs and procedures were developed for operation of the tractor data acquisition system and transfer of data to a laboratory computer. Equipment and procedures were developed for calibration of draft and wheel torque transducers on the four-wheel-drive tractor. The system is now ready for field use, for measuring tractor performance and implementing power requirements.

A time–temperature integrator controller was developed resulting in a large increase in the rate of ice production using winter coldness. A 300-t ice block is being used for the 3rd year at a commercial enterprise to operate a vegetable precooler and to maintain the vegetables at reduced temperature. A water–ice mixing system has been developed to utilize the ice directly in the packaging of vegetables for the fresh market. These systems provide a low-cost vegetable cooling alternative with a large capacity, which will encourage better market penetration of fresh produce.

The fuel alcohol facility built and tested under contract established that, at the current price of gasoline, fuel alcohol cannot be produced competitively at a farm community scale. The value of by-products plays an important role and these require further development to have economic merit. A system for utilizing fuel alcohol in a diesel tractor has been developed in close cooperation with a major world supplier of diesel engines for agriculture. With minor modification and at a low cost, farm tractors can be modified to utilize fuel alcohols.

Contracts on basic work on cellulose, lignin, and hemicellulose recovery and enhanced fermentation techniques demonstrated that the recovery and conversion rates are too low to justify scaling up to commercial applications based on agricultural feedstocks. The production of fructose from Jerusalem artichokes has been shown to be a viable alternative source of fructose and now awaits further crop development. Results from the contract program on anaerobic digestion of manure show that these systems are falling short of expectations. Economic payback for the required facilities is almost impossible for farm-scale systems. Refeeding of digester effluent to animals (protein recovery) is of questionable merit. Future research will focus on utilizing this technology to address pollution aspects associated with food processing wastes where economic prospects are more favorable.

Night covers and strip curtains were found to reduce energy consumption and improve temperature distribution in open multideck medium temperature refrigerated cases. New subcooling controls for retail food refrigeration systems showed that at least a 13% energy savings was possible with a payback of 3 months or less. Industrial scale refrigeration projects showed that the use of winter cold directly in a plant had payback periods greater than 8 years in Toronto, even for the most economical system evaluated. Passive use of winter cold in a mechanical re-

frigeration system has been found feasible and remains to be tested at the industrial level.

A novel canola oil extraction process using methanol–ammonia with hexane as solvent has been shown to be effective, efficient, and safe. Preliminary microwave-assisted peanut-roasting work has resulted in 20% energy savings and increased throughput.

Results from contracts on greenhouse design, retractable insulation systems, alternative heating systems, microprocessor controllers, and heat exchangers have contributed to substantial improvements in the energy efficiency of commercial greenhouses. Monitoring of a solar hot water heater installed through the PUSH (purchase and use of solar heating) program on the engineering building, showed that there were installation, design, and maintenance faults with the system, which resulted in a poor performance. A simple payback analysis indicated that the system was not cost effective.

Food Process Engineering

Tests using the continuous microwave processor were completed on mustard at a commercial plant in Alberta. The unit is now installed at the Alberta Agriculture Food Processing Development Center, where further development will be undertaken.

Studies using supercritical CO_2 extraction were conducted on fractionation of canola oil and egg lipid components. Other separation studies using liquid cyclones and membrane techniques were continued. A patent submission was filed on a process for separation and concentration of immuno-γ-globulin from porcine blood.

A computerized system for the measurement of thermal properties of foods was developed for fundamental studies on food characteristics. Work with the small-angle oscillatory testing of the rheological properties of foods continued with studies on starch, meat emulsions, and pectin gels. Studies on the specific heat of food during freezing were undertaken.

Technology transfer included technical support for ABCO Industries marketing of the IQB blancher. Two units were sold in Australia following the marketing trip to Australia and New Zealand. The food texture data acquisition and manipulation program was updated and several research establishments have adopted it. The contract study on high pressure washing of tin cans to remove residual lead was completed. This study is of particular interest to regulators in relation to residual lead in food. A one and one-half day seminar on microwave food processing was conducted in conjunction with the National Research Council. A masters degree candidate from the University of Manitoba is undertaking his thesis research on protein fiber formation in the laboratory.

Instrumentation and automation

The program on automatic grading and inspection of agricultural products by machine vision continued. Further instrumentation has been acquired, and the overall system for establishing the feasibility of the methodology has been upgraded. A prototype tomato grader using machine vision is in the final development stage under a contract. A "veal inspector" is now in commercial production (IDEE Inc., Montreal, Quebec).

A commercial digital micrometer was adapted for eggshell-thickness measurements. Provisions were made to transfer the data to a computer for further processing and archiving.

Various mechanical equipment was developed: a potato digger for research plots; a wing bander for 1-day-old chicks; an egg oiler for farm scale production; a sample mixer for large quantities of freeze-dried meat to provide samples for industry standards; and an environmental control chamber for micromanipulation of samples in biotechnology research.

A tobacco grader (color, porosity, and texture) has been further advanced and tests performed at the Delhi Research Station.

Advisory and technical assistance was provided to support new departmental initiatives in electronic identification (EID) of livestock. Staff are involved as members of a national technical advisory committee and in managing contracts to evaluate commercial EID systems.

STRUCTURES AND MECHANIZATION

Structures

The Canada Plan Service (CPS) completed 13 plan sets and 32 leaflets, with major emphasis on the beef, dairy, and swine series. Those leaflets intended for use by engineers only are in metric dimensions. However, for farmers and builders, a version showing imperial dimensions is also being produced.

The leaflet *Steel roof diaphragm wind bracing with stud walls* was published and subsequently revised following results of an agricultural engineering research and development (AERD) contract that tested full-scale CPS design diaphragm roofs. Truss gussets made from the new four-ply plywood (in contrast to the former five-ply plywood) were tested and found deficient for CPS

design trusses. The truss designs are being redesigned with thicker, five-ply plywood and bigger, fewer nails.

CPS drawings were revised, where appropriate, based on the results from full-scale truss tests completed earlier, so that construction economies can be achieved by farmers and builders.

Truss joint tests validated a theoretical analysis of truss joint rigidity, providing a new design method for CPS trusses.

New design information for spiral nails, developed previously by the institute, was included for the first time in the National Standard of Canada *Engineering Design in Wood* (CAN3-086.1-M84).

Techniques for remote detection and measurement of silo gases, and for ventilating silos with the forage blower, were developed. Under the agricultural engineering research and development (AERD) program, a low-cost, practical, and sufficiently accurate measurement method was developed for checking silo gas concentration in deep silo headspaces while standing on the outside safety platform. A CPS publication on manure gas was prepared and widely distributed.

Results on the evaluation of earth-lined manure storages were published; the loam site provided the best containment of manure nutrients, the clay site next, and the sand site provided the poorest.

Mechanization

Functional and operational improvements were made on a commercial penetrometer to achieve reliable soil penetration readings for a tillage project at the Harrow Research Station.

A fully mechanized system for tomato transplanting was developed using plastic cells wound to form a carousel that could be used for non-intertwining transplants started in greenhouses with adequate space for the circular carousels.

The successful juice apple pick-up technology that was developed was used by one company to build and test a similar prototype machine with additional improvements of their own.

STATISTICAL RESEARCH

Biometrical support was provided to all branch objectives by designing and analyzing experiments, by maintaining and enhancing computer software, and by doing research in areas lacking adequate statistical methodologies.

Collaborative work continued with scientists from across Canada on numerous projects including piglet behavior and housing; beef cattle production in the Northern Clay Belt of Ontario; vitamin and trace mineral uptake and metabolism in ruminants; and the relationship among volatile fatty acids in stored dairy cattle manure slurry. Statistical support was given to the studies on the effects of vomitoxin contamination of feeds on the performance of cattle, swine, and poultry.

The breeding programs for barley, oats, corn, wheat, and potatoes were supported through design and analyses of the experiments. Collaborative work with the Northern Agriculture Research Group included studies on forage crops, zonation studies, and research into honey production.

Collaboration continued on problems associated with the estimation of bioavailable energy and essential amino acids in poultry feeds. The effects of several commonly used labor-saving techniques and the errors introduced into the laboratory methodology by their use were examined. Procedures, which required less laboratory work and are suitable in many selection studies, were developed for estimating body composition of chicks.

Data collected from reference analytical materials prepared by Agriculture Canada were analyzed and the results indicated that these materials are suitable for use as biological reference materials; certification procedures are continuing.

Numerous taste panel experiments dealing with beef, turkey, and pork were designed in cooperation with the Food Research Institute (FRI). Other collaboration with FRI included studies on vitamin A retention in stored milk products.

In the area of statistical research, a nonrandom design with a special model for studying competition effects was developed. Methods were also developed for obtaining the optimum combination of replication number and plot size in field experiments. Methods for handling the problem of a constant coefficient of variation in yield data were made available to branch scientists. A method for the internal adjustment of field trial data for nonsmooth fertility trends was developed. A theorem showing that the clustering problem can be solved objectively by using maximum entropy and integer programming was established. Computer programs for simulation studies on the impact of outlier rejection techniques on the estimation of variance components were written.

Data analysis has been greatly improved by the acquisition of a VAX 750 minicomputer and the SAS, Genstat, and BMDP statistical packages. The systems and programming unit responded to 155 ad hoc requests for assistance, made over 60 enhancements to the library of statistical pro-

grams, and completed three large programming projects. The program library was used over 50 000 times in a 12-month period. Work is progressing on the specifications for a unique quantal bioassay package. The generalized lattice design has been included in the eastern cooperation trials module of programs.

TECHNICAL DEVELOPMENT AND SERVICES

Technical development machine shop

The machine shop is being modernized through the acquisition of numerically controlled (NC) equipment, including a lathe and milling machine. This will have an impact on the engineering research program through more efficient manufacture and fabrication of components for the development of machines and instruments. Shop staff are undergoing training to write their own programs for operating the equipment.

Maintenance services

The service for maintaining research equipment on the Central Experimental Farm campus continued. Some 1500 maintenance work orders were completed. The preventive maintenance (PM) program continued and proved its efficiency by the reduced number of emergency repair calls.

Engineering data base

The data base on agricultural engineering research and development was further expanded and now contains 24 000 entries encompassing reports from the agricultural engineering literature. The major focus is on North American and United Kingdom literature.

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B. Picard, B.Sc., M.Sc., Ph.D.	Microbial biochemistry
L.F. Russell, B.Sc., M.Sc.	Nutrient analysis

Departures

K. Lapsley, B.Sc., M.Sc. Transferred to Quebec Region	Food science services

C. Willemot, B.Sc., M.Sc., Ph.D. Transferred to Quebec Region	Lipid biochemistry
G. Paquette, B.Sc., M.Sc. Transferred to Food Production and Inspection Branch	Dairy products

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Kazi Shamsuzzaman Natural Sciences and Engineering Research Council postdoctoral fellowship, 1984–1985	Dairy microbiology
Carmen San Jose Food Science Department, University of Madrid postdoctoral fellow, October 1985–April 1986	Dairy product microbiology

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INTRODUCTION

The aim of the Food Research Institute (FRI) is to assist the Canadian food industry in becoming more efficient, productive, and competitive by developing new processes and prototype ingredients, and by improving the quality, safety, and nutritional value of food. Research activities and technical services are directed toward food quality, ingredient development, food safety, and nutrition. By a combination of in-house research, information, and advisory services, and the management of research contracts and grants, the Food Research Institute contributes to consumer protection and the development of the agri-food industry.

The institute manages the interdepartmental research contract fund aimed at resolving economic and technical problems in the food processing, distribution, and retail sector. In addition, institute staff evaluate and manage research projects funded by other government departments and agencies.

Institute staff make a significant contribution to the expert committees of the Canada Committee on Food. In addition, several scientists participate in international food programs such as Codex Alimentarius, the Food and Agriculture Organization, the International Dairy Federation, and the International Consultative Group on Food Irradiation. The Interdepartmental Committee on Codex Alimentarius is chaired by the director of FRI.

New emphasis was placed on the transfer of technology to industry. An inventory of technology developed at the Food Research Institute since 1960 was prepared. A list of pilot-scale processing equipment is also available. Collaborative arrangements with the food industry are being encouraged.

In 1985, Dr. L.E. Lloyd and M. Nazarowec-White joined the institute. Dr. Lloyd is team leader, Food Safety and Nutrition Section, and Maria Nazarowec-White replaces K. Lapsley in the food science services post. Dr. M. Sahasrabudhe was appointed assistant director.

This report provides highlights of research activities in 1985. Publications and more detailed information can be obtained by writing to the Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

N.W. Tape
Director

PROCESSING TECHNOLOGY

Oat starch

Rheological studies have been conducted on oat and wheat starches in order to explain the differences in functionality between them. Flow curves, developed on 3.5% cooked starch pastes, showed oat starch to display a high yield point at low shear rate and to exhibit a large degree of thixotropy when run at 70°C. In contrast, wheat starch possessed a small yield point and was substantially pseudoplastic. Oat, corn, and wheat starches were also cooked at low concentration (0.4% w/v) and centrifuged; then the volume fraction of the sediment (ϕ) and the concentration of starch in the soluble phase (C_s) were measured. Also recorded was the absorption maximum of each iodine-stained fraction. Results indicated that values of ϕ (oat) were 1.4 and 1.55 those for corn and wheat, respectively, while oat C_s values were 7.0 and 14.4 times. The λ_{max} for the corn and wheat iodine–starch complex was 635–640 nm compared with 590 nm for the oat complex. These results indicate that in oat starch, both amylose and amylopectin leach from the granule simultaneously, whereas amylose is preferentially leached from corn and wheat starches. Because oat starch displays a higher swelling power and solubility, the amount of water available to the soluble starch fraction is less. The combination of a highly swollen sediment suspended in a viscous soluble matrix of amylose and amylopectin contributes to the observed anomalous behavior of oat starch pastes.

Oat starch has been shown to contain in excess of 1.0% internally bound lipid, which upon heating in the presence of water forms a reversible complex with the oat amylose. Differential scanning calorimetry studies have shown that the presence and quantity of this oat amylose–lipid complex markedly retards the rate and extent of recrystallization of the starch polymer chains which is likely associated with the observed stability of oat starch pastes toward refrigerated storage.

Cereal phenolics

Reports of potent anti-inflammatory, antihistamine, and antifungal activities of *N*-aroylanthranilic acid derivatives such as the avenanthramides recently found in oats have led to attempts to structurally characterize this group of

oat constituents. To date some 20 different avenanthramides have been detected in oat bran and oat hull extracts. The structures of several avenanthramides have now been confirmed. These include the *N*-feruloyl, *N*-*p*-coumaroyl, and *N*-caffeoyl derivatives of anthranilic and 5-hydroxyanthranilic acids. A second group consists of the analogous amides of 4-hydroxyanthranilic acid. A third group contains at least four compounds in which both 5-hydroxy- and 4-hydroxyanthranilic acids are acylated with 4′-hydroxy- and 4′-hydroxy-3′-methoxy cinnamylideneacetic acids. These latter acids are of particular interest, because they may be involved not only in color quality of oat-based ingredients (breakfast cereals and baking formulations) but also in flavor quality.

Cereal β-glucans

Work has continued in collaboration with Carlsberg Research Laboratories to develop an assay of (1→3)(1→4)-β-D-glucan-4-glucanohydrolase activity based on release of dye from an insoluble dye–glucan complex. Substrate precipitated by Congo Red performed better than that prepared using Calcofluor. The rate of dye release, which is proportional to enzyme concentration, was also influenced by dye content in the substrate and source of substrate. Substrates that gave good linear response with bacterial enzyme at pH 6.5 did not necessarily give linear responses with malt extracts. However, suitable substrate and conditions have been determined, which allow measurement of malt β-glucanase.

Development of automated methodology for measurement of β-glucan has continued, based on the enzymic release of tri- and tetra-saccharides, the rate of which is determined by high-performance liquid chromatography. The method has been applied to measuring digestion of β-glucan products in chicks and rats. In collaboration with the Animal Research Centre, chicks fed 1, 10, and 20% oat gum in their diets showed approximately 0, 7, and 13%, respectively, of β-glucan in the feces. At the higher β-glucan level a significant (but small) reduction in starch digestion was evident (as determined by measurement of fecal starch), but this was insufficient to explain the low metabolizable energy of β-glucan-containing grains such as barley.

Collaboration with Laval University has indicated that in rats fed oat gum, β-glucan was detected in gastric contents, but appeared to be mostly degraded during passage through the intestine.

Oat proteins

The thermal aggregating and gelling properties of oat proteins were studied. Oat globulins formed both soluble and insoluble aggregates upon heating, but without dissociation into subunits. Gelation occurred at higher protein concentrations. Both the extent of aggregation and gel hardness were affected by various environmental factors such as pH, ionic strength, protein concentration, heating temperature, heating time, and additives, which caused changes in the protein native structure. The results indicate that hydrophobic and ionic interactions are playing a major role. Heating at 100°C also led to significant changes in physicochemical properties of oat proteins including hydrophobicities, differential scanning calorimetric parameters, and ultraviolet and fluorescence spectral properties. These suggest that the native structure of oat protein was altered although the denaturation temperature is about 110°C.

Oat protein isolates were prepared on a pilot plant scale and were modified by succinylation. The functional performance of the modified proteins was studied in a model wiener system. When compared with the unmodified control, succinylation improved the cook yield in beef wieners and the cohesiveness and firmness in pork wieners.

Oat albumen was prepared on a pilot plant scale and added to an angel food cake formulation as a substitute for up to 40% of the egg albumen. There was a progressive decrease in cake volume and an increase in specific gravity of the batter. However, texture profile analysis did not show significant changes in firmness, cohesiveness, or springiness.

Oilseeds

In the preparation of rapeseed protein concentrate (RPC), extraction solvent and conditions are selected that solubilize and remove solutes and retain the protein in an insoluble form. Phytates present in the seed also remain insoluble and appear concentrated with the protein at up to 4% or more of the RPC product. This level of phytic acid exceeds that in soya protein concentrates by a factor of two or more and is of concern to nutritionists because it is known to lead to zinc deficiency in test animals. Zinc supplementation of diets containing RPC overcomes this deficiency. However, there is concern that zinc supplementation of RPC might compromise copper uptake from the diet. To examine this possibility, the zinc and copper status of young rats was investigated. The animals were fed a basal diet containing 20% protein from RPC to which were added increasing amounts of zinc (100, 150, 200, 250, and 300 mg/kg). Copper status was assessed by differences in the activities of heart and liver superoxide dismutase, cytochrome C oxidase, and serum ferrox-

idase (ceruloplasmin). Differences in the copper and zinc levels in the serum, liver, and heart, and in zinc levels in the femur, were used to determine effects on both copper and zinc status. Cytochrome C oxidase and copper concentrations in the heart were slightly but significantly reduced in the two highest zinc diets when compared with the lowest zinc diet. Zinc in the serum and liver increased significantly in the highest zinc groups, compared with the lowest zinc group. No significant changes between the groups were observed. The results suggest that zinc can be added to RPC to overcome the effects of phytic acid associated with RPC without compromising copper status.

DAIRY TECHNOLOGY

Microbiological quality of milk

Psychrotrophic bacteria growing in refrigerated milk produce heat-resistant enzymes such as proteinases and lipases, which cause deterioration of the quality of dairy products. A simple, rapid assay for microbial lipase based on hydrolysis of β-naphthyl caprylate was developed. The assay was modified for skim milk by including a proteolytic enzyme (trypsin) to digest milk proteins. The assay was effective with a wide variety of lipases from different strains of psychrotrophs, and was sensitive enough to detect 1 L of spoiled milk in 40 000 L of skim milk.

Further studies on the mechanism of extracellular lipase and proteinase synthesis by psychrotrophic bacteria revealed that during mild thermal stress (32°C), enzyme synthesis was repressed; however, cells recovered rapidly after cooling to the normal growth temperature (20°C). Heat treatment was found to inactivate labile ribonucleic acid required for enzyme synthesis. In other studies, iron was found to repress extracellular enzyme synthesis. Enzyme secretion in a mineral medium was stimulated by the addition of an iron-chelating pigment, pyoverdine, normally produced by the psychrotroph during the latter stages of growth.

Quality of ultra-high-temperature milk

A heat-stable proteolytic enzyme native to milk (plasmin) has been implicated in the spoilage of ultra-high-temperature (UHT) milk. A computer program to predict survival of plasmin during UHT processing was evaluated in the UHT pilot plant at FRI. Highly significant correlations (r = 0.812 and 0.988) were obtained between theoretical and experimental residual activities. The computer model may be of value for predicting shelf life of UHT milk based on processing conditions.

Influence of pasteurization on survival of *Salmonella*

Recent incidents in which *Salmonella* have been found in Canadian dairy products (specifically Cheddar cheese) have raised concerns regarding the sensitivity of *Salmonella* spp. to temperatures normally associated with the heat treatments of milk. In a collaborative study between FRI and the Health Protection Branch, Health and Welfare Canada, 10 strains of *Salmonella* were exposed to temperatures of 60–74°C for 16 s. The results indicate that a temperature of 64.5°C produced a 4-log reduction in viable counts, whereas at 60°C, approximately a 3-log reduction was obtained.

Thermal stability of whey proteins

The functional behavior of proteins is determined by the structure and the nature of intramolecular forces. Differential scanning calorimetry (DSC) was used to determine the thermal stability and denaturation of β-lactoglobulin and to assess the nature of those forces.

Polyols modified thermal stability and denaturation of β-lactoglobulin. Anionic polysaccharides, starch, and gums increased thermal stability of β-lactoglobulin to varying extents; but, unlike most polyols, the anionic polysaccharides broadened the temperature range of denaturation.

The thermal characteristics by DSC of β-lactoglobulin were examined in the presence of various structure-perturbing agents, e.g., pH, ionic strength, salts, detergents, urea, disulfide-reducing agents, and ethylene glycol. An analysis of those characteristics demonstrated that thermal stability of β-lactoglobulin arose mainly from hydrophobic interactions and to a lesser extent by hydrogen bonds and electrostatic interactions. Disulfide bonds were less critical to the thermal stability.

Molecular genetics and physiology of lactic starter cultures

Characterization of lactic streptococcal strains carrying different plasmid DNA molecules has revealed a novel mechanism for development of high-level (>10 mg/mL) streptomycin resistance. Loss of 5 Md plasmid resulted in a high-level of resistance, whereas strains carrying it naturally or by genetic transfer inhibited the development of drug resistance.

Buffers are needed in media for growing cultures, but some result in genetic changes. Organic phosphate (disodium β-glycerophosphate) is widely and successfully used, but it is

expensive. Inorganic and organic phosphates were compared for their effect on buffer capacity and on stability of plasmid DNA. At equimolar concentrations, inorganic phosphate showed increased buffering capacity and plasmids were more stable. Plasmid stability was tested by the appearance of lactose-negative variants in batch culture and in continuous culture in a chemostat. The results showed clearly that successful propagation of lactic starter cultures in both batch and continuous culture with inorganic phosphate can be achieved at lower cost without any selection of cells with undesirable characteristics.

Ricotta and Queso Blanco cheeses

Improvements were made in the continuous process for producing ricotta and Queso Blanco cheeses. Handling characteristics and yield of cheese were improved by one or more of the following: adding 1% sodium chloride to the product prior to heating; increasing the pH of the milk–whey blend (to 6.8–7.0) prior to heating; using two-stage indirect heating followed by direct steam injection to denature the whey proteins; and injecting larger quantities of a weaker acid solution to obtain pH reduction.

STRUCTURE AND SENSORY EVALUATION

Carbohydrates

Research collaboration continued with the Delhi Research Station on the characterization of minor cell-wall polysaccaride components of cured laminae in tobacco leaves. Certain components from the sodium-hydroxide-soluble fraction were successively fractioned using chromatography on columns and finally copper complexing to yield a xylan which was ~70% pure. Methylation studies indicated that it was composed of a linear chain of β-(1→4)-linked D-xylose units.

The xylans of angiosperms generally consist of a backbone of β-(1→4)-linked D-xylopyranosyl units with branching through L-arabinose or D-glucuronic acid units (or its methyl ether) or both. Xylan from the tobacco leaf laminae appears to be unbranched and is similar to that reported from tobacco stalks. The characterization of a xylan from the laminae of tobacco leaves has not been reported before. The presence of xylans in the leaf laminae, midrib, and stalks support the view that these polymers originate in the vascular tissues of the tobacco plant. Being lignified, they protect the various parts of the plant against biochemical degradation and physical injury.

Microstructure

Effects of emulsifying agents (phosphates and citrates) on the microstructure of process cheese were studied by electron microscopy. Queso Blanco cheese (made by acidulating milk at 90°C) present in a cheese blend was detected in the finished process cheese because of its unique core-and-lining structure. Long protein strands were found in process cheese irrespective of its firmness. Crystals of melting salts present in some commercial cheeses have indicated their excessive use; the crystals were analyzed in situ by energy dispersive spectrometry for elements such as phosphorus, sodium, aluminum, and calcium. Emulsification of fat was evaluated from the shapes and dimensions of fat particles. Under similar conditions, melting salts that have a moderate calcium-sequestering ability, such as citrate, produced a soft process cheese with large fat particles, whereas melting salts with a stronger calcium-sequestering ability, such as sodium hexametaphosphate, produced hard cheese with small fat particles. Because it is a problem in the manufacture of process cheese, hot melt was studied from microstructural as well as rheological viewpoints.

Parallel orientation of protein strands in Kachkaval cheese was studied by scanning electron microscopy and related to a similar structure observed in Cheddar cheese.

Other collaborative studies revealed that syneresis in yogurt was related to the microstructure of the protein matrix, milk encapsulated in agar gel tubes did not retain its initial distribution of casein micelles, and casein micelles heated at 200°C reacted with glutaraldehyde at this temperature and became distorted and partially disintegrated.

Microscopy

Rapid and simple techniques of fluorescence microscopy were developed to study the size and distribution of fat globules in cheeses derived from different processing methods, using Nile Blue A as a lipid marker. Acridine Orange was used to probe structural differences between protein matrices of these cheeses. These staining techniques were applied to simultaneously study the structural and microchemical compositions of the ripe and the less-ripe zones of Camembert cheese. Fat globules were not detected in the ripe zone immediately below the surface molds, but were present in other areas of the cheese. On the other hand, the ripe zone contained a protein matrix that was structurally and chemically different from that of other areas.

Microscopic techniques suitable for detecting mineral deposits in various food (cereal and

cheese) structures were developed. These techniques (using Acriflavine HCl, Alizarin Red S, and Acridine Orange) were relatively simple to perform and provided convenient means for rapid screenings of food products.

Sensory

Collaborative research projects were conducted with the scientists at the Fredericton Research Station, the Food Research Institute, and some divisions of the Food Production and Inspection Branch of Agriculture Canada. Hull-less oats developed at the Ottawa Research Station were fed at various levels to barrows and gilts in place of corn–soybean meal. Sensory evaluation of the pork from this feeding trial revealed that at the 100% replacement level the meat was more flavorful, juicier, and more tender. Pork from animals fed at the 0 and 50% levels did not differ significantly.

In a similar study at the Fredericton Research Station, high levels of cull potatoes were incorporated in the diets of beef cattle. Trained panelists found that beef from animals fed cull potatoes was not significantly different in sensory qualities from beef from barley-fed animals.

Producers of canned tomatoes are required to pack tomatoes in tomato juice. In order to detect the addition of water to the juice, a simple rapid method was required for inspectors. All panelists were able to detect a color difference in juices from solid-pack tomatoes containing varying amounts of water. A photographic color standard for juices with various water contents was also prepared. Both methods, sensory and photographic standards, are being evaluated by Agriculture Canada inspectors.

FOOD SAFETY AND NUTRITION

Nitrite in cured meats

Treatment with nitrite prevented the oxidative breakdown of lipids during storage of pork meat, as measured by the thiobarbituric acid (TBA) test, lipid fluorescence, lipid phosphorus, total phospholipid fatty acids, and polyunsaturated fatty acids (PUFA) in phospholipids. Neither storage nor nitrite treatment affected the triglycerides. Nitrite also prevented the formation of an unidentified lipid during storage. Cooking with nitrite prevented the increase in TBA numbers and lipid fluorescence but not the decrease in levels of polar lipid PUFAs. An increase in free fatty acids (FFA) in the nitrite-treated samples, relatively high levels of PUFAs in this fraction, and a decrease in FFAs and PUFAs during storage suggest that FFAs were important intermediates in the oxidative degradation of the polar lipids. Lipid fluorescence as a measure of PUFA oxidation showed the same trend as TBA numbers.

Nitrite-free cures for cooked pasteurized pork were evaluated for their effectiveness to prevent the growth and toxin production of a mixture of spores from types A and B strains of *Clostridium botulinum*. Cures formulated with either sodium hypophosphite or monomethyl fumarate offer a level of protection that can be favorably compared with that provided by 150 ppm of sodium nitrite.

Vitamin C

Development of a method based on high-performance liquid chromatography for determining vitamin C (ascorbic acid) in fresh produce has been completed. Recoveries of the vitamin from fresh tomato samples that had been spiked with known amounts of ascorbic acid ranged from 96 to 104%. Determination of the vitamin C content of fresh tomatoes by this method compared favorably with similar analyses using the standard indophenol titration method; i.e., the results from these two methods differed by less than 2%.

A 3-year survey of the fork-level vitamin C content in table-ripe fresh tomatoes has been completed. Canadian consumers can reasonably expect fresh tomatoes, when purchased, to contain an average of 15.2 mg of ascorbic acid per 100 g of fresh weight. This is approximately 15% less than the United States value normally quoted by nutritionists and may be a reflection of the shorter local growing season and longer transit times inherent in northern markets. Domestic produce, on average, contained slightly more vitamin C than imported fresh tomatoes. In general, the vitamin C content of commercial fresh tomatoes followed a yearly cycle that peaked during the summer and was at its minimum during the winter.

Inhibition of surface mold on salami

To prevent the development of potentially toxigenic surface mold on salami, a double dip of the product in 5% (w/v) potassium sorbate proved to be the best treatment. A single dip of salami in 5% (w/v) potassium sorbate, with hydroxypropyl methycellulose (HPMC) as carrier, did not improve anti-mold efficacy. Both treatments resulted in residual levels of sorbate in the meat that were as high as, or higher than, those following a 10% (w/v) single dip in potassium sorbate. Desirable micrococci were inhibited in salami treated twice with 5% (w/v) potassium sorbate or with 5% (w/v) potassium sorbate plus HPMC. No discoloration of the meat was noted with either treatment.

Salmonella control in egg washwater

The survival and thermal resistance of *Salmonella typhimurium* were studied to better characterize conditions necessary for its elimination from egg washwater. *Salmonella* grew at ≤42°C when the washwater pH was ≥9.5, but substantial lethality was noted at pH ≥10.0. During refrigerated storage, *Salmonella* survived 18 h without lethality up to pH 11.0 in the washwater. Tests also showed that a pH paper with a narrow range (pH 8–10) could be used effectively at grading stations to monitor detergent additions to washing machines.

Digestibility of dietary proteins

Model digestible and undigestible fragments of dietary proteins (tripeptides) with highly racemized amino acids on the internal sites were synthesized for in vitro digestibility studies using intestinal enzymes. The results will serve to assess the nutritive value of racemized dietary proteins.

Availability of niacin in wheat bran

The availability of total niacin in coarsely ground versus finely ground wheat was studied. Experimental conditions were established (temperature, pH, digestion time, shaking action, type and quantity of enzyme, and dilution of samples) for an in vitro model system of the stomach (S), intestine (I), and combined stomach and intestine (S/I). The quantity of niacin released into the liquid portion of the in vitro model digestive system was determined by standard methods (Association of Official Analytical Chemists). The overall range of niacin released for all experimental conditions was 71–82%. For both the S and I digestive systems, the proportion of released niacin was slightly greater in fine bran than in coarse bran; however, for the combined S/I system, it was similar for the two types of bran. There was no obvious difference among the three in vitro model digestive systems in respect to the amount of niacin released.

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C. Tarnocai, B.S.F., M.S.	Soil correlation—British Columbia, Atlantic region, and North

Newfoundland Soil Survey (St. John's)

E.F. Woodrow, B.Sc.	Head of Unit
F. Hender, B.Sc.	Party leader

Prince Edward Island Soil Survey (Charlottetown)

C. Veer	Senior soil survey technologist

New Brunswick Soil Survey (Fredericton)

H.W. Rees, B.Sc.	Head of Unit
S.H. Fahmy, B.Sc., M.Sc.	Party leader

Nova Scotia Soil Survey (Truro)

K.T. Webb, B.Sc., M.Sc.	Head of Unit
D.A. Holmstrom, B.S.A.	Party leader
G.T. Patterson, B.Sc., M.Sc.	Party leader

Quebec Soil Survey (Sainte-Foy)

J.M. Cossette, B.Sc.	Head of Unit
L. Grenon, B.S.A.	Party leader
L. Lamontagne, B.Sc.	Party leader
M.C. Nolin, B.S., M.Sc.	Party leader

Ontario Soil Survey (Guelph)

C.J. Acton, B.S.A., M.Sc., Ph.D.	Head of Unit
R.K. Jones, B.Sc., M.Sc.	Party leader
E.W. Presant, B.S.A., M.Sc.	Party leader
G.J. Wall, B.S.A., Ph.D.	Party leader

Manitoba Soil Survey (Winnipeg)

R.E. Smith, B.S.A., M.Sc.	Head of Unit
R. Eilers, B.S.A., M.Sc.	Party leader
W.R. Fraser, B.Sc., M.Sc.	Party leader
W. Michalyna, B.S.A., M.Sc., Ph.D.	Party leader
H. Veldhuis, Ing., M.Sc.	Party leader

Saskatchewan Soil Survey (Saskatoon)

D.F. Acton, B.S.A., M.Sc., Ph.D.	Head of Unit
A.J. Anderson, B.Sc.	Party leader
W.D. Eilers, B.S.A., M.Sc.	Party leader
L.M. Kozak, B.S.A., M.Sc., Ph.D.	Party leader
G. Padbury, B.S.A., M.Sc.	Party leader
H.P.W. Rostad, B.S.A., M.Sc., Ph.D.	Party leader
H.B. Stonehouse, B.S.A., M.Sc.	Party leader

Alberta Soil Survey (Edmonton)

W.W. Pettapiece, B.Sc., M.Sc., Ph.D.	Head of Unit
J.A. Brierley, B.Sc.	Party leader
G.M. Coen, B.Sc., M.Sc., Ph.D.	Party leader
J.C. Hiley, B.A., M.A.	Party leader
J. Tajek, Eng.	Party leader
B.D. Walker, B.Sc., M.Sc.	Party leader

British Columbia Soil Survey (Vancouver)

D.E. Moon, B.S.A., M.Sc., Ph.D.	Head of Unit
A.J. Green, B.S.A., M.Sc.	Party leader
C.J. Selby, B.Sc., M.Sc.	Party leader
L.J.P. van Vliet, B.S.A., M.Sc.	Party leader

Yukon Soil Survey (Whitehorse)

C.A.S. Smith, B.Sc., M.Sc.	Head of Unit

Soil Classification

J.A. McKeague, B.A., B.S.A., M.Sc., Ph.D.	Head of Section
C.A. Fox, B.A., M.Sc., Ph.D.	Micromorphology
P.E.M. Lévesque, B.S.A., M.S.A., Ph.D.	Organic soils
S.P. Mathur, B.Sc., Assoc.I.A.R.I., Ph.D.	Organic soils
G.C. Topp, B.S.A., M.S., Ph.D.	Physics and water
C. Wang, B.S.A., M.S., Ph.D.	Chemistry
G. Wilson, B.Sc., M.Sc., D.I.C.	Engineering
K.C. Wires, B.A.	Physical structure

Land Use and Evaluation

J. Dumanski, B.S.A., M.Sc., Ph.D.	Head of Section
D.R. Coote, M.S., Ph.D.	Degradation
J. Culley, B.Sc., M.Sc.	Water quality
R. De Jong, B.Sc., M.Sc., Ph.D.	Water use
E. Huffman, B.Sc., M.A.	Land use
K.B. MacDonald, B.S.A., M.Sc., Ph.D.	Evaluation
K. Switzer-Howse, B.Sc.	Information

Agrometeorology

J.C. van Schaik, M.Sc., Ph.D.	Head of Section
J. Boisvert, B.Sc., M.Sc.	Farm weather service research
A. Bootsma, B.Sc., M.Sc.	Agroclimatological resources
R.L. Desjardins, B.Sc., M.A., Ph.D.	Micrometeorology
L.M. Dwyer, B.Sc., M.Sc., Ph.D.	Environmental meteorology
S.M. Edey, B.Sc.	Applications
H.N. Hayhoe, B.Sc., M.S., Ph.D.	Biomathematics
A.R. Mack, B.S.A., M.Sc., Ph.D.	Remote sensing
D.W. Stewart, B.S.A., M.Sc., Ph.D.	Crop-weather modeling

Departures

T.M. Lord, B.S.A. Retired 17 May 1985	Head, British Columbia Soil Survey Unit
B. Kloosterman, B.S.A., Ph.D. Retired 7 November 1985	Data system

VISITING SCIENTISTS

F. Chahuneau France	Computer analysis
R. de Faria Brazil	Soil-water engineering
S. Dumontet Italy	Postdoctorate
K. Maeda Brazil	Data processing
M. Yanuka Israel	Soil physics
S. Zegelin Australia	Soil physics
Z. Zeng China	Application of remote sensing to land use soil information system

INTRODUCTION

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

During the past 3 years the institute has responded to the growing concerns about the degradation of the Canadian soils. Degradation assessments of eastern Canada were undertaken and a western reassessment is to be completed shortly. Activities in the institute have emphasized the development of approaches and methods for assessing degradation and their application in the field. The institute has become more directly involved in the application of soil survey and agrometeorological information for agricultural regional development, conservation programs, the development of farm weather services, and similar activities involving the application of land information for development planning.

This report gives the outcome of the ongoing activities of the institute during 1985. More complete information can be obtained from the Land Resource Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J.S. Clark
Director

INSTITUTE ROLES

The activities of LRRI include research, development, and services related to Canada's land resources. These activities not only support other research within the Research Branch but also provide information essential to policy and decision-making for regional and national levels of government, educational institutions, and 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. The LRRI through 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.

Soil degradation. Increased effort has been devoted to the assessment of the degree and extent of soil degradation in all regions of Canada. At present, maps and data are being prepared to provide general broad-scale information on soil degradation in all regions. Technologies and procedures for monitoring soil degradation are also being developed.

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

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

Crop information system and agroclimatic resources. Agroclimatic resources are assessed to provide information for efficient management of agricultural resources. Work on crop information systems has been reduced and present activities are concentrating on maintaining familiarity with new developments.

Committees. LRRI contributes to the integration of land-related and agrometeorology 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
- Canada Expert Committee on Agrometeorology
- Atlantic Advisory Committee on Agrometeorology
- Ontario Climate Advisory Committee
- Canadian Advisory Committee on Remote Sensing and associated committees
- Comité de coordination des services agricoles du Canada (CCSAC)
- Commission d'agrométéorologie du Conseil des productions végétales du Québec (CPVQ)
- Atmospheric Environment Service (AES) Task Force on Standard and Nonstandard Climatic Data
- Canadian Committee on Climatic Fluctuations and Man
- Atlantic Forage Crops Zonation Committee (ad hoc committee of Atlantic Advisory Committee on Forage Crops)
- Interdepartmental Task Force (Crop Information System)
- Ontario Agrometeorology Research Committee
- Expert Committee on Agrometeorlogy Subcommittee on Automated Data Acquisition
- Canadian Climate Program Socioeconomic Committee
- Canadian Climate Program Data and Applications Committee

INSTITUTE PROGRESS AND ACHIEVEMENTS

Soil resource inventory and mapping

Newfoundland. The Port-au-Port and Botwood soil reports were published, as were the Canada Land Inventory agricultural capability maps for Gander, Red Indian Lake, Burgeo, and Bonavista. Newfoundland's contribution to the generalized soil landscape map was completed. This information provided the basic data for the soil erosion map of the province. The final manuscripts of soil reports for Red Indian Lake and Terra Nova were completed and sent to Ottawa for publication. The first drafts of the Stephenville, Port-aux-Basques, and Grandys Lake–Friars Cove soil reports and maps, as well as the soil and capability maps and reports for Green Bay, were submitted to LRRI for editing.

Prince Edward Island. A soil and water conservation program was initiated in cooperation with federal and provincial government agencies (Environment, Agriculture, Fisheries and Oceans, and Forestry). Interpretations of the suitability of soils for a number of uses were provided to various agencies. Soil moisture and temperature benchmark sites were monitored bimonthly.

New Brunswick. Aproximately 7500 ha were surveyed in the Woodstock–Florenceville area. A soil performance and management file was established for potato production in order to develop more accurate interpretation guidelines for this crop. Contract work under an Economic Regional Development Agreement (ERDA) on soil evaluation and mapping for agricultural land development and management in Westmorland County was supervised. A second ERDA project on the identification and characterization of dense compact subsoils in New Brunswick's agricultural lands was finalized. Soil moisture and temperature monitoring continued, with emphasis on the Woodstock–Florenceville area.

Nova Scotia. The soil maps for Colchester County, Pictou County, and the Kentville Research Station–Sheffield Farm have been digitized and preliminary maps are now available upon request. Correlation continued on the detailed surveys under contract in the Annapolis Valley, the Cobequid Shore, and the Northumberland Shore regions of the province with 41 map sheets completed at a scale of 1:20 000. Twenty-eight soil map sheets at the 1:20 000 scale, completed last year, are being prepared for publication in a preliminary form for public use. Assistance was provided to the Planning Department of Kings County for this work in protecting high capability agricultural land by interpreting 14 soil maps from the Annapolis Valley for agricultural capability. A very detailed soil survey (1:5000) of the Nappan Experimental Farm (250 ha) was completed in order to provide soil information for the farm's cropping and pasture program for beef cattle production. Monitoring of soil temperature and water table levels at 25 sites was continued, with over 1400 readings being collected.

Quebec. The Verchères County interim report and maps were completed. Reconnaissance mapping was completed in 10% of Rouville County and detailed mapping was completed in 80% of

Chambly County. A report on the peatlands of the St. Lawrence Valley was completed and sent to reviewers. An accompanying map manuscript of the peatlands of southern Quebec has also been completed and submitted for final drafting.

Ontario. The soil reports and generalized soil maps for the Haldimand–Norfolk and Chapleau–Foleyet areas were published. Maps were printed for the Blind River–Sault Ste. Marie, Sudbury, International Falls–Rainy River, and Kenora–Dryden map sheets, Pukaskwa National Park, and the Ottawa–Carleton region. Field mapping was completed in the Niagara region (13 000 ha) and continued in Middlesex County (15 000 ha) and soil maps were compiled for all of Brant County. Soil erosion research continued, involving testing and calibration of the rainfall simulator for evaluating soil erodibility. A final report was prepared on soil interpretations for forest land management in southern Ontario and program approval was obtained from the Ontario Ministry of Natural Resources for continuation of this work. User friendly software was developed to generate, on request, derivative maps for soil interpretations in support of the Niagara soil survey.

Manitoba. Soil survey reports and maps were published for the Waterhen map area; Swan River Townsite; Westbourne; St. Rose du Lac; Minnedosa–Hallboro; Beaudry Park; the townsites of Landmark, Letellier, Rosenort, and St. Jean; and the map only of the Grand Rapids study area. The survey of approximately 780 km^2 at 1:20 000 scale and 560 km^2 at 1:50 000 scale was completed in portions of the rural municipalities (RM) of Roland, Dufferin, Grey, Lorne, South Norfolk, MacDonald, and Woodlands; the Whitemouth peatland area; and the urban–rural fringe surrounding Newdale, Birtle, Shoal Lake, and Snow Lake townsites. Twelve LRTAP–acid rain monitoring sites and three timber harvest sites affected by heavy metal fallout from a smelter at Thompson were sampled for background chemical data for the federal Forestry Service and the provincial Department of the Environment. Completed to publication stage were a series of provincial maps at the 1:1 000 000 scale depicting the extent and degree of salinization of agricultural land on one map, two maps indicating the risk of soil erosion by water, and two maps indicating soil sensitivity to acidic inputs and potential of soils and bedrock for neutralizing acidic deposition. A contribution was also made to the development of the *Soil Survey Handbook* by completing the first draft of an engineering applications section in Chapter 500 and by working on the soil water and soil temperature monitoring field methods in Chapter 600.

Saskatchewan. Mapping was completed on approximately 85 150 ha in the Melfort area and 799 000 ha in the Battlefords area. Maps have been compiled and digitized, extended legends prepared, and the first drafts of reports completed for eight more rural municipalities (RM). The published report for the Wolseley RM, the first in a new, highly interpreted publication series, was distributed and evaluated. Similar reports for the Indian Head and Chester RMs were printed. Also prepared were soil salinity and erosion maps at the 1:1 000 000 scale. Research on the nature of soil acidity and the field response to liming was continued. Studies on the characterization and classification of clay soils, the nutrient-supplying power of minerals in selected Saskatchewan soils, available water capacity, and long-term monitoring of the hydrological properties of a typical prairie soil landscape were continued.

Alberta. Final editing was completed on the Warner and Oyen reports, the Medicine Hat map, the physiographic maps, and the water erosion bulletin, and all were submitted for publication. A joint survey project was initiated with the Alberta Research Council and Alberta Agriculture in Flagstaff County, with completion of a project outline and mapping of 20 townships (185 000 ha). A map at the 1:1 000 000 scale showing the water erosion potential in Alberta was completed using the computerized soil data base. The Alberta portion of a soil landscape map at the 1:1 000 000 scale was completed.

British Columbia. The Fort St. John–Dawson Creek soil report was submitted for publication and the three Indian Reserve lands reports and maps were published and distributed. The Nazko, Williams Lake, and Saltspring Island soil report manuscripts were submitted for editing. The agricultural capability ratings for the Peace River soils were updated. A paper on soil variability and its influence on soil interpretations was presented at the British Columbia Soil Science Workshop and a report on a reliability study of a high intensity soil survey on Vancouver Island was also completed.

Yukon Territory. Field work and preliminary maps were completed for the second portion of the Whitehorse area soil survey in the Takhini and Carcross valleys. A detailed (1:20 000 scale) soil survey of Herschel Island was completed and a preliminary map prepared for the Parks Branch of the Yukon Department of Renewable Resources.

In cooperation with the Yukon Government, the second year of forage crop fertility trials was successfully completed. An extensive report outlining the results of the first year's trials was prepared and distributed to local agriculture association members and relevant government agencies. The soil-testing program for commercial farmers was continued and a third year of results processed.

Northwest Territories. The Bathurst–Cornwallis Island soil report was completed, as were the first drafts of the Southern Keewatin soil landscape maps. The field work relating to soil studies on Ellef Ringnes Island and the study of buried soils in the Little Bear River area were completed. Soil temperature studies were continued in the Inuvik area.

Ottawa. Twenty soil survey projects were correlated by field reviews, legend reviews, and report edits. Reports on the peat resources of Canada, soil landscapes of Canada, and soil-water investigations were published or partially completed. Procedures were developed for using hand-held computers for field data collection.

Cartography. The cartography section has completed 29 soil maps for Agriculture Canada and 17 maps for Environment Canada. In addition, 22 maps have been digitized and 361 miscellaneous drafting projects have been completed. Sixty-eight new mapping projects have been started for Agriculture Canada and 15 for Environment Canada. A total of 126 digital maps have been completed for the Canada Soil Information System and 434 interpretive maps were produced.

Generalized Soil Landscape Mapping. The 1:1 000 000 scale computerized generalized soil landscape maps, including the associated soil and landscape data base, will provide a uniform national information system for various interpretive and derivative maps. Plans were finalized to compile maps in two phases, based on broad regional areas. Phase 1 includes the dominantly agricultural region approximating the area within the Canada Land Inventory boundary. Phase 2 includes the rest of the area of Canada. A map index for both phases and the base maps for phase 2 were prepared. For each map polygon, an extended legend data set was compiled in a computer-compatible format documenting the dominant and subdominant property classes that differentiate one map polygon from another. Provisional maps for phase 1 were prepared to satisfy immediate user requests. This was especially necessary since these maps serve as the data base for the national soil degradation maps.

Soil classification

The Soil Classification Section undertakes research relevant to the needs of soil inventory and interpretations thereof, publishes basic information on the nature and genesis of soils, and provides field and laboratory services for all sections of LRRI. Progress is reported in the projects and services.

Soil water and structure. The motivation behind this project is to show the ways by which soil structure influences the water and air regime of soils; and to develop improved methods to characterize the soil structure. A bulletin on describing and interpreting soil macrostructure has been published. It gives guidelines for estimating selected air–water properties of soil, such as horizontal and vertical components of the saturated hydraulic conductivity, aeration porosity, bulk density, and plant available water capacity. The thorough testing of these guidelines against current measurement methods resulted in improvements in the measurements for these properties, both in the laboratory and in the field. Workshops to prompt soil surveyors and other professionals to use the guidelines were held in Ontario and the Atlantic Provinces.

The aeration porosity determined during desorption of water from soil was lower than that obtained from micro- and macro-morphological analyses of pore geometry. The estimates from macromorphology in the field require much less time and effort than those from the other methods.

The shrinkage of a structured soil was measured in the laboratory using an improved procedure for measurement of very wet soils. The Dalhousie soil did not exhibit well-defined phases of shrinkage, as has been reported by others. A field site has been instrumented to monitor, in situ, the shrink–swell behavior of a structured soil.

A critical assessment of the performance of the IRAMS–TDR water content instrument led to an improvement of the operation of the instrument. The IRAMS, being manufactured in Ottawa, is now being marketed world wide. The potential for application of TDR to irrigation scheduling was investigated and reported. Theoretical development and experimental testing of the possible application of TDR to the measurement of soil conductivity (i.e. salinity) is currently under way.

Improvements were made in procedures for exchanging soil water by acetone prior to impregnation with resins and preparation of thin sections. A specific gravity method was found to be adequate for determining water in acetone during

the exchange process, but nuclear magnetic resonance was more sensitive.

Mineral soils. The mineralogical variability of the clay from Ap and BCg horizons of 20 pedons in a map unit near Ottawa was measured. Smectite, mica, and vermiculite were the dominant clay minerals. There were few significant differences in the lateral distribution of these minerals. There were, however, several highly significant differences, resulting from pedogenic weathering, in their vertical distribution. Although other soil properties such as particle-size distribution and organic matter content were variable laterally, their influence on clay mineralogy was not evident.

Determination of oxalate-extractable Si and Al is useful in assessing the degree of accumulation of allophane-like materials in Podzolic soils. Three procedures were tested for determining Si: an automated and a manual spectrophotometric method and an atomic absorption method. For lower concentrations of Si, results by atomic absorption were not reliable. Determination of Si by autoanalyzer is the preferred procedure as it is convenient, sensitive, and reliable. Methods for determining extractable boron in soils were compared and a procedure involving extraction with hot 0.02 *M* $CaCl_2$, color development with azomethine-H, and correction for background color was selected for use in the LRRI laboratory.

Sand-sized brown nodules in the C horizon of a soil from the Peace River region of Alberta were analyzed by scanning electron microscopy, energy-dispersive X-ray analysis, and X-ray microcamara and found to be composed of glauconite. The evidence was interpreted as indicating that the soil parent material was residual from the local shale bedrock rather than lacustrine.

Organic soils. Laboratory, greenhouse, and field studies on biochemical, agronomic, structural, and hydrological aspects of organic soils showed that (*a*) most mineral sublayers found in Canada, when mixed with their organic overlays in suitable proportions, attain good tilth, produce well, and offer wide crop choice; gyttja is improved only when mixed with an adjoining Ca-rich sublayer; (*b*) the limitations of Fibrisols regarding soil pH, temperature, water, tilth, and mineralization have been overrated; (*c*) the presence of wood is a serious hindrance only when distributed widely in the profile; and (*d*) the more fibric the soil, the less Cu is required to mitigate subsidence. Based on an integration of such results with improved methods developed here for characterizing organic soils and relevant experience in several countries, a nationally applicable land use capability rating system for organic soils was devised. Strategies for reclaiming various cutover peatlands in Canada were formulated. A handbook for identification of plant macrofossils has been prepared to facilitate peatland classification. An original concept that the hydraulic conductivity of peatlands decreases with depth because its pores become jammed by outgassed bacterial methane was published. The concentration of methane increased with depth in the Alfred bog.

Three different peats were tested as composting media for solubilizing rock phosphate, utilizing fish scrap, crab scrap, liquid hog manure, liquid and solid cattle manure, wood wastes, and blood. Of the 14 combinations and regimes tested at field scale, 12 were effective, including one with liquid manure. Up to 50% of the rock phosphate was solubilized in 4 weeks. The fish and crab waste composts were found to be rich in available plant nutrients, mature, and free from enterobacterial toxins by studies in the greenhouse, nuclear magnetic resonance analysis, and tissue culture, respectively.

Data on seven elements in 15 crop portions, 55 soils, and 700 extracts were statistically analyzed with the aim of developing soil tests. Several conclusions were drawn, e.g., that only total and water-soluble forms among 18 soil species of Cu examined reflect plant-available Cu in organic soils.

An expansion of the micromorphological system for describing organic materials was completed to incorporate qualitative and quantitative data with the use of codes and symbols into the descriptive symbols. This system now provides a comprehensive method for describing the micromorphology of organic materials.

Field and laboratory services. Greenhouse and field experiments were maintained, data were collected systematically, samples were prepared for analysis, and a total of nearly 4000 soil and water samples were analyzed for some 20 LRRI scientists in Ottawa and in soil survey units. Precision of soil physical and chemical data was improved and a formal quality control procedure was instituted in the laboratory.

LAND USE AND EVALUATION

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

Land evaluation and crop production. A major departmental publication on soil and water resource issues was prepared for the Canadian Agricultural Outlook conference. This was based on recent evaluations of land degradation combined with previous research. The paper demonstrated the limited extent of agricultural land in Canada, the rate of land conversion, and the impact of degradation on farm income. It also discussed water supply relationships, water quality, and the off-farm impact of sedimentation. Results demonstrated that the economic impact of land degradation in Canada is between $750 million and $1.2 billion a year. A series of displays on soil degradation were also prepared for the conference.

Crop yield assessment activities have resulted in some further refinement of the Manitoba wheat model (to account for high water tables), and in modification of the grain model for forages proposed by the United Nations Food and Agriculture Organization and LRRI. The corn study for Ontario was completed demonstrating decreasing yields over time in certain areas. The quarter-section data base for Alberta (SIDMAP) was completed, a report and papers were prepared, and refined procedures were developed to access these data. Activities were initiated to develop a data base for Manitoba, based on soil series, quarter sections, the generalized soil landscape maps (1:1 million) for the province, and climate data. Yield probabilities at various levels were calculated for Saskatchewan and Alberta. Completion of the update on the land potential data base (1:5 million) was delayed because major errors were detected in the climate data.

Evaluation of soil moisture models (SPAW and MUST) for Canadian conditions gave mixed results. An analysis of soil-water resources in Saskatchewan soils was completed. This showed that fine-textured soils have higher than average moisture in 9 out of 10 years, compared with sandy soils. It further indicated that long-term grain yields in more humid areas exceed those in drier regions in 9 out of 10 years. A computer program was completed to calculate the available water content for profiles stored in CanSIS.

The Haldimand–Norfolk land use report was prepared and the Niagara land use report was submitted for publication. Maps of agricultural zones in Ottawa–Carleton (1:50 000) were prepared, along with land use policies for compatible uses. Preliminary evaluations and a project proposal was completed for a major cropping systems–land use inventory of Alberta. Assistance in land use systems was provided to numerous government and private agencies.

A prototype national land evaluation system for Canada has been developed under contract with the University of Guelph.

This research, which until now has been centered at the university, will be terminating this fiscal year and plans have been made to transfer the data and the software system to an LRRI computer.

Land degradation. A considerable amount of time, effort, and resources were directed toward a study of the economic impact of land degradation in eastern Canada and British Columbia. This study was based primarily on the universal soil loss equation, with other classifications developed as needed. Results showed that water erosion represents an annual on-farm loss of about $156–218 million in these regions, with an additional $11 million coming from wind erosion. Soil compaction and structure deterioration was shown to have an impact of almost $130 million per year and acidification added a further $9 million per year. A report has been published.

Preliminary maps have been prepared that show wind and water erosion risk at a scale of 1:1 million in the Prairie Provinces, and 1:500 000 in southern British Columbia and eastern Canada (1:125 000 in Prince Edward Island). Soil sensitivity to acidification is now mapped at 1:2 million in the Prairie Provinces and 1:500 000 in the rest of Canada; and soil compaction risk has been estimated for soil landscape maps throughout eastern Canada and southern British Columbia. Results of applying the risk estimation procedures in eastern Canada and southern British Columbia have been used in an economic impact assessment carried out for Regional Development Branch. A preliminary map of soil salinity has been prepared for Manitoba at a scale of 1:1 million and another is in preparation in Saskatchewan. Two more soil erosion risk map sheets have been completed for the Peace River Region.

An assessment of the potential for drainage improvements has been made for eastern Canada and southern British Columbia. This showed that crop production could be increased on substantial areas if drainage was installed in all soils in which benefits are anticipated.

Field evaluation of methods of assessing past erosion and seasonal variation in erodibility have been completed, as have studies of soil management effects on soil structure. Field monitoring of erosion in the Peace River Region has continued.

A workshop on soil degradation monitoring was held and a proceedings was published. A detailed plan for the establishment and long-term monitoring of degradation benchmark sites in the Prairie Provinces was prepared.

Canada soil information system (CanSIS). The capabilities of the stand-alone digitizing work station being developed under contract were fully evaluated. The results were somewhat disappointing, in that these work stations appear to be limited in input capacity to maps of less than 300 polygons. The analysis and output capabilities are weak. While an evaluation benchmark was prepared and the contractor agreed to meet these requirements, no output and analysis software packages have been received.

Considerable efforts were devoted to defining the user requirements for a Geographic Information System (GIS) for Ottawa and regionally. A pilot study was successfully carried out to test the capabilities of the Animal Research Centre (ARC) – Info software package to meet the Ottawa requirements. A computer requirement benchmark was also carried out. The benchmark and pilot information will be combined to provide justification for acquisition of an ARC–Info package and all necessary hardware. A team of programmer–analysts has been assembled to implement a full-scale GIS and carry out the development necessary to incorporate the existing data and bring it to an operational level.

The existing cartographic system has been upgraded to use tapes with a capacity of 1600 bytes per inch (bpi) (instead of 800 bpi which were no longer generally supported) and to incorporate a PDP 11/34 to relace one of the outdated PDP 11/10 minicomputers. Procedures to code interpretations for cartographic data have been streamlined to reduce turnaround time and transfer more control to the interpreter.

It has been determined that it is not feasible to increase the allowable map size in the current system and that the cartographic production files should remain on Crowntek until a new system is adopted. The Manitoba stand-alone digitizing work station is not yet operational because the digitizing tablet has not been received.

Development of the National Wetland Registry was brought to a successful conclusion with the completion of output report procedures. These output procedures involved the development and refinement of up to 10 report modules and a procedure to link them together in an integrated, formatted output package. The registry is now recommended as the file for input, storage, manipulation, and output of organic soil data.

Development of output reports for the soil data (DETAIL) file has proceeded more slowly than anticipated. The concepts and techniques developed for the National Wetlands Registry can be readily adapted to the soil data report modules that have been developed to complete this project. Preliminary analysis of the data format and content of the soil data file was completed.

Technical support was diverted to assist in handling data associated with the generalized soil landscape maps and with the eastern Canada soil degradation project. Extra effort was expended to accommodate the large volume of corrections submitted by the regions to the soil data file.

The capability of a general purpose microcomputer to handle a typical daily soil survey file was developed, documented, and demonstrated.

AGROMETEOROLOGY

Agrometeorology addresses problems related to soil–crop–weather interactions that affect crop production, farm management and decision-making, and agricultural resource evaluation. The Canadian climate is an important factor limiting agricultural land use, and research and development are necessary to discover and define relationships that provide a quantitative basis for climatic evaluation of land resources. Analysis of climatic variability results in probability tables and risk profiles useful at an operational farm level. Detailed analysis of crop response to climate is also critical to timely market estimates of crop growth, development, and yield. When crop response to climatic variability can be accounted for, time trends in production resulting from other factors become clearer. Furthermore, if, as has been suggested, increased climatic variability and climatic change are to occur, research to assess crop response to weather is a prerequisite of adjusting food production in Canada to changing environmental conditions.

Crop environment assessment. Maps were completed at a scale of 1:1 000 000 for the major agricultural areas of the three Prairie Provinces. The maps delineate areas having similar patterns of vegetation, biomass, and cropping practices. The boundaries of the areas are associated with dominant soil climatic factors affecting crop growth and management practices in the prairie region. The vegetative patterns were mapped from standard color infrared Landsat MSS data. These vegetative and soil patterns were then related to the soil climatic units on the generalized landscape map prepared previously by Dr. J. Shields. The generalized landscape map quantitatively identifies the dominant soil–climate properties affecting dryland agriculture at a rural municipality RM subunit level. Thus each uniform productivity area (UPA) is characterized by the dominant soil–climate properties affecting its long-term crop growth. Manitoba was mapped

into 17 UPAs, Saskatchewan into 26, and Alberta into 22 areas. Land use maps were prepared in association with the UPA maps. These were prepared by updating the boundaries of the main land use classes mapped by the Canada land inventory program a number of years ago. The combination of these two maps can be used to outline the main cultivated crop areas to identify the main soil textural classes on National Oceanographic and Atmospheric Administration and Landsat imagery. Within these areas, variations can be compared in crop conditions during a growing season or among growing seasons. These may also be used for providing yield estimates on an areal basis for specific soil textures from meteorological data.

An airborne system for measuring the uptake of CO_2 and the transpiration of water by various types of vegetation was carried out over southern Manitoba. In July, CO_2 and H_2O flux measurements were made over various cultivated crops, grasslands, and forest areas between Winnipeg and Melita. Flying at an altitude of 50 m, a wide range in uptake of CO_2 was monitored between the heavy crops of the Red River Valley, the grasslands of central Manitoba, and the light crop growth of the dry areas near Melita. Detailed coverage was made repetitively in the test area near Winnipeg to evaluate the sensitivity and reproducibility of the measurements for a range of weather conditions. The measurements were carried out in a cooperative study with the National Aeronautical Establishment of the National Research Council and McGill University.

Estimates of cereal crop yields and soil moisture reserves on fallow and stubble land, based on spring soil-water reserves and daily weather data, identified a severe shortage of soil moisture in southwestern Saskatchewan by mid June. These estimates quantitatively monitored the expansion of the drought areas throughout the summer. Yields of under 300 kg/ha were estimated in these crop-reporting districts in June and July in contrast to the high yields of 2000–2400 kg/ha in central and northern Saskatchewan and in Manitoba. Less than 20 mm of reserve soil water was present in southwestern Saskatchewan as compared with 120 mm northeast of Saskatoon by the end of June.

Support for research on microwave properties of crops was provided in cooperative arrangement with the Canada Centre for Remote Sensing for establishing a Scatterometer Laboratory at the University of Saskatchewan to study in detail the microwave backscatter of crops and soil. Other studies involved the use of data obtained with a very high resolution radiometer (infrared–red channels) from the National Oceanographic and Atmospheric Administration for assessing large-scale crop conditions in Saskatchewan and for assessing Thematic Mapper data for identifying special crops grown under small-field conditions (i.e. less than 8 ha) in Manitoba.

Agroclimatic resource assessment. Progress continued on modeling plant growth and development in relation to physiological and environmental factors. The main crops under investigation are corn, soybeans, and barley. Three years of field data on growth and phenology of these crops on four soil types are being used to develop and test the models. In a greenhouse experiment, the response of phenological development of barley to water stress and photoperiod was examined. Mathematical functions were formulated to express the relationship between development stage of barley as measured by the Feeke's scale, photoperiod, and accumulated growing degree–days under various water stress treatments. Work on corn demonstrated the influence of leaf and plant age on photosynthesis and established a method of estimating leaf area of corn from parameters related to air temperature and soil moisture. The contribution of photosynthesis to yield of dry matter was investigated for six corn hybrids with different heat unit requirements and rates of development.

A model was developed and is being validated to simulate soil nitrogen transformations and plant nitrogen uptake. This will be used as part of a wheat yield–protein model for western Canada. The wheat yield–protein model was successfully used to estimate yield and protein levels for 22 years in the three major soil zones in the prairies. Analyses of time trends are being undertaken to quantify the influences of changes in weather, technology, and soil condition on wheat yield and protein content.

An improved regression-based soil temperature model was developed for the Atlantic region. A significant improvement over previously developed models was achieved by replacing snowfall with depth of snow on the ground as a predictive parameter during winter. The model will be useful for estimating average monthly soil temperatures for characterizing overwintering conditions for crops in the Atlantic region. Computer archives of daily snow depth on ground are being upgraded in cooperation with Environment Canada to include data from about an additional 160 stations in agricultural areas across Canada.

A zonation map of estimated optimum seeding dates of winter wheat was completed and published in the 1985–1990 *Field Crop Guide for the Atlantic Region*. Zonation maps on optimum ma-

turity dates for first cut of forages and on the critical autumn rest period for alfalfa in the Atlantic region were also published in the same extension bulletin. Climatic data during the fall are being used to draft winter wheat seeding date maps for regions in British Columbia and Ontario. These efforts are expected to promote improved crop management practices in these regions.

Climate station catalog files and base maps were prepared to identify the location of all stations that have 1951–1980 normals data available from Environment Canada. These will be used for future mapping of derived agroclimatic indices at the 1:5 million scale for all of Canada and 1:2 million for selected regions, and in conjunction with the soils map of Canada.

Information on frost behavior and freeze prevention methods was prepared for Ontario farmers in cooperation with the Ontario Ministry of Agriculture and Food. Seminars on the application of climate and weather data to agricultural management decisions were held for several professional and agricultural organizations. The potential involvement of agrometeorology in integrated pest management was documented in a strategy paper.

Daily soil temperature data have been acquired on computer tape for all available locations from Environment Canada. Guidelines have been prepared for the development of computer software to evaluate data quality and estimate missing data where possible.

Research continued toward improving soil-water modeling methodologies. Root-water uptake and soil-water transfer were simulated for soybeans on a sandy loam soil at a location in southern Ontario and the results were compared with a more empirical approach. Studies comparing average climatic data for use as input into soil-water models with actual daily data showed that average data tended to underestimate deep drainage and aridity indices and overestimate actual evapotranspiration. Results of previous studies on infiltration, evaporation, and salt movement in soil columns were reported. Large and less frequent water applications resulted in more efficient leaching of salt. Good agreement was obtained between measured and predicted salt redistribution profiles.

Operations management. The Agrometeorology Section is actively involved in research to develop and demonstrate the usefulness of indices and parameters that integrate weather and soil conditions into decision-making aids for agricultural production. As part of this project current weather conditions and derived soil moisture were monitored on a weekly and monthly basis during the year for the Prairie Provinces. Twenty soil moisture evaluation reports were produced, together with 350 manuscript maps for reproduction on the Grassroots videotex services. Current computer weather data files for Ontario and the Prairie Provinces were updated on a weekly basis for use by regional agricultural researchers for near real-time weather-based estimates of insect populations, disease development, and crop maturity.

A study to monitor derived soil moisture on a weekly basis for two soil textures was initiated for the Agriculture Canada research station at Smithfield, Ont., relative to orchard crop management. A system to acquire, via computer, real-time climatic data from the data banks of Alberta and Saskatchewan was completed. Preliminary work was completed toward the development of a low-cost automatic weather station to monitor temperature and precipitation. The unit will incorporate the sonar snow depth sensor, which was tested during the winter of 1984–1985.

The soil moisture observations from the network established in three areas in Quebec were analyzed and used to determine parameters for a soil water budget, which includes a function to estimate the contribution of the water table for corn growing on three different soils. Functions for apple bud survival and growth were combined to provide an estimate of apple yields. A study to compare estimated and observed apple yields from the Saint-Jean Research Station was initiated. A barley crop yield model developed in Alberta for use on farm microcomputers was evaluated on 3 years of yield data from Ottawa. It was concluded that the model in its present form was not suitable for application in this region.

Field testing of the new low-cost leaf wetness sensor was continued. The tests suggest that this sensor could be useful in monitoring leaf-wetting duration for prediction of development and control of disease for fruit and vegetable production.

A project was initiated with five Agriculture Canada research stations in Quebec to develop guidelines for alfalfa management based on degree–days. Seeding of the experimental plots was completed. A field experiment was continued in Ottawa monitoring the response of strawberries to irrigation, which was scheduled according to three different criteria.

The amount of snow on the ground was investigated as a model input for estimation of soil temperature in winter. Soil temperature data collected through fall, winter, and spring on plots in Ottawa and Saskatoon where snow cover was both undisturbed and manually controlled were used in conjunction with a simulation model to quantify the effect of snow on the survival of overwin-

tering crops and insects. Water movement and freeze–thaw processes were monitored using a neutron probe and time-domaine reflectometry. A frost probe based on electrical conductivity measurements was evaluated under winter field conditions. When combined with a digital recorder the probe provided an automatic procedure for monitoring the depth of frost penetration.

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INTRODUCTION

Research Program Service supports research and development in the branch by maintaining computerized scientific and technical information systems, providing publications services, and administering branch awards and international scientific exchange programs. The service is divided into four sections: Administration, which contains the awards, branch liaison, and word processing units; Graphics, which contains the art and design and the photography units; Scientific Editing, which comprises English and French editors; and Scientific Information Retrieval, which contains the biocontrol, inventory and systems, and pesticides units.

The Scientific Information Retrieval Section has put into service a new component to the Pesticide Research Information System, namely, the Paralease (Insect Release Data). The Administration Section continued to administer the program for operating grants and visiting fellowships, and to coordinate international missions with the USSR, People's Republic of China, Czechoslovakia, France, Algeria, the Arab republics, the Federal Republic of Germany, Japan, Romania, and the United Kingdom. Research Branch staff was informed of news, happenings, and accomplishments through the 10 issues of *Tableau*. Graphics, photography, and scientific editing combined their efforts to maintain and improve the high quality of production of publications and support material necessary for the transfer of knowledge and technology to the scientific community and the agri-food sector.

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

Yves Bélanger
Director

AWARDS AND BRANCH LIAISON

Research Program Service continued to administer the operating grants, visiting fellowships, and scientific exchange programs during 1985. Operating grants are awarded to individual researchers at Canadian universities as contributions toward the costs of proposed research projects that will be of value to the agricultural industry. The selection committee is made up of three representatives from Agriculture Canada, seven from faculties of agriculture and veterinary science, and one from the Canadian Agricultural Research Council. In 1985, the committee received 276 applications.

The visiting fellowship program gives promising young scientists, from all over the world, the opportunity to work with distinguished researchers in their respective fields before embarking on careers in scientific research. The program is administered by the Natural Sciences and Engineering Research Council on behalf of Canadian government departments and agencies. Research Program Service acts as liaison between the council and Agriculture Canada. In 1985, there were 364 applications for fellowships in this department.

The branch liaison unit arranged for 99 scientists to visit branch establishments during the past year: five missions from the People's Republic of China; three missions from Czechoslovakia; two missions from France; and one mission each from Algeria, the Arab republics, Federal Republic of Germany, Japan, Romania, and the United Kingdom. The unit also made arrangements for nine scientists to visit France and one each to visit Japan and the USSR.

GRAPHICS

A wide variety of services in research photography, art production, illustrations, and audiovisual presentations were provided to the branch and other agencies within the department. A total of 2461 jobs were handled, representing an increase of 10% over the previous year and generating the production of 47 685 pieces of work.

The demand for services has increased in specific areas such as color enlargements and contact prints (11%), production of black-and-white slides (11%), and graphic illustrations (11%).

The addition of color computer graphic equipment has enabled the photography unit to expand the variety of services to include production of high-resolution color slides. This new feature is intended to improve the quality of tools available to Research Branch staff for information and technology transfer to clients.

Thirty-nine display projects were produced by the art and design unit.

SCIENTIFIC EDITING

During the year, 22 departmental (3 priced) and 66 Research Branch publications were issued. Some of the publications released were *Tomato diseases/Maladies de la tomate*; *Sweetclover production in western Canada/Le mélilot dans l'ouest du Canada*; *Agricultural practices and environmental conservation/Agriculture et conservation de l'environnement*; *Grass, legume, and cereal silages for ruminants/Ensilages de graminées, de légumineuses et de céréales pour l'alimentation des ruminants*; *Biting flies affecting man and domestic animals in Canada/Diptères piqueurs du Canada qui s'attaquent à l'homme et au bétail*; *Barley register/Catalogue des variétés d'orge*; *Growing field beans in Canada/Les haricots de grande culture au Canada*; *Insects damaging corn in eastern Canada/Insectes nuisibles au maïs dans l'est du Canada*; *Red clover/Le trèfle rouge*; *Soils of the Barkerville area, B.C.*; *Soils of the Botwood–Wesleyville area, Nfld.*; *Symposium on postharvest handling of vegetables*; *Pesticide research report*; 16 Expert Committee reports; 10 issues of *Tableau*; and 4 issues of *Pesticide information/Information pesticides*.

The long-awaited *Poisonous mushrooms of Canada and other inedible fungi* was finally published in December 1985. The French edition, also being published through the government-sponsored copublishing program, is expected to be released by early summer 1986.

In preparation for the Centennial celebrations in 1986, four station guides were prepared; three bilingual history folders were issued; and one long history was completed. Manuscripts were submitted for 16 bilingual history folders and 12 long histories, 9 of which are bilingual.

SCIENTIFIC INFORMATION RETRIEVAL

The Inventory of Canadian Agricultural Research was renamed in 1985 to Inventory of Canadian Agri-Food Research (ICAR) to reflect a new reality. It, as well as the Research Branch project system, were updated in the course of the year. Access to both these systems continues to be provided across Canada to the whole research community and to Research Branch personnel. In addition, the section has been identified as a national focal point for exchange of scientific information with other nations belonging to the Organization for Economic Cooperation and Development. Visiting delegations were welcomed from Algeria, China, and the Philippines.

A seventh component on beneficial insect liberations was added to the Pesticide Research Information System (PRIS) in 1985. Subscriber base to this computerized information system has expanded in Canada and international access has successfully been provided to Italy. Discussions are now under way on networking this system with other similar Canadian data bases.

The biocontrol unit continued to import foreign collections from which to rear parasites and predators for establishments in the Research Branch and Canadian Forestry Service. In 1985, 14 shipments were received from seven countries and included 41 000 individuals. From these, 17 000 individual parasites and predators belonging to 19 species were sent to seven forestry and six agricultural establishments for release or studies against four forest and five agricultural pests.

In addition to their regular activities, section staff have supported the activities of several expert committees (pesticide use in agriculture, weeds, insect pests of animals, and grain diseases), participated in national work-planning meetings, and served in official functions with professional organizations (Entomological Society of Ontario and North American Plant Protection Organization).

Atlantic Region
Région de l'Atlantique

W.B. Collins

R.S. Bush

S.C. Cassidy

Acting Director General *Directeur général intérimaire*	W.B. Collins, B.Sc.(Agr.), M.Sc., Ph.D.
Acting Program Specialist *Spécialiste en programmes intérimaire*	R.S. Bush, B.S.A., M.Sc., Ph.D.
Chief, Administrative Services *Chef des Services d'administration*	S.C. Cassidy

PREFACE

The Atlantic Region, with headquarters in Halifax, consists of four research stations, two experimental farms, and two substations. These research establishments serve the agricultural communities in New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland. In addition, the regional establishments make major contributions to national programs on potatoes, food processing, livestock feeds and nutrition, postharvest storage and control of insects, diseases, and weeds. In 1985, the region managed a budget of $23 million and employed 100 professionals to carry out its programs.

The soil management program is developing practical management technology to cope with problems of erosion, drainage, and the physical constraints related to impermeable subsoils and the potential of peatland resources in the region. Crop production potential and management procedures for soils and crops leading to reductions in erosion losses are used in soil evaluation.

The research program on livestock and livestock feeds is developing improved feeding and management systems with emphasis on the utilization of locally produced feedstuffs for beef and dairy cattle, swine, poultry, and sheep operations in the region. Ruminant nutrition is related to forage research, whereas all animal research is related to cereals research. There is also some work conducted on livestock and poultry diseases, physiology, reproductive physiology, and basic aspects of metabolism.

The cereal research program is developing and identifying superior cereal cultivars that meet regional requirements for yield, disease resistance, cold tolerance, and climatic adaptability. Breeding and evaluation are currently conducted on spring and winter wheat, spring barley, winter rye, and conventional and hull-less oats. Studies are also in progress on *Fusarium* species, biotechnology of winterhardiness, cereal management, fertility requirements, effectiveness of growth regulators, and interaction of inputs.

The forage crop research program is developing superior forage management techniques, breeding and testing new forage varieties, developing conservation technology, and assessing forage persistence and winterhardiness. Forage research is closely tied to the programs on soil fertility and drainage and to evaluation by feeding the product to ruminants.

The horticultural crops research program deals with potatoes, other vegetables, tree fruits, berries, and ornamentals. Potatoes research involves the national breeding project, evaluation of potential new varieties, assessment of diseases, control and measurement of diseases, measurement of physiological parameters, and handling techniques. Other areas of horticultural research involve variety assessment, yield comparison, disease-resistance screening, and management technology development. There is also a small program in tobacco variety evaluation recorded under field crops.

Research into processing technology and storage is directed to improving the competitive advantage of regionally produced products for both the domestic and export markets. Most of the work is related to the processed products of fruits and vegetables and to increasing storage life with a controlled atmosphere.

Significant staff changes in 1985 included the appointment of Dr. G. Rousselle as superintendent of the Senator Hervé J. Michaud Experimental Farm, succeeding Mr. R. Rioux, who transferred to the Quebec Regional Office, and the transfer of Dr. E.E. Lister to the Pesticides Directorate of Food Production and Inspection Branch in Ottawa. Dr. W.B. Collins has been acting director general and Dr. R.S. Bush from the Fredericton Research Station has been acting 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, Halifax, N.S. B3J 3J8.

W.B. Collins
Acting Director General

PRÉFACE

La région de l'Atlantique, dont l'Administration centrale est à Halifax, comprend quatre stations de recherches, deux fermes expérimentales et deux stations satellites. Ces établissements de recherches offrent des services aux collectivités agricoles du Nouveau-Brunswick, de l'Île-du-Prince-Édouard, de la Nouvelle-Écosse et de Terre-Neuve. En outre, les établissements régionaux jouent un rôle important dans les programmes nationaux sur la pomme de terre, la transformation des aliments, l'alimentation et la nutrition du bétail, l'entreposage des récoltes et la lutte contre les insectes, les maladies et les mauvaises herbes. En 1985, la région a administré un budget de 23 millions de dollars et employé 100 professionnels pour mener à bien ses divers programmes.

Le programme de gestion des sols est axé sur la mise au point de techniques pratiques permettant de solutionner les problèmes d'érosion et de drainage, de surmonter les contraintes physiques posées par les sous-sols imperméables, ainsi que les problèmes de développement du potentiel des tourbières de la région. Le potentiel de production culturale et les méthodes de gestion des sols et des cultures susceptibles de réduire les pertes par érosion servent à l'évaluation des sols.

Le programme de recherches sur le bétail et son alimentation a pour objet d'améliorer les systèmes d'alimentation et de conduite d'élevage en utilisant des aliments produits localement pour les bovins de boucherie et les bovins laitiers, les porcs, la volaille et les moutons. La recherche sur la nutrition des ruminants est en rapport avec celle sur les fourrages, alors que la recherche sur tous les animaux est reliée à celle sur les céréales. Certains travaux sont également effectués sur les maladies du bétail et de la volaille, la physiologie, la physiologie de la reproduction et les aspects fondamentaux du métabolisme.

Le programme de recherches sur les céréales a pour objet de mettre au point et d'identifier les cultivars supérieurs capables de satisfaire les besoins régionaux pour le rendement, la résistance aux maladies, la tolérance au froid et l'adaptabilité climatique. Des travaux de sélection et d'évaluation sont couramment effectués sur le blé de printemps et d'hiver, l'orge de printemps, le seigle d'hiver et les avoines classique et nue. Il est également question d'études sur les espèces de *Fusarium*, la biotechnologie de la résistance au froid, la gestion des céréales, les exigences en matière de fertilité, l'efficacité des régulateurs de croissance et l'interaction des facteurs de production.

Le programme de recherches sur les cultures fourragères vise à mettre au point des techniques supérieures de gestion des fourrages, à sélectionner et à tester de nouvelles variétés de plantes fourragères, à mettre au point une technologie de conservation et à évaluer la persistance et la résistance au froid des plantes fourragères. Le programme est étroitement lié aux programmes sur la fertilité et le drainage des sols et vise à évaluer les fourrages en les servant à des ruminants.

Le programme de recherches sur les cultures horticoles porte sur les pommes de terre, d'autres légumes, les fruits de verger, les petits fruits et les plantes ornementales. La recherche sur les pommes de terre comprend le projet national de sélection, l'évaluation de nouvelles variétés potentielles, le diagnostic des maladies, la lutte contre les maladies et l'évaluation des dommages, la mesure des paramètres physiologiques et des techniques de manutention. Les autres domaines de la recherche horticole sont l'évaluation des variétés, la comparaison des rendements, la sélection pour la résistance aux maladies et la mise au point de techniques de gestion. Est également inclus un petit programme d'évaluation des variétés de tabac rattaché au secteur des grandes cultures.

Les recherches axées sur les techniques de transformation et sur l'entreposage visent à améliorer la position concurrentielle des produits de provenance régionale sur les marchés intérieurs et étrangers. La plupart des travaux portent sur les fruits et les légumes transformés et sur le prolongement de la conservabilité à l'étalage en atmosphère contrôlée.

En 1985, la composition du personnel a subi de profonds changements, dont la nomination de M. G. Rousselle à titre de régisseur de la Ferme expérimentale du sénateur Hervé J. Michaud, qui succède à M. R. Rioux lequel est passé au bureau régional du Québec, et la mutation de M. E.E. Lister à la Direction des pesticides de la Direction générale de la production et de l'inspection des aliments, à Ottawa. M. W.B. Collins fait office de directeur général suppléant et M. R.S. Bush de la Station de recherches de Fredericton remplit la fonction de spécialiste des programmes.

Pour de plus amples renseignements au sujet de nos programmes, on peut écrire à l'établissement de recherches concerné ou s'adresser à l'Administration centrale de la Région de l'Atlantique, Direction générale de la recherche, Agriculture Canada, 1888, rue Brunswick, Halifax (N.-É.) B3J 3J8.

W.B. Collins
Directeur général intérimaire

Research Station, St. John's West, Newfoundland

PROFESSIONAL STAFF

H.R. Davidson, B.Sc., Ph.D., P.Ag.	Director
Horticulture	
B.G. Penney, B.Sc., M.Sc.	Vegetable crops
Plant Breeding and Pathology	
K.G. Proudfoot, B.Agr., M.Agr.	Program Leader; Potato breeding
M.C. Hampson, B.Sc., M.Sc., Ph.D.	Plant diseases
Entomology	
Vacant	Program Leader; Insect control
Agronomy	
Vacant	Program Leader; Soil fertility and drainage
Agricultural Engineering	
G.A. Bishop,[1] B.Eng., M.A.Sc.	Agricultural machinery
Departure	
A.F. Rayment, B.Sc., M.Sc. Retired 30 April 1985	Program Leader; Soil fertility and drainage

[1] New appointment effective 13 May 1985.

INTRODUCTION

The Research Station located at St. John's West, 8 km from the city center, is responsible for agricultural research in Newfoundland and Labrador. Two additional research facilities are operated: a peat research substation at Colinet, 80 km southwest of St. John's, and a blueberry research substation near Avondale, 67 km west of St. John's. Research programs include the development of drainage techniques for peat soils and the designing and adaptation of equipment for cultivating, fertilizing, seeding, and harvesting peat soil crops. Potato breeding for resistance to wart disease and golden nematode, rutabaga breeding for resistance to clubroot, pathology for the biological control and elimination of wart disease, economic insect control, and vegetable nutrition and adaptation trials are also important research areas.

This report provides brief summaries of some of the results obtained in 1985. Further information, reprints of listed publications, and copies of previous reports can be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's West, Nfld. A1E 3Y3.

H.R. Davidson
Director

HORTICULTURE

Peat soil

Carrot. In 1985 the effect of N source and rate was again studied in a field experiment with the cultivar Spartan Fancy at the Colinet Peat Substation. Treatments included factorial combinations of three N sources (urea, ammonium nitrate, calcium nitrate) and four N rates (0, 100, 200, 300 kg/ha). The N source did not significantly affect marketable or total yields, or mean carrot length. Increasing the N rate from 0 to 200 kg/ha increased marketable and total yields from 0.7 to 20.2 and from 1.4 to 24.1 t/ha, respectively, but a further increase of N to 300 kg/ha did not significantly affect production.

Mineral soil

Cabbage. During 1984 –1985 the cultivars Bartolo, Bislet, Ladina, Lennox, Stark Winter, Houston Evergreen, Polinius, and Custodian were evaluated for yield and storability. Differences in marketable yield among Custodian, Lennox, Houston Evergreen, and Bartolo were minor but they were significantly higher than those for Ladina, Polinius, Bislet, and Stark Winter. Evaluations conducted after approximately 5 months of refrigerator storage showed that Bartolo, Bislet, Ladina, and Lennox were the best storage cultivars.

Lingonberry. During 1980–1982 a cooperative study was conducted by the St. John's and Kentville research stations and the Newfoundland Department of Rural, Agricultural and Northern Development to obtain information on the productivity of natural stands of lingonberry (*Vaccinium vitis-idaea* L. var. *minus* Lodd) in five of the better producing areas (Little Catalina, Newmans Cove, Adams Cove, and Pouch Cove and Riverhead, St. Mary's Bay) in eastern Newfoundland. Production varied with location and year, with the highest average total yields from Little Catalina (1030 kg/ha), Pouch Cove (1010 kg/ha), and Adams Cove (880 kg/ha). Yield increased with maturity, but decreased after most of the crop was ripe. Crop maturity was earliest at Pouch Cove and Adams Cove, but there was little difference among the other sites. In all 3 years the average mature berry weight was greater at Adams Cove than at the other locations.

Lowbush blueberry. In 1978 a trial was established at the Avondale Blueberry Substation, in cooperation with the Kentville Research Station, to determine whether interplanting transplants of the cultivars Chignecto and Augusta in natural blueberry stands would improve production. Planting density for each cultivar was four plants per square metre. These plants did not receive any nutrients, either at time of planting or during the growing season, but they were covered with straw in the fall to help prevent frost heaving. All plots were pruned by burning in November 1981, and yields were recorded in 1983.

Results of survival counts indicated that establishment had been poor, since by 1981 the survival had dropped to approximately 54%. In regard to production, neither of these cultivars increased yields of natural stands.

Based on these results, it appears that the interplanting of blueberry cultivars in natural stands without special care is not likely to lead to success under Newfoundland conditions.

POTATO BREEDING

Trials of selection N664-127 resistant to both potato wart disease and golden nematode have been concluded, and it is proposed to release this selection as the cultivar Cupids. Yields are similar to those of Kennebec, but specific gravity readings are considerably higher. In cooking tests, tubers have been rated as very good both for boiling and for home-produced French fries. A drawback to grower acceptance of this cultivar may be its susceptibility to common scab, which has been a problem with most cultivars in the last two seasons.

Included in screening trials for wart resistance at Avondale were 25 selections and named cultivars submitted for the 1985 NE107 trial. Three cultivars remained free of infection—Hampton, Jemseg, and Kennebec. Hampton, a cultivar from New York State resistant to golden nematode, has been wart-resistant in 2 years of testing and will be further evaluated in 1986. Sunrise and Islander, which had been free of wart disease in 1985, were included in this year's trial but were found to be susceptible. Also screened for wart resistance were 99 F82 selections from the national breeding program; of these, 84 were susceptible, 9 had trace infections, and 6 were free of any disease symptoms. In a trial of 20 advanced selections from the St. John's program, only tubers of one selection showed any symptoms of infection.

A number of blue-skinned selections with resistance to both cyst nematode and wart disease have been evaluated for a number of years. The most promising has been selection N1051-1, which has produced consistently high yields in trials, but a major fault is its late maturity. Several white-skinned selections bred from Mirton Pearl and various nematode-resistant selections show promise, having remained free of warts and nematodes after 3 years of testing. Further trials to evaluate yield and other desirable horticultural characteristics will be required before they are entered into growers' trials.

RUTABAGA BREEDING

Grower evaluation of RST by commercial growers indicated that this material was highly clubroot-resistant and produced well-shaped and well-colored roots of excellent table quality. In a small-scale trial at the research station, RST seeded in soil that was known to be heavily infested with the clubroot organism yielded 22 kg/10-m row of marketable roots, compared with less than 2 kg/10-m row for Laurentian. Fewer than 1% of RST roots were infected by clubroot. Studies are under way to determine if infection results from the presence of a new race of clubroot or if RST stocks are not homozygous for resistance to the races 2 and 4. A large quantity of RST seed was produced from selected roots for the establishment of basic seed stocks and for further trial.

Two radish cultivars, Saxafire and Red Boy, were both found to be resistant to the clubroot races present in the test area, but the summer turnip cultivars Tokyo Market, Tokyo Cross, Ping Pong, Early Tennoji, Yorii Early, Express White, Just Right, Scarlet Ball, and Shimofusa were highly susceptible. Approximately half the plants of the cultivar Purple Top White Globe were free of infection. Plants of the forage crop Tyfon, a hybrid of Chinese cabbage and turnip, were free of infection but plants of Texsel, a cultivar of *B. carinata*, were highly susceptible.

The most promising roots for yield and appearance from crosses of RST were obtained from a cross with the Norwegian cultivar Vige. Crosses with herbicide-resistant Laurentian produced much smaller roots that were quite severely damaged by root maggot attack. Organisms isolated from rutabaga roots showing a very dark decay of vascular tissue have been identified as specimens of the bacterial species *Pseudomonas*, most being *P. fluorescens marginalis*. No isolates of *Xanthomonas campestris* have been found. Specimens of *Alternaria* sp. and *Fusarium* sp. have also been isolated from diseased roots.

Potato wart disease

Pathogenesis. To produce suppression of wart disease in soil, chemically purified chitin was found to induce 80% suppression or more. In the greenhouse both disease severity and disease intensity were reduced; in the field, however, only disease severity was reduced. Glucose and urea were also examined for suppression value. Their influence was less than that of chitin. In other experiments suppression through chitin was found to be less when the soil medium was sterilized.

A series of soil treatments in the greenhouse failed to generate a soil-cleansing effect, as has been described in the literature on European experiments. The levels of suppression, after three 2-month periods of soil treatment, was in the following descending order: monoculture; treatment with ammonium nitrate only; treatment with urea only; a sequence with ammonium nitrate, urea, and potatoes; and control.

Germination. The appearance of germination vesicles in *S. endobioticum* was recorded. The average day of appearance in aqueous culture was

11 days; the average day of maximum appearance was 14 days. Cultures were generally examined for 21 or 28 days. Zoospore discharge from the vesicle–sporangium was recorded on videotape. This is the first recorded instance of this phenomenon. The discharge of the sporangium from the vesicle was also recorded. Changes in vesiculation intensity are being recorded daily for each month. The intensity falls as the days shorten.

AGRICULTURAL ENGINEERING

An experiment conducted at the Technical University of Nova Scotia, using a laboratory rainfall simulator, produced data used to model concentrations of organic and inorganic forms of nitrogen, in runoff and leachate, from soil receiving surface application of dairy manure. The experiment was designed to examine the effects of soil slope, manure application rate, and rainfall intensity.

The organic and ammonium forms of nitrogen were found to be significant in runoff, while nitrite and nitrate nitrogen were most prominent in leachate. Higher rates of manure application resulted in greater concentrations of each form of nitrogen, and soil slope was found to have a significant effect on the concentration of ammonium nitrogen in runoff. Concentrations of organic and ammonium nitrogen in runoff decreased with time, whereas concentrations of nitrite and nitrate tended to increase. Regression equations for organic and ammonium nitrogen fit the data, with regression coefficients of 67 and 77%, respectively. For nitrite and nitrate nitrogen, regression coefficients were less than 50%, indicating much variability in the results. Nitrogen mass balances showed that from 15 to 54% of ammonium nitrogen in the system was lost by volatilization.

PUBLICATIONS

Research

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Hampson, M.C. 1985. Pathogenesis of *Synchytrium endobioticum*. V. Wart disease suppression in potato in soils amended with urea and/or ammonium nitrate in relation to soil pH. Plant Soil 87:241-250.

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Penney, B.G.; McRae, K.B.; Hall, I.V.; Morris, R.F.; Hendrickson, P.A. 1985. Effect of harvest date and location on yield of *Vaccinium vitis-idaea* L. var. *minus* Lodd in eastern Newfoundland. Crop Res. 25:21-26.

Research Station, Charlottetown
Prince Edward Island

PROFESSIONAL STAFF

L.B. MacLeod, B.Sc.(Agr.), M.Sc., Ph.D., F.C.S.S.S.	Director
L.S. Thompson,[1] B.Sc.(Agr.), Ph.D.	Assistant Director
B. Stanfield,[2] B.S.A., M.S.A., M.L.S.	Librarian
M.B. Bourdon, D.Journ.	Information Officer
B.L. McFarlane, B.Sc.(Biol.), M.Sc. (Microbiol.)	Technology Development Program (ERDA) Projects Officer
B.J. Murray	Administration Officer

Cereals

J.A. MacLeod, B.Sc.(Agr.), M.Sc., Ph.D.	Head of Section; Forage and cereal nutrition
A.J. Campbell, B.Eng., M.Phil.	Agricultural engineering
M.R. Carter, B.Sc.(Agr.), M.Sc., Ph.D.	Soil tillage
L.M. Edwards, B.Sc., M.Sc., Ph.D.	Soil management
U.C. Gupta, B.Sc.(Agr.), M.Sc.(Agr.), Ph.D., F.C.S.S.S., F.A.S.A., F.S.S.S.A.	Soil and plant micronutrients
H.W. Johnston, B.Sc.(Agr.), M.Sc., Ph.D.	Cereal diseases
R.A. Martin, B.Sc., B.Sc.(Agr.), M.Sc., Ph.D.	Cereal diseases
H.G. Nass, B.S.A., M.Sc., Ph.D.	Wheat breeding, cereal physiology
J.D.E. Sterling,[3] B.S.A., M.Sc.	Barley breeding

Forage and Livestock

L.S. Thompson,[1] B.Sc.(Agr.), Ph.D.	Head of Section (February to August 1985) Forage, cereal and potato insects
H.T. Kunelius, B.Sc., M.Sc., Ph.D.	Head of Section (September to December 1985) Forage management
R.G. Andrew,[4] B.Sc.(Agr.)	Agricultural economics
T.M. Choo, B.Sc., Ph.D.	Red clover breeding
L.J. Halliday,[5] B.Sc., Ph.D.	Ruminant nutrition
P.R. Narasimhalu, B.Sc., B.V.Sc., M.S., Ph.D.	Forage quality and utilization
M. Suzuki,[6] B.Sc., Ph.D.	Forage and cereal biochemistry and physiology
C.B. Willis,[7] B.Sc.(Agr.), Ph.D.	Forage diseases
K.A. Winter, B.Sc.(Agr.), M.Sc., Ph.D.	Cattle nutrition

Horticulture and Tobacco

J.A. Cutcliffe, B.Sc.(Agr.), M.Sc.	Head of Section; Vegetable nutrition and management
W.J. Arsenault, B.Sc.(Agr.)	Tobacco management and nutrition
J.A. Ivany, B.Sc.(Agr.), M.S., Ph.D.	Vegetable, potato and cereal weed control
J. Kimpinski, B.S.A., M.Sc., Ph.D.	Nematology
J.G. McDonald, B.Sc.(Agr.), M.Sc., Ph.D.	Potato virus diseases
H.W. Platt, B.Sc., Ph.D.	Potato diseases
D.C. Read, B.Sc.(Agr.), M.Sc., Ph.D.	Pesticide bioactivity, vegetable insects
J.B. Sanderson, B.Sc.(Agr.), M.Sc.	Potato management and nutrition
J.G. Stewart,[8] B.Sc., M.Sc.	Entomologist in training
R.P. White, B.S.(Ed.), M.S., Ph.D.	Corn and potato nutrition and management, soil chemistry

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[1]Appointed Assistant Director effective September 1985.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]Retired December 1985.
[4]Educational leave, September 1985.
[5]Postdoctoral fellow, November 1985.
[6]Transfer of work January–June 1985.
[7]Transferred to Program Coordination Directorate, Research Branch Headquarters, Ottawa.
[8]On educational leave.

INTRODUCTION

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

In September, Dr. Leith Thompson was appointed assistant director, replacing Dr. Carl Willis, who joined the Program Coordination Directorate, Research Branch Headquarters, Ottawa. Dr. Tapani Kunelius was appointed head of the Forage and Livestock Section. In June, Dr. Michio Suzuki completed a 7-month transfer of work at the Welsh Plant Breeding Station, Aberystwyth, Wales. In August, Dr. Winston Johnston began a 1-year transfer of work to the Plant Breeding Institute, Cambridge, England, to study the characteristics of various *Fusarium* species that affect cereals in the United Kingdom and eastern Canada.

Rollin Andrew, research economist, left in September for the University of Alberta, Edmonton, where he is undertaking an M.Sc. program in production economics. In November, Dr. Leslie Halliday joined the staff as a 1-year postdoctoral fellow to study forage degradation in the rumen as it relates to forage quality.

This report includes brief summaries of some of the research completed in 1985. More detailed information may be obtained by referring to the station's research summary, which is published annually, or by contacting the Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I. C1A 7M8.

L.B. MacLeod
Director

CEREAL CROPS

Breeding and testing

Spring wheat. A license will be requested for the milling wheat variety, Max, for eastern Canada. Max, developed by Hege in Germany, is a milling variety when managed properly during field production and yields at the level of feed wheat varieties in the Atlantic Region. It yields 25–30% more than the check spring wheat milling variety, Sinton.

Triticale. A license will be requested for the spring triticale, Trit. 3, an introduction from Mexico. In 4 years of tests in the Maritime Provinces, Trit. 3 has exceeded all spring wheat varieties in yield. In 1985, it exceeded the triticale check variety, Triwell, by 11%. It has good straw strength and is the first suitable spring triticale for the Maritime Provinces.

Spring barley. The Charlottetown line AB 73-3 yielded well for a third year in maritime trials. It has resistance to net blotch (*Pyrenophora teres* Drechs.), but is susceptible to scald [*Rhynchosporium secalis* (Oud.) J.J. Davis] and spot blotch, *Bipolaris sorokiniana* (Sacc. in Sorok. 1). AB 73-3 is a two-row barley with strong straw. AB 79-17 is a two-row top-yielding line that has resistance to spot blotch.

Corn hybrid evaluation. The Atlantic corn hybrid evaluation subcommittee (coordinated at Charlottetown) supported the licensing of LG 2221 and LG2 2080 as early-maturing corn hybrids, and added one new silage and one new grain hybrid to the region's recommended lists. Cold-tolerance trials at Charlottetown, which evaluate experimental hybrids from the Ottawa corn breeding program, indicated that most emerged one or more days earlier than the Atlantic Region's three early standard hybrids, and 25 out of 42 hybrids evaluated had an at-harvest grain-moisture content below the mean of the early standard hybrids. The identification of earlier maturing hybrids is essential for the improvement of corn production in the Maritime Provinces.

Management and nutrition

Manganese content of cereals grown in Prince Edward Island. A field study indicated that concentrations of Mn in the tissue of cereals were as low as 20–25 mg/kg. Such levels are close to suboptimal for several crop species. Field studies conducted at several locations in Prince Edward

Island showed that Mn concentrations as low as 22 mg/kg in cereals were not related to Mn deficiency. Limestone applications to raise soil pH to 6.6 decreased the amount Mn in the tissues, but the level not low enough to cause Mn deficiency. It is recommended that levels of Mn in tissue of cereals grown in Prince Edward Island be monitored at periodic intervals to detect any significant changes. Should an Mn deficiency occur in the future, foliar or band applications of manganese sulfate would be advisable, since broadcast Mn is poorly utilized by plants.

Effect of disease control on nitrogen utilization efficiency. Efficiency of N utilization by barley was estimated by yield response per unit of N applied, by increased N uptake per unit of N applied, and by fraction of N taken up by the crop, which was found in the grain. All methods of expressing N utilization efficiency were improved when the pressure of disease was reduced either by application of foliar fungicides, which reduced leaf and head diseases, or by crop rotations, which reduced root diseases.

Tillage and rotation for corn production. No significant differences in the yields and general performance of corn have been found over 3 years in a comparison of no-till corn planting and planting after plowing and discing. A corn–barley rotation did not improve corn production compared with planting corn alone on this fine, sandy loam soil. Elimination of tillage operations saves both time and money, and helps in erosion control.

Simultaneous seeding of a winter cover crop and digging potatoes. A seeding device, jointly developed with the Engineering and Statistical Research Institute, was directly mounted onto a potato digger and field tested in the fall with three seeding materials (winter wheat, winter rye, and pregerminated winter rye) and three temporal modes of seeding (before, during, and after potato digging). Fall performance was measured as emergence count. There was no difference between seeding materials; however, there was a significant difference because of the temporal mode of seeding. Broadcast seeding, after potato digging, was significantly inferior where the seeds were not raked in. Simultaneous seeding and digging showed a 20–40% advantage over other modes of seeding. Pregerminated seed afforded no higher an emergence count than dry seeds, but this was considered a result of seed damage during handling. Comparative ground cover performance will be measured in early spring.

Diseases

Common root rot and nematode levels. A survey was conducted on barley in Prince Edward Island to observe the incidence of common root rot and population levels of nematodes. The dominant nematode genera in plants were stunt nematodes, *Tylenchorhynchus* spp., and root lesion nematodes, *Pratylenchus* spp. The majority of root lesion nematodes were *P. penetrans*, and the primary fungal pathogen was *Bipolaris sorokiniana*. The general trend was for the incidence of root rot to be positively correlated with the number of stunt nematodes in the soil and negatively correlated with the number of root lesion nematodes in the soil and roots.

Influence of seeding rate on net blotch development in barley. Adjusting row spacing and altering seed spacing within the row was found to have a significant influence on net blotch development in barley, as caused by *Pyrenophora teres*. Increasing in-row seed spacing, from 2 to 4 cm between plants, resulted in a significant decrease in the intensity of net blotch, up to 60%. Reductions of up to 50% in the severity of net blotch were recorded when the spacing between rows was increased from 12 to 28 cm. The degree of difference between treatments was dependent on the leaf rated and the timing of disease assessment.

FORAGE AND LIVESTOCK

Red clover breeding

Plant regeneration from zigzag clover. Plants have been successfully regenerated from callus in zigzag clover (Saint-Hyacinthe strain) on L2 medium. Therefore, genetic manipulation of this perennial species through tissue culture is feasible.

Red clover seed production. A 2-year study on four red clover cultivars showed that the second crop produced either the same seed yield as, or a higher seed yield than, the first crop and that the growth regulator Alar-85 increased the seed yields of Dollard and Hungaropoli red clovers. Seed yield of red clover and number of bumblebees per hectare were both low in Prince Edward Island.

Forage management and nutrition

Biochemistry and physiology. Timothy, *Phleum pratense* L., one of the most winter-hardy forage crops in the Atlantic region, accu-

mulated a high concentration of phlein, a fructan with a high molecular weight, during the acclimation process in the fall. Synthesis and accumulation of fructan appeared to be associated with adaptation of grasses to stress factors.

A new enzyme, phlein sucrase, was prepared from seedling shoots of timothy, which catalyzed the synthesis of fructan with a molecular weight of 34KD using sucrose as the substrate. Activity was fully sedimentable at 25 000 × *g*, and had a pH optimum of 7.0 and a K_m for sucrose of 0.15 *M*. Raffinose and stachyose, but not members of the ketose series of oligofructans, could act as fructosyl donors in addition to sucrose. Formation of oligosaccharides during phlein synthesis was minimal. Synthesis occurred by a mechanism apparently analogous to bacterial levansucrase.

Alfalfa (*Medicago sativa* L.) is a valuable forage legume but is short-lived in many regions. Periodic reseeding is necessary to maintain adequate alfalfa in swards. Sod seeding is a fast, one-pass method of renovation, but variable seedling establishment of sod-seeded alfalfa has been experienced in Atlantic Canada. Two experiments were conducted in consecutive years to determine the effect of seeding date on establishment and growth of sod-seeded alfalfa in timothy (*Phleum pratense* L.)-dominant swards at two sites. In experiment 1, alfalfa sod-seeded at four dates in swards band-sprayed with paraquat at 0.5 kg/ha was compared with sod-seeded red clover (*Trifolium pratense* L.). In experiment 2, the effects of four sod-seeding dates of alfalfa and broadcastor band-spraying paraquat of swards were determined. Sod-seeding alfalfa between late April and mid June resulted in the best establishment and yields. Yields of sod-seeded alfalfa were usually greater when paraquat was broadcast-applied rather than band-applied. In experiment 1, red clover became established more readily and made a greater contribution to total yields than did alfalfa.

Effect of harvest date on quality of corn silage. Early-maturing forage corn, DK-22, was harvested in mid September, before the occurrence of frost, and again within 2 days, 1 week, and 2 weeks after the first killing frost; it was ensiled for 3 years. Voluntary intake and digestibility of each silage were measured on six sheep. Silages harvested on the last 2 days were drier, higher in pH, and significantly higher in detergent fibers than were the other silages. Voluntary intake was higher for silages harvested on the two earlier dates, and the difference in intake because of harvest date was significant in 1 of 3 years. Digestibility, especially of N, was low in all years for silages prepared from frozen material. The corn silages prepared from harvests obtained 1 and 2 weeks after the occurrence of killing frost, as compared with normal crop silage, were 16 and 34% lower in feed value, respectively.

Residual effects of spring-seeding method on the perennation of ryegrass and red clover. In a field trial, annual ryegrasses and red clover were spring-seeded into standing winter rye, by first burning out strips (with herbicides) of the standing rye crop to facilitate drill seeding late in the spring.

Plant material was harvested the first year, and dry-weight performance of the system was measured. Recovery and growth of the interseeded crops were observed the following year, and some soil physical characteristics were measured. As in the previous year, the strip-kill-and-seed method gave higher dry weight than regular drill seeding. Unlike the previous year, however, with no standing crop in competition, ryegrass equaled red clover in dry-weight performance. Measurement of soil strength showed resistance to penetration to be significantly higher where interseeding took place. This is thought to have been a result of extra vehicular traffic in early spring over treatments where the soil was still somewhat wet.

Livestock

Extending the grazing season. Grazing studies have shown excellent potential for permanent pastures and have successfully extended the grazing season by 75 days. Holstein steers gained 1 kg/day throughout the usual grazing season on either rotational grazing or fresh daily grazing systems. Extended-season grazing, from 8 October to 11 December, using kale and annual ryegrass pastures, gave gains of 0.8 kg/day.

POTATO PEST CONTROL

Nitrogen management of Russet Burbank potatoes. Total tuber yield was not influenced by N rates of 100, 135, and 170 kg/ha or by how N was applied: all the N banded at planting; N banded at 50 kg/ha and the remainder broadcast before planting; or N banded at 50 kg/ha and the remainder side-dressed in early July. Petiole nitrate levels were lowest with broadcast N but increased with N rate.

Potato diseases. In studies on control of potato late blight the use of metalaxyl–mancozeb on three occasions as part of a 7-day spray program for disease prevention provided better control of late blight (*Phytophthora infestans*) on foliage and tubers than mancozeb used alone throughout

the season. Oxadixyl, a new systemic fungicide, used in combination with protectant fungicides also provided acceptable control of late blight. Resistance to foliar late blight in two potato seedlings (F73008 and F74123), for which licensing is pending, was confirmed. In control studies on verticillium wilt, thiophanate-methyl, alone and in combination with imazalil, and thiabendazole provided excellent control of *Verticillium albo-atrum* on Kennebec. Vigor and stand reductions occurred with several fungicide seed treatments for control of *Fusarium* and *Rhizoctonia*. Disease responses for about 15 cultivars were determined, with Kennebec, Norgold, Russet, and Chieftan demonstrating the greatest levels of susceptibility to *V. albo-atrum*; Russet Burbank, Wauseon, and Abnaki were the most resistant. Disease susceptibility and resistance determinations for internal tuber-borne transmission of *V. albo-atrum* were also made, with Irish Cobbler being the most susceptible and Russet Burbank the most resistant.

Effect of quack grass competition on potato yield. The effect of various periods of quack grass (*Agropyron repens* L. Beauv.) competition after crop emergence was studied for potato (*Solanum tuberosum* L. 'Russet Burbank'). Delaying quack grass removal for 2 weeks after crop emergence reduced the yield of small-sized tubers, the yield of marketable tubers, and the total yield by 6, 27, and 21%, respectively, averaged over 4 years. Successively longer delays in quack grass removal showed progressively greater reductions in yield.

Potato flea beetles affect tuber yields. Potato flea beetle feeding damage reduced the yield of marketable tubers of Superior, Kennebec, Russet Burbank, and Red Pontiac potatoes in a 1984 study, whereas yields of Sebago and Shepody were not affected. In a 1985 study, the yields of marketable tubers of Russet Burbank, Sebago, Superior, and Red Pontiac were reduced, whereas yields of Kennebec, Shepody, and Irish Cobbler were not. Differences in effect of feeding damage on variety appears to be a result of timing of flea beetle damage in relation to tuber set and other stresses, such as lack of moisture at critical periods during the growing season. Indications are that most yield reductions occur as a result of late-season feeding by flea beetles.

Potato leaf roll reduction with aldicarb applied at ground crack. Studies have shown that potato leaf roll virus infection can be reduced by applying granular aldicarb in the furrow at planting time. In 1984, when aldicarb granules were applied as low as one-half the recommended rate and at 25% ground crack rather than at planting, leaf roll infection in Kennebec potatoes was also effectively reduced.

Postharvest detection of potato virus Y in tubers by ELISA. Treatment with Rindite or bromoethane to break the dormancy of Russet Burbank tubers, harvested at various stages of maturity, indicated that immature tubers did not respond by increasing their virus concentration, whereas more mature tubers did. No significant differences were observed in virus response to the two dormancy-breaking treatments. Virus levels in the tuber were not affected by whether or not the plants were chemically desiccated with reglone.

The effect of aldicarb and oxamyl on the root lesion nematode *Pratylenchus penetrans* and tuber yields of Superior, Russet Burbank, and Shepody potatoes were examined over 3 years in experimental plots on Prince Edward Island. Temik G (15% aldicarb) with active ingredient (a.i.) at 1.12 and 2.24 kg/ha and Vydate G (10% oxamyl) with a.i. at 2.24 kg/ha, applied in the furrow at planting, reduced the size of nematode populations. Yields of Superior increased by up to 38% when nematicides were applied. The influence of aldicarb did not appear to be significantly different from that of oxamyl, nor were yields at the higher rate of aldicarb appreciably different from those at the lower rate.

HORTICULTURE AND TOBACCO

Vegetables and tobacco

Asparagus cultivar evaluation trial. Results of an evaluation trial indicate that several cultivars are suitable for production in Prince Edward Island and that recently introduced European hybrids are considerably more productive than those included in the test from North America. Lucullus (mid-early) and Aneto have produced the greatest cumulative yield during the three seasons that the trial has been harvested.

Effect of calcium on internal browning in Brussels sprouts. Field experiments conducted over a 3-year period in Prince Edward Island showed that the incidence of internal browning in Brussels sprouts was not affected by preplanting applications of calcitic limestone, dolomitic limestone, or gypsum at rates of 3, 3, and 5.5 t/ha, respectively. Soils at the experimental sites had initial pH levels of 5.1–5.8, and yields were increased by about 10% by the application of either calcitic or dolomitic limestone. The application of gypsum (calcium sulfate) increased yields by about 30%.

Boron nutrition of carrots and table beets. Soil applications of B at 0–4 kg/ha had little effect on yield of carrots and beans grown at several locations in Prince Edward Island. Boron deficiency impaired the quality of beets. Boron-deficient beets had brown tops, and roots were rough, scabby, and off-color. The cut sections of roots were darker and necrotic compared with the bright purplish red roots with sufficient B. In a greenhouse study on a soil depleted of B, B deficiency in carrots resulted in yellow tops and rough roots. Boron concentrations of 32–40 mg/kg in the leaf tissue of beets and 22–28 mg/kg in the leaf tissue of carrots were related to B deficiency. Boron concentrations as high as 120 mg/kg in the leaf tissue of beets and 149 mg/kg in the leaf tissue of carrots were not associated with B toxicity.

Weed control in native lowbush blueberries. A single application of hexazinone at rates of 1 or 2 kg/ha in early May 1983, after burning and before growth started, resulted in increased yields in 1984 and 1985. The hexazinone treatments increased the yields in 1984 from 2.3 to 3.6 t/ha and in 1985 from 0.8 to 1.3 t/ha. Applications of hexazinone at 3 and 4 kg/ha in 1983 resulted in lower yields in 1984 than when it was applied at 1 or 2 kg/ha; however, second-crop yields in 1985 were as great where hexazinone was applied at 3 and 4 kg/ha in 1983 as at the lower rates.

Soil pesticides and root maggot control. A single preplanting soil treatment of chlorfenvinphos or terbufos effectively controlled root maggot in rutabagas throughout the growing season in areas of near neutral pH soils, where accelerated microbial breakdown of aldicarb, fensulfothion, and carbofuran has resulted in almost complete lack of control by these insecticides. Fensulfothion and carbofuran gave good control in areas of more acidic soils and in fields not previously treated with these insecticides. The strains of microorganisms adapted to breaking down fensulfothion, carbofuran, or aldicarb rapidly also caused accelerated breakdown of the other two insecticides; but they did not cause any decrease in the residual persistence of chlorfenvinphos, terbufos, fonofos, or isofenphos. However, because of dry weather in 1985, fonofos and isofenphos did not give good root maggot control in any of three test areas.

Microorganisms selected for rapid breakdown of carbofuran and aldicarb. In contaminated water these microorganisms were found to maintain their effectiveness over long periods. In replicated tests, the microbes degraded each of 24 successive applications of insecticides at 50 ppm in less than 3 days without loss of potency. However, after periods of 30–60 days without insecticide, the microbial populations decreased. Thereafter, there was a lag before rapid breakdown of insecticide at a concentration of 50 ppm that had been added to the cultures.

Slug control. Methomyl and methiocarb gave excellent control of slugs when applied at night but were ineffective as daytime sprays. Treated Brussels sprouts were analyzed for residues, and action has been taken to have methomyl registered under the pesticide minor use program.

Tobacco

Application of additional nitrogen to flue-cured tobacco after transplanting. In a 3-year study two methods of N application after transplanting were examined under conditions of low fertility. Yield increases occurred when N was applied by the traditional method of side-dressing 2–4 weeks after transplanting. However, increases in yield also occurred when N, dissolved in water, was dripped between rows 2 weeks before or at topping.

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H.W. Hulan, B.Sc.(Agr.), M.Sc., Ph.D.	Head of Section and Program Leader; Nutrition and physiology
F.G. Proudfoot, B.Sc.(Agr.), M.Sc.	Physiology and management

Nappan Experimental Farm, Nappan, N.S.

F.W. Calder, B.Sc.(Agr.), M.S.	Superintendent; Forage crops and agronomy
J.E. Langille, B.Sc.(Agr.)	Agronomy, cereal and forage crops
T.A. Van Lunen, B.Sc.(Agr.), M.Sc.(Agr.)	Swine management and nutrition
N.R. Williams, B.Sc.(Agr.)	Sheep management and nutrition
L.F. Laflamme, B.Sc.(Agr.), M.Sc., Ph.D.	Ruminant nutrition
R. Troelstra, B.Sc.(Agr.)	Beef management and nutrition

Departure

R.G.Ross, D.F.C., B.Sc.(Agr.), M.Sc., Ph.D.	Assistant Director and Head; Crop protection, tree fruit diseases

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[1]Seconded from Marketing and Economics Branch.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]Seconded from Systems and Consulting Directorate, Finance and Administration Branch.
[4]Educational leave to University of Guelph.

INTRODUCTION

The Kentville Research Station conducts a comprehensive research and development program, which is focused on the horticultural, poultry, and winter cereal sectors of the agricultural industry in Atlantic Canada. The research is multidisciplinary and encompasses genetic improvement, nutrition, and management as well as the protection of economic crops from insects, diseases, and weeds. Increasing emphasis is being placed on the research and development needs of the food processing industry through development of new products as well as improvements in process technology. The extension of the effective marketing season for domestic fruit and vegetable produce is also being stressed through innovative storage research.

The management of livestock and their related feed crop requirements are studied extensively at the Nappan Experimental Farm. Emphasis is on the beef cow–calf, sheep, and swine production systems.

The research results reported herein are intended to provide an overview of current studies and progress achieved. More complete information may be obtained in the annual research reports of the two establishments as well as by writing to the Research Station, Agriculture Canada, Kentville, N.S. B4N 1J5, or the Experimental Farm, Nappan, N.S. B0L 1C0.

G.M. Weaver
Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Cranberries

Cultivar performance. In both 1984 and 1985 the cranberry cultivar Crowley outyielded seven others in trials on a commercial bog at Aylesford, N.S.

Lowbush blueberries

Fertilizer study. The clone Chignecto and the seedlings Augusta × 451 and Chignecto × 70-13 received treatments in the spring of 1985 that included a control and three rates and sources of N, P_2O_5, and K_2O. Results from the second successive crop show that Chignecto responded best to N applied at 50 kg/ha for the second year in a row. The average yield for Chignecto from N applied at 50 kg/ha was 36% higher than the yield from N applied at 150 kg/ha and 54% higher than the control. Results from the seedlings do not show any definite trend this season.

Incidence and spread of red leaf disease in lowbush blueberries in Atlantic Canada. A 5-year study showed that red leaf disease, caused by the fungus *Exobasidium*, was widespread but usually of low incidence in lowbush blueberry fields in the Atlantic Provinces. Few new infections were found during the study period. Observations of naturally infected plants suggested clonal differences in susceptibility to and tolerance for infection. In greenhouse-grown plants inoculated through stem wounds, symptoms developed only on new growth, and the mycelium was slow to spread from serial shoots to rhizomes. Two clones tested were resistant to infection. These observations support the view that host resistance and regular burn–pruning control the spread of red leaf disease in lowbush blueberry clones in native stands.

Micropropagation of lowbush blueberry. Rapid multiplication of select lowbush blueberry clones was achieved using shoot tips cultured in vitro. Material taken directly from the plant was often slow to become established in culture, and it was preferable to start with axillary buds flushed in vitro. In established cultures, shoot multiplication occurred mainly by outgrowth of axillary buds, but adventitious shoots developed occasionally on leaves touching the medium. Brent and McCown woody plant medium gave healthier shoots than other basal media tested. Exogenous auxin was not required for multiplication, but the cytokinin 2iP was essential. Rooting was obtained by placing individual shoots directly in soil under intermittent mist. During the first year, micropropagated plants resembled seedlings in growth habit but tended to produce more basal branches than either seedlings or rooted cuttings. One-year-old micropropagated plants were successfully transplanted to the field for further observation.

Pruning. No significant differences in length of stems, number of flower buds, and number of branched stems were found on shoots of lowbush blueberry (*Vaccinium augustifolium* Ait.) following burn-pruning using a conventional and modified burner. Intensity of branching increased following pruning with the modified burner. The modified burner required less oil, making it competitive with mechanical pruning.

Sawdust mulch and trickle irrigation. The clone Chignecto and the seedling Chignecto × 70-13 were harvested for the second consecutive time. Chignecto outyielded the seedling by 178% over all treatments. The addition of a sawdust mulch increased, whereas supplemental irrigation showed no effect. Blueberry plants mulched with sawdust but not irrigated produced marketable yields that were 40% (clone) and 56% (seedling) higher than those from plots without sawdust.

Weeds. An account of the weedy vetch (*Vicia* spp.) species occurring in Canada has been written for the series *The Weeds of Canada*. Five species were found in a wide range of habitats, with the main centers of distribution in eastern Canada and the south, as well as in the coastal regions of British Columbia. Burning destroys the above-ground stems of *V. cracca* in lowbush blueberry fields. In the year following burn, there is strong vegetative growth from dormant buds of below-ground roots, and this grows to greater height than the new sprout growth of blueberries. Vetch species are sensitive to a number of herbicides, but there appears to be differential tolerance among species to chlorthal dimethyl, 2,4-DB, and others.

A second account has been written for St. John's-wort, which is an introduced weed growing in waste places, roadsides, pastures, and similar habitats. It is poisonous to livestock, causing photosensitization in grazing animals with light-colored hair. St. John's-wort has become a problem in lowbush blueberry fields in the Atlantic Provinces. Management practices such as burning and the use of hexazinone for weed control may even benefit its spread and growth.

Raspberries

Red raspberry breeding. Eighteen raspberry seedlings were selected for further testing from 1625 seedlings derived from 25 crosses. These seedlings excel in some of the following traits: fruit size, flavor, appearance, yield, vigor, winterhardiness, and resistance to late yellow rust.

Kentville seedling K74-1 (Avon × Matsqui) performed well in the 1985 cultivar trial with a yield of 8.6 t/ha. Fruit size was medium (2.4 grams per fruit) and flavor and appearance were very good. K74-1 has also proven to be winter-hardy and resistant to late yellow rust. In addition, it ripens early, with peak production about 6 days before Festival and Nova.

Strawberries

Day-neutral strawberries. The day-neutral cultivars Tribute and Tristar have been tested at Kentville during 1983–1985. With conventional growing methods (narrow-matted row) these cultivars produce 4–6 t/ha in the fall of the planting year. In the second year, 10–11 t/ha are produced during the early midseason and a further 2–7 t/ha in the fall, primarily during the period of 15–30 September. The cultivar Tristar produces fruit with excellent flavor and is recommended for the home garden. Further experimentation is required before large-scale production can be recommended.

Strawberry breeding. Nine strawberry seedlings were selected for further testing from 4600 seedlings and were screened for resistance to *Phytophthora fragariae* before field planting in 1984. The parents of these selections included Allstar, Annapolis, Blomidon, Cardinal, Cornwallis, and Honeoye.

One red-stele-resistant selection from 1982 and four from 1983 were identified in 1985 as having cultivar potential and will be entered in replicated cultivar trials. These selections ripen in the early-mid to mid-late season, thus complementing the early season Annapolis and Cornwallis, cultivars currently recommended in Nova Scotia with resistance to *P. fragariae*.

CEREALS

Winter rye. Danko is a winter rye (*Secale cereale* L.) cultivar with higher yield, better lodging resistance and winter survival, and higher kernel mass and test mass than Animo and Kustro, the current most commonly grown cultivars in the Maritime Provinces. It was developed at the Plant Breeding Institute, Poznan, Poland, where breeder seed will be maintained. Seed will be distributed by King Grain Limited and the Alberta Wheat Pool. The testing of this cultivar was coordinated from Nappan.

FORAGES

Annual ryegrass silage compared with brome–alfalfa silage. A mixture of a legume and a grass normally produces substantially more animal gain when fed as silage than when grass is grown alone.

Steers fed a brome–alfalfa silage in 1985 consumed 8.10 kg of dry matter per day to gain 0.83 kg per head per day. In the same experiment, Aubade annual ryegrass silage was consumed at the rate of 8.21 kg of dry matter per day and the steers gained 0.74 kg per head per day, which is close to the results achieved with the grass–legume mixture and is a much better gain than that produced by other grasses ensiled singly.

Brassica species for fall grazing with lambs. Three blocks of Tyfon, Kale, and Rape were seeded with a Hunter Mark II pasture renovator on 0.2 ha each of sod killed with Roundup. Areas of permanent pasture of 0.1 ha in size were left in each paddock for the lambs to graze. During the fall, animals on Tyfon, Kale, and Rape gained 0.22, 0.16, and 0.16 kg/day, respectively. Grazing days accumulated on each species were 759, 821, and 843 for Tyfon, Kale, and Rape.

ORNAMENTALS

Commercial chrysanthemum production in flowing nutrient solution. A system for chrysanthemum production using the nutrient flow (NF) technique has performed well under commercial greenhouse conditions. Production of a mid-winter crop of the cultivar Polaris was possible in NF, whereas in conventional soil beds, flowering was not achieved. Subsequent crops of Polaris and various Marble cultivars produced equivalent numbers of stems in NF and soil, but NF production time was reduced by 6 or 7 days. Analysis has shown that investment in NF systems for cut-flower production is preferable to conventional methods based upon three economic indices.

Eastern regional plant-testing network. New taxa were added at all sites in the network during 1985. Evaluations were completed on taxa planted in 1980 at Kentville and L'Assomption. Of the more recent additions, various cultivars of heather (particularly Peter Sparks and H.E. Beale) continue to show promise at all locations, with extremely vigorous growth and flowering at Kentville and L'Assomption. The heaths *Erica carnea* Pirbright and Silberschmeltze have proven hardy and floriferous at Kentville and L'Assomption, but Vivellii performed less well. The heaths have not survived at Blissville, N.B., or Charlottetown, P.E.I. Full reports for 1979 to 1985 on a wide selection of woody plants are available.

Efficacy of Nutricote as a controlled-release fertilizer for container production. Nutricote 16-10-10 (100-day release formulation) produced better growth than Nutricote 14-10-10 when incorporated into media used in the container production of *Juniperus horizontalis* Moench 'Plumosa compacta'. Best growth was obtained with an incorporation rate of 5 kg/m^3. Further experiments suggested that excellent season-long nutrition and growth can be achieved with type 70 (70-day release).

Nutricote as a premixed medium constituent at a rate of 5 kg/m^3, types 100 and 180, produced inferior mid-season growth. Additional soluble nitrogen incorporated with Nutricote had no effect on early or mid-season growth rates.

Supplemental lighting for scheduled production of Gypsophila paniculata. Flowering of *Gypsophila paniculata* L. 'Bristol Fairy' was promoted by supplemental lighting from September to February (fall) and January to June (spring) in greenhouses. Plants that received 6 or 9 weeks of night-time supplemental photosynthetic flux (PPF) from high-pressure sodium lamps before transplanting flowered earlier and showed more vigorous vegetative growth than those subject to only 3 weeks of supplemental PPF. Flowering did not occur in the fall crop for plants that received only low-level photoperiod extension lighting. Further studies in growth chambers have indicated that flower initiation does not occur in this cultivar before a cumulative total of 550 mol m^{-2} has been received. It appears that provision of supplemental light early in plant development, to achieve this total, may facilitate year-round gypsophila production in northern greenhouses.

TREE FRUITS

Comparison of magnesium sulfate and THIS magnesium chelate foliar sprays; response of magnesium-deficient Beautiful Arcade apple seedlings. Magnesium sulfate, applied as foliar sprays at 0.2% Mg, was more effective than THIS Mg in correcting Mg deficiency of Beautiful Arcade seedlings grown in solution culture in the greenhouse. The foliar sprays of THIS Mg chelate (4% Mg) were applied at a dilution of 1:200 (0.02% Mg). Conductivity measurements suggest that absorption of Mg from THIS Mg will occur above 65% relative humidity compared with the level of 80% relative humidity required for absorption from magnesium sulfate.

Effect of varied soil calcium-to-magnesium ratios on calcium and magnesium concentrations in leaf samples of two apple cultivars. A range of soil Ca and Mg was established to a depth of 1 m on sandy loam tree sites 3 × 3 m, before planting 2-year-old Macspur McIntosh–M.26 and Northern Spy–M.26 in the spring of 1980. Leaf Ca increased and leaf Mg decreased with increase in soil Ca and Mg in each year from 1980 to 1982. Leaf composition (leaf Mg, leaf Ca, and leaf Ca and Mg) was highly correlated with soil composition (soil Mg, soil Ca, soil Ca and Mg, and $\log_{10}$ soil Ca and Mg). The relationship between leaf

composition and soil Ca and Mg was logarithmic, i.e., the effect of unit increase in soil Ca and Mg on leaf composition decreased as the ratio increased. Soil Mg accounted for as much variation in leaf composition as did $\log_{10}$ soil Ca and Mg: up to 88% when leaf composition was expressed as a ratio. A decrease in soil Mg of 1 mequiv/100 g soil, accompanied by a similar increase in soil Ca, was associated with an increase in leaf Ca of 0.10% and a decrease in leaf Mg of 0.06%.

Dwarfing and yield effects of apple rootstock and interstem combinations. Thirty-six combinations of dwarfing interstems were developed for a field trial with virus-indexed Blackmac McIntosh as the grafted cultivar. Cropping and tree size for this field trial of 9 years were recorded for the stem pieces M.27, Ottawa 3, M.26, Ottawa 7, M.4, and McIntosh each on rootstocks M.26, MM.106, MM.104, Alnarp 2, Antonovka seedling, and Beautiful Arcade seedling. There were some interactions among stem pieces and stocks in both tree size and cropping. Small trees had less total crop but were more efficient as revealed by total yield per cross-sectional area of the trunk. Cropping efficiency appeared to be additive rather than synergistic. For example, assigning an efficiency rating of 100, the efficiency for all stocks with Ottawa 3 interstem was 118, for MM.106 rootstock 117, for the combination of Ottawa 3 interstems and MM.106 rootstock 137.

Fresh fruit versus juice production for apples. Net revenue over operating costs for the cultivar McIntosh in a mature orchard was greater for the fresh-fruit system than for juice production by $1059 and $454 in 1984 and 1985, respectively. Yields were greater from trees in the fresh-fruit system than those in the juice system in 1984 but approximately equal in 1985. Spray applications were reduced with the juice program. New production techniques could change the net revenue position for either system, necessitating continued study.

Field performance and micropropagation of a hardy apple rootstock, candidate KSC-3. Thirty Beautiful Arcade seedling apple rootstock selections (designated the KSC series) were established in a field trial, with McIntosh and Red Delicious as scion cultivars. The selection KSC-3 promoted high vigor, and McIntosh promoted both precocity and high yields. KSC-3 was successfully micropropagated using benzylaminopurine and indolebutyric acid in the shoot and root medium, respectively.

Fundamental principles of orchard layout and form of apple trees. After 25 years of investigation, work at Kentville has developed general parameters that must be effected by a suitable combination of orchard layout, and rootstocks and tree training, if apple yields of maximum quality are to be achieved.

For any given apple clone or cultivar to reach its maximum genetic potential of high-quality yields, three principles must be followed:

- High capture of skylight from sunrise to sunset per unit area (hectare) is necessary. Skylight is nearly as important in Nova Scotia as direct sunlight. Total coverage of the ground area by the orchard canopy does not need to be complete, provided lateral light in the morning and afternoon is captured. Further work on the direction of rows and on ground reflectance is needed and is under way.
- Fairly uniform pattern of leaf arrangement is necessary, perhaps not more than one or two leaves thick. No leaves should receive less than 50% of full light at any time and should receive more than 75% full light for at least one-quarter of the day.
- Optimal seasonal balance between vigor and cropping must be maintained. Genetic expression of a given clone may be reduced if management procedures induce either too little or too much growth, either in total or at a critical time during the season. Further work is required on the rates of development of the most desirable canopy size and shape, and its control when the best dimension has been reached.

It now appears that the high efficiency of the size-controlling stocks is, in part at least, due to better exposure of individual leaves. The corollary of this is that alternative methods may achieve the same end. Work on these methods such as pruning, growth regulators, and spur types, together with work on stocks and the interrelationships among them, is continuing.

Rootstock hardiness. Exposure of potted 2-year-old apple rootstocks to a range of cold stress has been successful in defining both trunk- and root-hardiness thresholds. The apple rootstocks Ottawa 3 and Beautiful Arcade have demonstrated superior trunk hardiness in initial tests, which included M.26, MM.106, MM111, Alnarp 2, and EMLA 7. Root damage is prevalent below –10°C. Quantification of the degree of hardiness below this level is in progress.

Winter injury to Gravenstein apple strains as influenced by trunk scoring. Eleven Gravenstein apple strains (*Malus domestica*) in an 8-year-old field trial were trunk-scored 4 weeks after bloom before and after the 1980–1981 test winter that injured many trees in eastern Canadian orchards.

Regression analysis revealed that scores that healed poorly and initial light cropping reduced lower trunk hardiness, whereas growth had no effect. The incidence of injury was greatest below the score but always occurred above the graft union, and fruit size was negatively correlated with trunk damage.

VEGETABLES

Comparison of a commercial fertilizer (17-17-17) with pelleted fish silage. Transplants of broccoli, Brussels sprouts, cabbage, and cauliflower received N at 150 kg/ha supplied by either the commercial fertilizer 17-17-17 or pelleted fish silage; both materials were applied broadcast preplant. Yields of broccoli, cabbage, and cauliflower were similar from both nutrient sources; however yields from Brussels sprouts supplied with 17-17-17 were significantly higher than yields from plants supplied fish silage.

Multiple plants in direct-seeded broccoli production. Results obtained in 1985 with direct-seeded broccoli, when two or three plants were allowed to grow together at plant-to-row spacings of 30 × 60, 37.5 × 75, and 45 × 90 cm, were essentially identical to those obtained with transplanted broccoli as reported previously. At the 37.5 × 75 cm spacing, the two and three plants yielded 11 and 19% higher than single plants, and at 45 × 90 cm they yielded 38 and 26% higher, respectively. Yields with multiple plants at these spacings were generally higher than yields of single plants at a 30 × 60 cm spacing. The multiple-plant system for direct-seeded broccoli offers several commercial advantages over single plants, including high yields at relatively wide spacings, full plant stands without hand thinning, and adaptability to existing equipment.

Multiple plants per transplant unit for broccoli production. With the cultivar Premium Crop, the use of two plants per transplant unit gave yields 5–10% higher than those of single plants at a plant-to-row spacing of 37.5 × 75 cm. At 45 × 90 cm, the use of two or three plants per unit gave yields 20–30% higher than single plants. At both of these spacings, multiple plants gave yields as high as those of single plants spaced 30 × 60 cm. The savings in number of transplant units needed at 37.5 × 75 cm and 45 × 90 cm compared with 30 × 60 cm are 47 and 67%, respectively. Both two and three plants per unit performed well with Kord 809 cells, with a volume of 53 cm^3 per cell, but three plants did not perform as well as two in the smaller Plastomer 200 cells, with a volume of 29 cm^3 per cell. Results in 1985 followed the general trends of previous years, but yields with multiple plants tended to be about 20% below those of 1984. This was attributed to wet soil conditions in 1985, both in cold frames just before field planting and during the first week after planting.

Favorable results with the use of multiple plants were also obtained with the cultivars Green Hornet, SGI, Improved (Southern) Comet, Green Comet, Septal, and Kayak. At a spacing of 45 × 90 cm, multiple plants of these cultivars yielded 7–90% higher than single plants.

Plastics for advancing maturity of rutabagas. All floating row covers resulted in yields of marketable rutabagas that were higher than yields of uncovered check plots on a 16 August harvest date. Row covers consisted of the commercial materials Agplast, ASB, Reemay, and Xiro. Yields with the covers were 30–60% higher than the 15–20 t/ha yields of check plots and were the result of larger rutabagas. The cultivar Laurentian had early yields that were 33% higher than those of York.

Row covers advance maturity of carrots. Plots with all types of floating row covers gave higher yields of carrots than unprotected plots on a 14 August harvest date. Row covers consisted of the commercial materials Agplast, ASB, Reemay, and Xiro. Agplast and ASB gave the highest early yields, and their total yields of 50 t/ha were 35% higher than the 37 t/ha of the uncovered check plots. Xiro and Reemay gave yields 18 and 9% higher than check plots, respectively. The higher early yields were the result of larger carrots in the covered plots. The three cultivars All Seasons, Klondike Nantes, and Scarlet Nantes Touchon responded similarly to the covers. All Seasons had the highest early yields and seems well suited to early production with plastics.

Row covers for advancing maturity of cabbage and broccoli. Floating row covers of Agplast, ASB, Reemay, and Xiro advanced maturity by only 3–5 days with Emerald Acre cabbage and with the early broccoli cultivars Green Hornet, Improved (Southern) Comet, Bishop, Bravo, Laser, and Green Charger. With broccoli cultivars that matured 10–12 days later than the early ones, row covers advanced maturity by 5–12 days. The later maturing cultivars included Green Comet, Surfer, Ritados, Septal, and Premium Crop.

Vegetable cultivar evaluation. Trials included 495 cultivars of the following crops: asparagus, beans (snap), broccoli, Brussels sprouts, cabbage, carrots, cauliflower, lettuce, muskmelons, onions, peppers, potatoes, tomatoes, and watermelons. Reports for each crop are available.

PROTECTION OF CROPS AGAINST PESTS

Insect pests

Effect of populations of the European red mite on yield of Red Delicious apples. In a 4-year study, counts of mites and of the number of dormant clusters, blossom clusters, and harvested apples were taken from a peripheral sampling zone (1.3 m above ground extending 1 m inward from the outer edge of the canopy) in each of 96 trees. Mite samples taken twice weekly through the summer (number of mites per four spur clusters per tree) were used to calculate cumulative mite-days per leaf (motile stages only) to 30 June, 15 July, 31 July, 15 August, and 31 August for each tree and each year. Bloom was the ratio of blossom clusters to dormant clusters and set the ratio of harvested apples to blossom clusters. In 1967 and 1969 there were higher levels of bloom (40.8 and 30.8% versus 26.8 and 20%) and harvested apples per sampling zone (328 and 242 versus 218 and 185) than in 1968 and 1970. There was a significant negative association between set and cumulative mite-days to 15 July in 1967 and 1969, the years of heavier bloom and fruit load. In Nova Scotia, during late June and early July, trees drop excess fruit because of competition for nutrients and water among fruits, vegetative growth, and developing flower buds. Mites exacerbate this competition. In 1967 and 1969 there was also a significant negative association between mite-days to 15 July and number of harvested apples per sampling zone. Conversely, in 1968 and 1970 there were no significant associations between mite-days and set.

Cumulative mite-days per leaf to 31 August in 1969 had a negative effect on the number of apples harvested in 1970, this decline being a consequence of reduced bloom because of interference with the formation and maturation of flower buds. As a consequence of this study, the economic threshold for the European red mite (mid-June count) has been lowered from 40 eggs plus mites per leaf in 1983 to 35 in 1984 and 30 in 1985.

Monitoring the blueberry maggot with Pherocon AM traps to determine spray needs. Pherocon AM traps are very attractive to adults of the blueberry maggot, and when two traps per hectare are deployed in areas with a plentiful supply of berries protected from the prevailing winds, they will detect the presence of the adults before eggs are laid. One spray of dimethoate 480 EC, 500 mL/ha, applied with a tractor-mounted automatic mist sprayer, 7 days after the first adult capture, provided very good seasonal control in 1984 and 1985. Sprays are currently recommended based on the prevalence of maggot (larvae) in the berries at harvest and are not applied until the next crop year (usually 2 years later): one spray in those fields with light infestations and two in those with moderate or heavy infestations. The use of traps to determine spray needs would be more appropriate than present methods and can result in fewer sprays.

Diseases

Control of twig and blossom blight of lowbush blueberries. Two applications of Funginex 190 EC (triforine) with a.i., the level of a.i. decreasing in series from 0.32 to 0.03 kg/ha, resulted in an exponential increase in the incidence of blighted leaf shoots and blossom clusters caused by *Monilinia vaccinii-corymbosi* (Read) Honey. A marked increase in disease occurred at rates below 0.15 kg/ha. One application of triforine at 0.27 kg/ha timed according to the presence of ascospores during bud break controlled the disease as effectively as two applications arbitrarily timed 10 days apart. Two applications of Easout 70 WP (thiophanate-methyl) during bloom did not control the formation of mummyberries.

Evaluation of fungicides on apples. Under extreme disease pressure, apple scab on foliage was effectively controlled by many of the experimental sterol-inhibiting fungicides. However, scab control on the fruit was poor primarily because of the lack of persistence of the sterol inhibitors and their inability to control late or pin-point scab. The addition of manzate to the sterol inhibitors greatly enhanced scab control and produced a smoother fruit finish.

Tolerance of Botrytis cinerea to thiophanate-methyl. Tolerance of the fungus *Botrytis cinerea* to the fungicide thiophanate-methyl was determined in a survey of 54 lowbush blueberry fields in 1984 and 1985. Isolates from two fields were fully tolerant, with EC_{50} values >100 μg/mL, whereas isolates from 10 fields were designated as partly tolerant, with EC_{50} values of 0.58–1.45 μg/mL. The fully tolerant isolates produced sclerotia at 100 μg/mL, and two of the partly tolerant isolates produced sclerotia at 10 μg/mL but not at 100 μg/mL. Tolerance in isolates from the remaining fields was not detected.

Weeds

Degradation of hexazinone in soils of lowbush blueberry fields. In spring-treated field soils, hexazinone is degraded by demethylation and hydroxylation. Metabolite B, a demethylated derivative, was the predominant metabolite extracted 10 and 28 weeks after application; and

metabolite C, a hydroxylated, demethylated product, was also present at high levels. In soil incubation studies, metabolite D, a demethylated trione, was the major metabolite in one out of two nonsterile soils, and it formed readily during sterilization by autoclaving and during subsequent incubation. Evidence was also obtained for cleavage of the *s*-triazine ring.

Effect of plastic row covers on tomato productivity and weed control with selected herbicides. A system consisting of a clear plastic surface mulch and a clear plastic row tunnel significantly increased tomato growth, and early and total yields, compared with uncovered plants. Pretransplant metribuzin at 0.5 kg/ha provided superior weed control under the plastics and increased yields above those of diphenamid-treated or hand-hoed plots. Metribuzin, trifluralin, and diphenamid provided better weed control on covered plots than uncovered plots, without crop injury.

Factors affecting persistence of metribuzin in soils. The half-life of metribuzin applied before emergence in a Berwick sandy loam ranged from 7 to 14 days. Residual levels at 30 and 60 days after application were increased by shallow incorporation immediately after application or by artificially shading the sprayed soil surface.

Response of lowbush blueberry to weed control with atrazine and hexazinone. Atrazine at 4, 8, and 12 kg/ha and hexazinone at 1, 2, 3, and 4 kg/ha were tested at 9 and 13 locations, respectively. There was no indication from any location that atrazine adversely affected lowbush blueberry (*Vaccinium angustifolium* Ait.). However, at 6 of 12 harvested locations, hexazinone at 4.0 kg/ha decreased yields relative to lower rates. At only two locations, characterized by poor drainage, were yields below those of the untreated plots. On average, atrazine and hexazinone treatments increased yields about 85% and 70%, respectively, although response varied widely among locations. Increased yields resulting from greatly improved weed control were related to increases in the density of fruiting shoots and to the number of flower buds per shoot.

Tolerance of select clone lowbush blueberries to terbacil and its residues in fruit. Out of 27 3-year-old clones treated with terbacil at a rate of 1.25 kg/ha, two had >20% foliar injury, seven had 2–9% injury, eight demonstrated no injury, and the remainder had minor injury. Differential tolerance was confirmed in greenhouse studies with rooted cuttings. Residue analysis indicated no relationship between tolerance and terbacil residues in the fruit (0–0.008 ppm), which in all cases were well below acceptable tolerances (0.04 ppm).

STORAGE

Apples

Effects of storage humidity on fruit quality and the incidence of internal browning in McIntosh apples stored in conventional controlled-atmosphere or low-oxygen storage. McIntosh apples stored in either 5% CO_2 + 3% O_2 or 1% CO_2 + 1% O_2 at a high level of humidity were firmer and had a lower incidence of internal browning than fruit stored at a lower humidity (75–81% relative humidity). Firmness retention under higher storage humidity regimes was greater for apples stored in low-oxygen atmosphere. Levels of storage humidity were positively correlated with retention of titratable acids in apples stored in conventional controlled atmosphere (CA), but did not influence titratable acids in fruit stored in 1.0% O_2. Benefits in potential fruit quality may be obtained with a high storage humidity, and a low relative humidity in storage may be a factor in predisposing fruit to low-oxygen breakdown.

Programmed controlled-atmosphere storage of apples. The technology of programmed CA storage developed at Kentville Research Station has been successfully tested in a commercial trial. Two hundred tonnes of McIntosh apples from 29 selected growers were cooled, and oxygen was reduced to 2.5% O_2 within 10 days of initial harvest. The initial CA atmosphere was established at <1% CO_2 + 1.0% O_2 within 20 days of harvest, after which both carbon dioxide and oxygen levels were allowed to increase linearly until they reached 5% CO_2 + 3% O_2 after 330 days of storage.

Apples removed from the programmed CA regimen were approximately 9 N (0.9 kg) firmer and retained 7% more acid than the control fruit held in conventional CA. Programmed CA storage eliminated the incidence of senile brown core and senescent breakdown from 6% and 10%, respectively, in fruit stored in conventional CA, whereas only a trace of low-oxygen injury was observed in 2 of the 29 grower lots stored in programmed low-oxygen storage.

Retarding loss of apple firmness by application of flavonoid glycosides. Vacuum infusion or dipping fruit in solutions of an apple extract containing chlorogenic acid, catechins, and quercetin glycosides (isolated from Spartan apples) suppressed fruit softening of Spartan and Golden Delicious apples held at 20°C. Quercetin or rutin at 0.01% (w/v), applied by postharvest vacuum

infusion or dipping, reduced softening of Golden Delicious apples held at shelf temperatures (20°) and those held in cold storage (0°). The structurally related compounds catechin, coumaric acid, and chlorogenic acid showed some potential for retarding fruit softening but had inconsistent effects.

The addition of 0.25% (w/v) thickener plus 0.1% surfactant to the dipping solution containing the above-mentioned compounds slowed firmness loss. When quercetin or rutin were vacuum-infused either before or after CA storage, fruit was firmer than control fruit over a shelf-life period of 25 days.

Sensory evaluations of texture of McIntosh and Red Delicious apples stored in air and in controlled atmospheres. A limited consumer population was used to examine the textural preferences for McIntosh and Red Delicious apples stored in air, in commercial, controlled atmospheres, and in low-oxygen storage. Very firm or very soft fruit was generally least preferred, but textural preferences appeared to be dynamic over the 200-day study. The consumer population tested was heterogeneous in texture preference, with individuals preferring very hard or very soft apples at each examination.

Broccoli

Controlled-atmosphere storage. Preliminary studies have identified Green Valiant as having superior storage potential in 0°C air compared with Skiff, Green Comet, and Premium Crop cultivars grown under late-season conditions in Nova Scotia.

Reducing the oxygen levels in ambient air from 21 to 15% and raising carbon dioxide levels in ambient air from 0.03 to 6% resulted in a modest 3.5% retention of chlorophyll and a 30% reduction of trim loss as compared with air after 13 weeks of storage. Storage of Green Valiant in 8% CO_2 + 10% O_2, 6% CO_2 + 2% O_2, or 8% CO_2 + 1% O_2 reduced chlorophyll loss by 13, 9, and 32% and reduced trim loss 40, 45, and 41%, respectively, as compared with air.

Control system for a multichamber, fluctuating-temperature frozen storage system. An inexpensive system was developed and constructed for the purpose of subjecting foods to various fluctuating subzero temperature storage regimes for use in time, temperature, and tolerance (TTT) tests. This system was developed to enable simulation of the potential time and temperature regimes encountered in the storage, distribution, and retailing of frozen fruits and vegetables in the Atlantic Region, and to determine the critical parameters that affect product quality. Eight insulated chambers were constructed, each with a capacity of 0.2 m^3, with heating elements and fans to enable both controlled heating and cooling. Internal chamber temperatures were monitored and controlled using a Rockwell AIM 65 microprocessor. A relatively simple and easily expanded program was developed to enable the time–temperature profile to follow a variety of functions, from a constant temperature to step, linear, logarithmic, or sinusoidal functions. Preliminary tests have shown the temperature to follow the programmed temperature within ±2°C. Temperature gradients within the chambers have been minimized through the use of forced versus natural convection. Preliminary tests of simultaneous independent control of two chambers have been conducted, with expansion to control of eight chambers to be completed shortly.

Control system for multichamber controlled atmosphere storage system. A collaborative study was undertaken with the Technical University of Nova Scotia to develop a system for monitoring and controlling specific gas concentrations in a multichambered (up to 60), CA storage system. The normal method of monitoring and controlling these chambers is labor-intensive by nature, consuming up to 4 hours a day, 7 days a week, and can be accomplished only once a day. At present, there are no tested systems available to manage this number of chambers.

A system was designed and constructed, and the software was developed based on an Apple IIe microprocessor. Preliminary attempts were made to reduce the hardware costs of multiple output parts by combining two 10-point solid-state logic steppers (SSLS) to create a 100-point matrix. Unfortunately, initial tests were unsuccessful using an AC power supply, requiring the SSLS to be used independently. The monitoring system has subsequently been completed and successfully tested. The control system is nearing completion, requiring some minor adjustment. It is expected that the system will be completed and operational for the 1986–1987 storage season.

Cryogenic freezing of strawberries. The feasibility of producing high-quality, individually quick frozen (IQF) strawberries by cryogenic freezing was evaluated on a commercial scale using a small industrial-scale, cabinet-type liquid CO_2 sprayer freezer.

Nine varieties of handpicked, cold-stored strawberries were run over the washing–dehulling–inspection line, then placed in a single layer in perforated plastic trays and put in the freezer. Berries were held in the freezer for about 20–25 min (approximately 7 min for the center of the berry to freeze and the remainder to

bring the temperature of the berries down to approximately –20°C). Freezer temperature was set at –75°C. Approximately 7075 kg were frozen per run, and a total of about 2000 kg of final product was produced. Once frozen, the berries were shaken off the trays, producing a free-flowing frozen product, and packed in poly-lined pails or cardboard boxes. Samples were taken for quality analysis (to be conducted at 3-month intervals) and stored at –18°C and –30°C.

Sample analysis included presence of clumping, color of whole, drained berries and of crushed berries (Hunterlab Colorimeter L, a and b values). A damage score was assigned, based on weighted frequencies of deflated, mushy, and flat-sided berries, percentage of drip loss, percentage of soluble solids, titrable acidity, pH, and texture (Kramer Shear Press). A taste panel was held to evaluate the samples for color intensity, quality, appearance, flavor, and texture. Samples included trial berries, various commercially available brands, and whole berries blast-frozen with sugar.

The use of a liquid CO_2 cabinet freezer for cryogenic freezing of strawberries appears to be feasible for a small-scale processor. The quality of the berries appears to be comparable to blast-frozen berries, with and without sugar. Areas for further work include elimination of the problem of berries that freeze to the plastic trays and improvement in controlling the freezing cycle and the final temperature of the berries. Disadvantages of cryogenic freezing appear to be cost (costs for CO_2 are estimated at 12–20 cents per pound of product). Further investigation and implementation of this technology will depend on market opportunities.

Development of deep-fried vegetable chips. Progress was made in manufacturing a variety of deep-fried, thinly sliced vegetable chips. Research was limited to root vegetables (carrots, rutabagas, parsnips) and cucurbits (squash). Deep frying other vegetables such as green peppers, tomatoes, and cauliflower showed less promise, but these foods may have potential as batter-coated products.

Pretreatments employed to reduce excess fat absorption and browning included a maltodextrin soak, a low-temperature blanch, and surface drying by convection oven. Deep-frying time and temperature parameters varied depending on the vegetable and pretreatment employed.

Several products were well received in informal tasting sessions. Experimentally, it was noted that squash chips, because of their porosity and low content of solids (94–96%), tended to absorb the most oil when deep-fried.

Discoloration and off-flavor development in creamy coleslaw. Coleslaw manufacturers have been experiencing discoloration (the browning effect) and flavor changes (peppery flavor or bite effect) of their product during storage. Enzymatic browning of cabbage occurs when cabbage is cut and phenolic substrates in the cabbage are enzymatically oxidized by phenolase to orthoquinones, which polymerize to form melanins (brown pigments) in the presence of copper, which is a constituent of cabbage. Off-flavor development in cabbage occurs because of an enzymatic (peroxidase) reaction. The specific enzyme responsible is myrosinase, which acts upon sinigrin (glucosinolate) substrates in the presence of iron to form allyl isothiocyanate and allyl cyanide, which cause flavor changes. Inhibition of the browning reaction and off-flavor development may be accomplished by adjusting pH levels of the product and by addition of sequentrants. Ascorbic acid alone or in combination with citric acid or sodium acid pyrophosphate (or both) prevented discoloration and slightly reduced the development of peppery flavor in coleslaw. Further studies on flavor changes will be carried out using gas chromatography to monitor changes in allyl isothiocyanate and allyl cyanide concentrations over storage time.

Factors affecting textural changes of lowbush blueberries in yogurt. Research was conducted to determine factors affecting textural changes in uncooked lowbush blueberries added to Swiss-style yogurt. The blueberries became woody in texture after 3–7 days, and caused syneresis and color bleeding to occur in the surrounding yogurt. This instability was significant enough to require a manufacturer to remove the product from the market. Tests indicated the change in texture was affected by pH, berry size, and chemical interactions with the yogurt. A number of alternative procedures were investigated, and a suitable process was established to produce a shelf-stable yogurt.

Development of frozen fruit bars. Research was carried out on the development of product formulations for a variety of frozen fruit bars including blueberry, strawberry, plum, apple, and cranberry. The greater portion of the bar was pureed fruit pulp. Added sugar, in the form of cane, honey, or maple syrup, was limited to 10%.

For textural and esthetic reasons, partial seed removal of some fruit purees, before freezing, was required. Methods such as fining and heating the puree were used. Results of preliminary taste panels indicated a preference for a slightly tart product (1.10% titratable acidity), with flavor preferences in the following descending order:

strawberry, blueberry, apple, plum, and cranberry.

Mechanical processing of strawberries. A processing line for mechanically harvested strawberries was evaluated, based on machine harvesting of a solid-set planting on a once-over basis. Yields for 1985 for the solid-set beds averaged 23 700 kg/ha, ranging from 15 000 kg/ha (for Midway) to 34 100 kg/ha (for Blomidon).

In 1985, the complete processing line was evaluated, including declusterer, decapper, sizer, and inspection belt. Nine cultivars, two harvest dates, and two pick configurations were used. Berries were picked in clusters, and samples thus included fruit of varied maturity, stems, and trash.

In over 120 evaluation runs, the average line output in percentage by weight was as follows: 33% rollbacks, 17% rollovers, 16% trim loss and trash, 12% sized-out berries, 12% sorted-out berries, and 10% good finished fruit. Breakdown varied with cultivar, with Honeyoe and Cornwallis (K78-6) performing better than average. The average feed rate was 690 kg/h.

Both decapper and declusterer require modification to increase efficiency and, in the case of the declusterer, to decrease the damage it is causing. The sizer worked quite well, removing trash, small greens, and rot. It needs improvement, however, with respect to mechanical reliability.

The yield of 10% finished fruit could be increased somewhat by optimizing certain parameters (e.g. amount of water put over the line, feed rate); however, to make the line economical some recovery of product from the losses in the line would probably have to be made.

Microbiological quality of frozen vegetables manufactured in Nova Scotia. A comprehensive survey of the microbial content of major frozen vegetables produced in the province of Nova Scotia during the 1984 and 1985 seasons has indicated final product counts—in colony-forming units (CFU)—ranging between 3.2×10^4 and 1.6×10^5 CFU/g. The higher counts were obtained at the start of each season, when fluctuating harvesting schedules and plant start-up difficulties resulted in variable delays in processing of raw material. The consequent increase in raw material counts ($>10^8$ CFU/g) carried through proportionately into the final product, despite the use of water blanching required at 90–96°C for 15 min. Thus, although the higher levels were below the maximum of 2.5×10^5 CFU/g set by Agriculture Canada for frozen vegetables, it is clear that much wider differentials are attainable by appropriate vigilance by manufacturers in the handling of raw material.

Postblanching processing stages also require careful monitoring for microbial build-up. Salt-grading equipment for peas can be particularly troublesome because of the general practice of continuously recirculating flume water and brine for up to 4 hours. The presence of leached nutrients and temperatures of 15–20°C provide suitable conditions for microbial growth and consequent transfer to otherwise "clean" ($<10^3$ CFU/g) blanched peas. In general, considering that final product averaged around 10^5 CFU/g, postblanch contamination contributed to a 10- to 100-fold increase in the microbial load.

Modified-atmosphere packaging. Techniques of modified-atmosphere packaging demonstrate potential for shelf-life extension of prepackaged vegetables and berries. Using a range of copolymer films, modified atmospheres were produced naturally by the respiratory process or by application of gas-flushing techniques. Film composition ranged from linear low-density polyethylene, through various polyvinyl chloride films, to a number of experimental films produced by several plastic film fabricators. Daily film permeabilities, ranging from 3000 to 30 000 mL/m^2 of atmospheric oxygen, were studied. Temperatures from 0°C to 20°C were applied to retail packs of shredded lettuce and cabbage, julienne carrots, broccoli, Brussels sprouts, and potato chips covered with differentially permeable films. At intervals of approximately 2 days, samples were removed to determine gas concentrations prevailing within the pack and to be checked for visual defects such as browning and yellowing or the presence of rots and off-odors. Shelf life was extended when film permeability and product respiration rate were balanced to produce equilibrium gas concentrations containing at least 3% O_2. This extended shelf life ranged from a few days to several weeks, depending on the product. Rapidly respiring products such as broccoli require exceptionally permeable films; otherwise packages become anaerobic very rapidly, even at chill temperature. Respiration rates of all products under study were measured over a 4-day period, and the effects of lowering temperatures, preparation techniques, bruising, and surface freezing on the products under study were determined quantitatively.

ANIMAL SCIENCE

Beef

Crab meal versus soybean meal in the feed of young beef heifers. Forty-five weaned heifers

were fed 3 kg of a barley ration, unsupplemented or supplemented with soybean meal or crab meal. The resulting grain ration had 10.5, 14, or 17.5% protein with access to hay.

The use of soybean meal increased the daily gains from 0.57 kg to 0.60 and 0.69 kg, while crab meal decreased the gains to 0.53 and 0.45 kg. The heifers showed early refusal to the crab meal and never performed as well as those fed barley alone. Crab meal (28% protein) appears to be an unacceptable protein supplement for young heifers when used as the sole protein source.

Effect of weathering on large round bales. A survey of local large round bales was completed. The samples included hay stored inside or outside, hay of 1, 2, and 5 years of age kept outside, and hay kept as haylage in plastic bags. Each bale was sampled at three main sites and each sample was divided to represent the top, middle, and inside layers of the forage.

Observations showed that weathering affected only the first 15 cm of the bale kept outside. The use of plastic bags or the storage of the hay inside appeared to minimize losses resulting from weathering. Weathering resulted in an increase in water, acid detergent fiber, and protein but a corresponding decrease in neutral detergent fiber, total digestible nutrients, and digestibility of the protein.

Feeding of culled cows. Twenty-four culled beef cows were grain-fed for 0, 28, 56, or 84 days and then slaughtered. The young cows grew, the middle-aged ones became fatter, and the old ones stayed unchanged. Feeding of grain to both young and old culled cows was concluded to be uneconomical. Meat quality, as measured at the 12th rib, was also unaffected by grain feeding.

Pigs

Suitability of open-front barns for feeder pigs. A 4-year study to determine the performance and profitability of rearing feeder pigs in an open-front and modified open-front barn has been completed. Results indicate that pigs kept in such a facility take 14 days longer to reach market weight and consume 8% more total feed than pigs reared in conventional facilities. Performance results were unaffected by the addition of a curtain across the open face. Economic analysis indicates no financial advantage to rearing pigs in such a facility.

Poultry

Effects of age at photoperiod change and dietary protein on performance of four dwarf maternal meat parent genotypes and their broiler chicken progeny. A factorial experiment was conducted with 3030 chickens of four maternal dwarf genotypes mated with normal males to estimate the effects of age at a photoperiod change from 8 to 12 hours (daily) at 140 or 154 days, and two levels of dietary protein (15 or 17%) on general performance, incidence of fatty liver syndrome, and financial returns. Three of the four maternal genotypes performed similarly for most traits measured, but one genotype exhibited better feed efficiency of egg production, produced more eggs, and although the eggs were smaller, resulted in the highest financial returns. Delaying the increase in photoperiod change retarded sexual maturity and reduced egg weight at 203 days and specific gravity of the eggs at 406 days. The 17% protein diet improved egg production (including hatching eggs), feed efficiency of egg production, and egg weight; female body weights at 154 and 446 days of age were also higher. Dietary protein levels had no effect on mortality ($P > 0.05$). Mean monetary returns from the sale of table eggs, hatching eggs, and salvage meat, in excess of the costs of day-old breeder stock and feed, averaged $1.07 more per bird fed the 17% diet. The progeny test revealed significant differences among genotypes for male mortality, male and female body weights, and feed conversion; however, financial returns over feed and chick costs were similar. The time of change in photoperiod and dietary treatments had no significant effect on the performance of broiler progeny, but there was a genotype × parental diet interaction for 43-day female body weights.

Effects of a wide range of dietary salt levels on the performance of broiler chickens. Two experiments, using 2000 broiler chicks and 4000 broiler chicks, were conducted to evaluate the effects of five dietary levels of sodium chloride (0.2, 0.4, 0.6, 1.0, and 1.8%) in both starter and finisher diets to 41 days of age. The results of this study show that increasing the salt level from 0.4 to 1.0% had no adverse effects upon body weight and feed efficiency. Mortality tended to be higher at the levels of higher dietary salt, which was largely attributed to an increase in the incidence of sudden death syndrome.

Effects of stocking density on the incidence of scabby hip syndrome among broiler chickens. An experiment using 1200 broiler chickens was conducted to evaluate the effects of stocking density (providing either 840, 720, 585, or 454 cm^2 of floor space per bird) on the incidence of scabby hip syndrome at slaughter (42 days). The incidence of scabby hip syndrome was higher at the higher stocking density. Differences were significant for males and approached significance for females ($P < 0.05$). Body weights (42 days) were

lower among birds housed at the higher stocking density levels, but other traits were not significantly affected ($P > 0.05$).

Pathological changes associated with the feeding of soybean oil or oil extracted from various rapeseed cultivars to Single Comb White Leghorn cockerels. A total of 384 Single Comb White Leghorn cockerels of the Hyline strain were fed either a basal (control) diet containing no added oil or a diet supplemented with 20% by weight of soybean oil; rapeseed oil from cultivars Tower or Candle; a mixture of Echo and Arlo high erucic acid rapeseed (HEAR); or R-500. Levels of erucic acid (22:1) in the rapeseed diets varied from 0.03 to 10.31%. Three birds from each unit were killed at 28, 56, 85, and 112 days and a wide range of tissues were examined histologically. A number of birds in all dietary groups had healed lesions of avian encephalomalacia. Two cockerels fed HEAR oil and 12 fed R-500 developed marked ascites, firm shrunken livers, hydropericardium, and cachectic muscular atrophy. Marked periacinar necrosis was present in birds dying of ascites. A significantly higher number of birds fed the rapeseed oils developed hepatic sinusoidal distention than did birds fed the basal or soybean oil diets. Degenerative myocardial changes were seen only in R-500 and HEAR oil-fed birds. This, coupled with heptatic changes, producing shrunken, firm livers, led to the development of ascites, cachectic muscular atrophy, and periacinal hepatic necrosis. These changes were probably produced by the high erucic acid content of the HEAR and R-500 oils and the resultant grossly imbalanced diet.

Pink discoloration in cooked broiler chicken. Three experiments were conducted to estimate the effect of nitrates (50 ppm) and nitrites (3 ppm) on the development of pink discoloration in the flesh of cooked broiler carcasses. Significant color development occurred when carcasses were held for more than 3 days at 4°C in water or ice containing 3 ppm nitrite or 50 ppm nitrate. Poultry-processing plants should ensure that their water supplies contain minimal amounts of nitrates and nitrites to avoid this problem.

The effect of various totals and ratios of dietary calcium and phosphorus on the performance and incidence of leg abnormalities of male and female broiler chickens. A factorial experiment using 1404 day-old Shaver broiler chicks (702 of each sex) assessed the effects of total calcium (Ca) and available phosphorus (AP) and their ratio (Ca:AP) during the starter (0–21 days) and finisher (22–42 days) periods on general performance, tibia strength, tibia ash, Ca and P content of tibia ash, tibial dyschondroplasia, twisted legs, and total leg abnormalities. Nine starter and nine finisher diets were used, with the percentage Ca and AP ranging from 0.98 to 1.47 and 0.39 to 0.67, respectively, for the starters and from 1.00 to 1.40 and 0.32 to 0.51, respectively, for finishers. In general, optimum weight gain, live-body weight, feed conversion, tibia strength, tibia dry weight, and tibia ash were obtained when the highest Ca + P was fed, but lower Ca:AP ratios were also effective for some traits. Tibial dyschondroplasia (TD) and total leg abnormalities, however, were highest when these diets were fed. The results indicate that the ratio of Ca:AP in the diet is a determining factor in causing TD in broiler chickens. As the ratio of Ca:AP in the diets widened in response to increased Ca or decreased P, the incidence of TD and total leg abnormalities decreased ($P < 0.05$).

Sheep

Control of maedi-visna by removing lambs at birth. The removal of ewe lambs at birth from positive maedi-visna ewes seems to be an acceptable practice of reducing or eliminating the maedi-visna virus. A flock of 50 ewes has been established in this manner, with blood testing for the virus being carried out on a 6-month basis. A control group from the March 1984 catching currently has 35% of the ewes turning positive for the virus, whereas the flock that was removed at birth currently has negative test results. Final assessment cannot be made until 1988 because of the varying time it takes for the specific antibodies that are used to detect the virus to develop in the ewes.

Feed pregnant cows and ewes in the afternoon. Cows and ewes were fed once, either at 8 a.m. or 4 p.m., for the last month of pregnancy in three experiments. In both species, a 50% increase in the number of births before midnight was observed when they were fed in late afternoon (43 versus 28; 29 versus 16). The births were evenly distributed over the day with females fed at 8 a.m. The birthrate per quarter-day tended to change when they were fed at 4 p.m. Our results showed no relation to breed, sire, newborn's weight or sex, weight or age of dams, level of nutrition, or date of birth.

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INTRODUCTION

The Fredericton Research Station is located on a 300-ha farm east of the capital of New Brunswick. Founded in 1912, the station has now a staff of 120 employees. Fredericton also has a substation at Benton Ridge, approximately 100 km west of the parent station. The Benton Ridge Substation comprises some 340 ha of land typical of New Brunswick potato soils. The Hervé J. Michaud Experimental Farm at Bouctouche, N.B., with 28 ha, is part of the Fredericton establishment and has a staff of 12 employees.

The Fredericton Research Station is the center for the national breeding program for potatoes and has a comprehensive research program on potato pest management, animal and crops (dairy, beef, cereals, forages), engineering, horticulture, and soils.

The potato breeding program is supported by research on breeding methodology and studies on heritability and selection efficiency using a large data base; and crop development modeling including genotype environment and the utilization of wild and primitive cultivated species. Efforts are also made to develop superior systems for pest management and to improve technology for the harvest, handling, and storage of potatoes.

Animal and crop research is centered on the nutrition and management of dairy and beef cattle. Research is focused on the production, conservation, and nutritional quality of forage crops, and on the utilization of protein sources by dairy and beef cattle. The researchers at Fredericton evaluate cereal, forage, and corn cultivars to make more efficient use of locally produced feeds.

Finding solutions to soils problems is also a high priority at the Fredericton Research Station. The goal is to improve the agricultural land base in New Brunswick and develop the technology to improve drainage and prevent soil erosion. Horticulture research includes the evaluation of apple and strawberry cultivars, and the management of those crops including studies on winterhardiness. The Agricultural Engineering Section deals with the improvement and development of machinery used in agriculture.

The results herein reported provide an overview of continuing research programs. More complete information can be obtained from the Research Station, Agriculture Canada, P.O. Box 20280, Fredericton, N.B. E3B 4Z7.

Y. Martel
Director

POTATO BREEDING

New format for potato variety introduction. Two potato seedlings, F73008 and F74123, that have characteristics of interest to Canada's overseas seed potato customers and that have been tested in a number of market countries have been granted exclusively to organizations in the private sector.

The objective of this experimental release procedure is to encourage the private sector to invest in the evaluation and promotion of varieties in the marketplace, on the basis that it will profit from subsequent sales. This experimental release will be monitored carefully in light of proposed legislation on plant beeders' rights in Canada.

F74123, named Donna, is yellow-fleshed, high-yielding, of good table quality, and mid season to late in maturity. Donna is resistant to golden nematode, has some resistance to late blight in both foliage and tubers, and is moderately resistant to verticillium wilt. In addition, it is highly resistant to potato virus X (PVX) and moderately resistant to potato virus Y (PVY).

F73008, as yet unnamed, also has yellow flesh, late maturity, a high set, and excellent yielding ability. F73008 has an extremely high level of resistance to late blight in both foliage and tubers.

Potato genetics. Thus far, relatively little is known about potato genetics. Since diploids are much more suitable for genetic analysis than tetraploids, some mutants that have been identified in our diploid breeding project are used for genetic studies. One such mutant (pigmented flesh) has authocyanin pigments distributed throughout the tuber flesh. This trait was found to be controlled by a single dominant gene and is linked to other genes that distribute pigment. This gene and other previously described pigmentation genes have no apparent deleterious effect on the plant and are therefore particularly suitable for further studies in potato genetics. The linkage of several genes that have a similar function (in this case distribution of pigment) has implications for the organization of genetic material in the potato.

Differences between reciprocal crosses of potatoes. Crosses between locally adapted selections of primitive cultivated Andigena potatoes from the South American Andes and North American Tuberosum breeding lines produce high-yielding hybrids. The most easily made crosses are with Tuberosum females and Andigena males, but the progeny are frequently sterile, and so the use of selections in further crossing is difficult or impossible. Field experiments comparing two groups of exact reciprocals (Tuberosum × Andigena and Andigena × Tuberosum) have been completed. Five pairs of reciprocals and five Tuberosum cultivars were grown in 1983, and seven pairs of reciprocals and 10 Tuberosum cultivars were grown in 1985.

In 1983 yields were greater and more traits showed significant differences than in 1985, but in both experiments the trends between the reciprocal pairs were generally in the same direction. The largest difference between reciprocals was for total yield. This difference showed advantages of 20 and 8% in favor of the Tuberosum × Andigena families and was significant in both years. Crosses in this direction also had larger tuber sizes and marketable yields that were 30 and 8% higher than those of the reciprocals. The Tuberosum × Andigena families had greater plant vigor and earlier maturity than the Andigena × Tuberosum families. There were no differences in specific gravity, a measure of tuber quality, or in the general acceptability of tuber type. However, the fertility of the Andigena × Tuberosum families was twice that of the reciprocals.

In relation to the Tuberosum cultivars, both groups of hybrids have late maturity, small tuber size, and low marketable yield. However, the yield potential of these hybrid families is reflected in total family yields, which are equal to or only 15% less than the total yields of the selected cultivar checks.

Although the differences favor families of the type Tuberosum × Andigena, the much greater fertility of the reciprocal crosses suggests that a first cross should be made in the direction Andigena × Tuberosum, that superior clones should be selected from these families, and that these selections should be backcrossed as males onto Tuberosum females. This procedure avoids problems with sterility and puts the final cross, which is necessary to improve maturity and marketable yield, into the cytoplasm that confers the greatest improvements in these traits. Preliminary results with this type of backcross progeny support this breeding strategy.

Biometric genetic analysis of tetrasomic inheritance based on matings of diploid parents that produce 2n gametes. Haploids extracted from potato cultivars (*Solanum tuberosum* L.) and their diploid hybrids with other diploid species may produce $2n$ unreduced gametes. The $2n$ gametes are produced by either first- or second-division restitution during meiosis. These two mechanisms of $2n$-gamete formation have been found useful for biometric genetic analysis of tetrasomic inheritance of quantitative traits based on mating designs that involve a series of tetraploid–diploid, tetraploid–tetraploid, or diploid–diploid matings. Now a new mating scheme is found for estimating genetic parameters of autotetraploids. The two parents used in the scheme are homozygous diploids that produce $2n$ unreduced gametes. All matings in the scheme are of diploid–diploid type. The estimation of genetic parameters involved in tetrasomic inheritance uses the means of autotetraploids of the two parents, their F_1, and progenies in six backcross generations.

Confidence intervals for expected response to multi-trait selection. A potato-breeding program involves simultaneous selection of many agronomic and economic traits of the progenies. An attempt to measure the precision of expected response to multi-trait selection is often difficult because of complicated statistical properties. One of the most useful multi-trait selection procedures is the construction of a selection index based on data of a number of traits. Studies on effect of sampling errors on the efficiency of index selection are often based on mathematical statistics. A more practical way to study the usefulness of multi-trait selection procedures such as index selection is to construct confidence intervals for expected response to selection. Relatively simple statistical procedures are used for deriving confidence intervals of expected response to indirect selection and index selection. These intervals can be used for measuring the efficiency of a selection procedure as well as comparing various selection strategies. They can also be used for studying the influence of size of a breeding population and number of replicates used in breeding experiments on the precision of response to multi-trait selection procedures.

Effect of various lamps on the growth and morphology of potato plantlets in vitro. Cultured plantlets were derived from single-node cuttings of the cultivars Caribe and Shepody, and were grown under standard conditions in a defined medium. The plantlets were exposed to eight

different lamp combinations: cool-white fluorescent; incandescent; cool-white fluorescent and incandescent; Agrolite fluorescent; Agrolite fluorescent and cool-white fluorescent; grolux fluorescent; grolux florescent and cool-white fluorescent; and TL-84 Phillips fluorescent. Some lamps (e.g., TL-84) produced potato plantlets with very short internodes ($\bar{x}$ = 3.5 cm) compared with a combination of Agrolite and cool-white fluorescents ($\bar{x}$ = 6.1 cm). The plantlets with short internodes produced under TL-84 lamps were unacceptable for potato multiplication regimes because of the risk of injury to the explants during dissection. A combination of both Agrolite and cool-white fluorescents produced plantlets of both Caribe and Shepody, which exhibited maximum measurements for the following characters: leaf area, number of leaves, stem length, fresh weight, and dry weight. The formation of compound leaflets and aerial roots at the nodes of the cultured plantlets appeared to be influenced by the illumination received. It may be possible, therefore, to manipulate the size and shape of potato plantlets in vitro by the use of various types of lamps.

POTATO PEST MANAGEMENT

Clones of Solanum berthaultii resistant to potato spindle tuber viroid. Seventeen United States Department of Agriculture PI of *Solanum berthaultii*, resulting in 945 clones, were tested for resistance to potato spindle tuber viroid (PSTV). Two clones, 1726 and 1729, of PI 473340 were resistant to the mild and severe strains of PSTV. Both clones were resistant to PSTV by sap inoculation but were susceptible by graft inoculation. Even after graft inoculation, plants remained symptomless and PSTV was not detected by polyacrylamide gel electrophoresis. However, bioassay on *Scopolia sinensis* and dot-blot tests detected PSTV in such plants. Both clones were susceptible to potato viruses A, S, X, and Y by sap inoculation and to leaf roll virus upon grafting. The importance of the PSTV resistance in these clones assumes additional significance because the clones also possess resistance to aphids and the Colorado potato beetle.

Nucleic acid diagnostic probes for potato virus X. The potato virus X RNA was isolated by proteinase K digestion, phenol extraction, and was found to be 60–75% intact as determined by formaldehyde-agarose gel electrophoresis. The RNA was tailed with poly A, reverse transcribed, and the second strand was synthesized using Klenow fragment. The dsDNA was cloned into Bam H1 site of the plasmid psp 65. The clones were probed with 5′-^{32}P-labeled viral RNA. About 15% of the colonies gave a positive hybridization signal. Characterization of the size of the inserts showed that several different fragments of the viral genome had been cloned. These probes were used to detect PVX in dormant tubers. Detection was positive in 90% of samples; however, high background was a problem in others.

Reevaluation of the common potato aphid as vector of potato virus Y. The effectiveness of the common potato aphid, *Macrosiphum euphorbiae* (Thomas), to transmit potato virus Y (PVY) to potato has generally been overestimated because tobacco was used as an indicator. It was demonstrated that although apterous *M. euphorbiae* can acquire PVY from potato and tobacco plants and transmit it to tobacco plants, it did not readily transmit it to potato plants. Winged forms of the aphid did transmit it to potato plants but only in 4.5% of cases. This relative inability to transmit the virus to potato seems independent of the potato cultivar. Thus, the role of the common potato aphid in the spread of PVY in the potato crop is negligible.

Crop protection: Green peach aphid. The aphid alert program uses yellow pan water traps to determine the arrival of winged green peach aphids, vectors of leaf roll, in the province. Recommendations to topkill the potato crop shortly thereafter help growers reduce the spread of leaf roll. An analysis of the data for the period 1974–1983 has shown that the timing of yearly first inflights is relatively constant, with 50% of the cases taking place between 22–27 July. The other 50% present yearly variations that affect crop management decisions. A thermal summation of 1188 degree-days after 1 March was found to simulate adequately the years of especially early or late flights, which require early or late topkills. Results of the analysis will permit a streamlining of the program's operations.

Aphid control: Native predators. The role of polyphagous predators in the control of pests in temporary crops has been relatively little studied. Exclusion barriers were used during the last 3 years to determine the role played by ground-level predators in aphid control on potatoes. Results indicate that the Carabidae do play a role in aphid control. It is, however, a minimal one, 15–20 times less important than the control offered by specific predators and parasites working at the level of the foliage.

Colorado potato beetle: Field colonization. Three years of field studies have shown that an important proportion of beetles colonizing the young potato plants in late plantings originate in the earlier plantings. Results of a concurrent insectary test suggest that these beetles have a 15% higher total fecundity than the beetles that stayed on the older plants. It is postulated that colonizing beetles abandon rapidly maturing potato plants around flowering time in search of younger plants where they can realize their full reproductive potential. The significant effect of planting date on colonization suggests that it would be agronomically advantageous, in New Brunswick, to plant fields as simultaneously as possible over a whole region.

Toxic chemicals program: Sublethal effects of insecticides on aphids. Myzus persicae (Sulzer) and *Aphis nasturtii* (Kalt.) are two major potato-colonizing aphids in Atlantic Canada and two of the most important vectors of potato virus diseases. Original studies conducted under the toxic chemicals program investigated, in a comprehensive manner, the effect of several insecticides on the behavior of these two aphids.

Preliminary results demonstrated that aphid behavior is altered by exposure to insecticides. Aphids exposed to sublethal levels of the pyrethroid insecticides deltamethrin or fenvalerate fed for a significantly shorter length of time than aphids not exposed to these insecticides. Carbamate and organophosphate insecticides did not reduce the amount of time aphids fed, and aphid feeding times actually increased marginally with exposure to some of these pesticides.

The reduction in aphid feeding on pyrethroid-treated leaves likely resulted from the characteristically rapid mode of action of the synthetic pyrethroid insecticides, but there is evidence that these pesticides might have a deterrent action on aphid feeding as well. Aphids rapidly withdrew their mouthparts from treated leaves, became hyperactive, and spent a greater amount of time off the treated leaves. The characterization of the changes in pest behavior brought about by various pesticides suggests a potentially important means of controlling virus diseases of potatoes.

Water relations of the potato (Solanum tuberosum L.) cultivars Raritan and Shepody. The potato plant (*Solanum tuberosum* L.) is very sensitive to drought stress, with significant tuber yield reductions the most apparent outcome. The current study evaluated shoot and root responses to controlled drought stress in the cultivars Raritan and Shepody, which originated in the Fredericton breeding program. Under well-watered conditions, Raritan exhibited a higher transpiration rate than Shepody. This higher rate could be related to a lower calculated stomatal resistance on abaxial leaf surfaces. Under drought stress conditions, Raritan consistently demonstrated superior performance over Shepody in the following areas: leaf water retention, epicuticular wax levels, desiccation tolerance, and root growth. During the slow drying of intact plants of Raritan and Shepody, there was no evidence for significant osmotic adjustment in young expanding leaves or mature, fully expanded leaves. The estimated relative water content at the leaf water potential of −1.0 MPa was higher for Raritan than for Shepody, regardless of leaf age, and may indicate a greater drought resistance in the former cultivar.

Glandular trichome chemistry and resistance in potatoes. The foliage of many wild potato species are covered with glandular trichomes (type A, or tetralobate, and type B, or ovoid) that utilize chemical secretions to entrap arthropod pests. Type A trichomes release a quick-setting fluid when ruptured, but the type B constantly exude droplets of a clear sticky substance. We have now isolated and identified a novel complex of trisubstituted sucrose fatty acid esters as the major nonvolatile constituents in the exudate from the type B trichomes of an *S. berthaultii* Hawkes clone. Preliminary studies with the sucrose ester isolates indicate that they may play a role in defending the potato plant against disease. If so, the presence and composition of sucrose ester complexes is a feature that could be easily monitored in attempts to incorporate related resistance factors from wild potatoes into domestic species. Surprisingly, although synthetic long-chain fatty acid esters of sucrose (i.e., sucrose polyesters) are widely utilized in the food, detergent, pharmaceutical, and polymer industries, to our knowledge only one other naturally occurring sucrose fatty acid ester complex has been reported, a tetracylated mixture extracted from green tobacco leaves.

ANIMALS AND CROPS

Beef quality from animals fed potatoes. Cull potatoes and potato processing wastes are important, high-energy feeds for fattening beef cattle in the Maritime Provinces. While subjective observations suggest that the tenderness and organoleptic qualities of beef from potato-fed cattle are fully satisfactory, until recently there had been no controlled comparisons. Roasts were obtained from beef heifers fed on comparable diets, except that one group was fed potatoes and another barley as a major energy source. Testing of the beef was carried out at the Food Research

Institute, Ottawa. There were no significant differences in the eating quality of the beef from the two groups of cattle. The criteria examined included sensory evaluations for flavor, tenderness, juiciness, cooking rate, cooking weight loss, drip loss, free moisture, and Warner Bratzler sheer values. These results prove that potato-fed beef is good to eat.

Iodine content of milk. Milk samples from most dairy farms in New Brunswick were assayed for iodine content. The average value was 266 μg/L but the range was from 40 μg to 2891 μg/L. The normal value for cow's milk is considered to be about 90 μg/L. Concern has been expressed in several areas of the world that high iodine levels in milk pose a threat to human health. These results show that there is no cause for concern by the general public about consuming milk from processing plants in New Brunswick, where several sources of milk are blended. However, there is reason for concern by about 15% of New Brunswick dairy farm families about consuming relatively large amounts of milk from their own farm. The only cause so far identified for excessively high levels of iodine in the milk is the use of feed medicated with ethylenediamine dihydriodide.

Zinc content of milk produced on New Brunswick farms. Analyses of grass forages grown in New Brunswick showed that the zinc content was often lower than the recommended 40 ppm for feeding dairy cows. Milk samples collected from over 500 New Brunswick farms in winter (January–March 1984) and summer (July–August 1984) were analyzed for zinc content. The mean value was 3.65 ppm zinc in winter and 3.47 ppm in summer. These mean values are not greatly different from a commonly accepted normal value of 3.8 ppm. However, about 11% of the values were below 3.0 ppm, suggesting that these herds would benefit from supplemental zinc.

It was interesting to note that samples from Jersey (4.79 ppm) and Guernsey herds (4.23 ppm) were higher than for Holstein (3.57 ppm) or Ayrshire (3.75 ppm) herds.

Mineral deficiencies in forages grown in New Brunswick. Previous analysis of over 1000 samples of forages grown in New Brunswick showed that of the minerals analyzed, only potassium and iron can safely be assumed to be present in adequate amounts for cattle. The calcium and magnesium contents are adequate in legumes but not always in grasses. Selenium, sodium, zinc, copper, and phosphorus need to be fed to cattle receiving most of their daily nutrient supply from forages grown in New Brunswick. Calcium, magnesium, and possibly manganese, will need to be fed if predominantly grass forages are fed.

Up to now, it has been generally assumed that cobalt supplements are necessary in New Brunswick, but few hard data were available to back up this assumption. New instruments made available by the New Brunswick Soil and Feed Testing Laboratory have allowed us to analyze about 100 forage samples for cobalt content. Our results show that on average, grass samples contain less than half the 50 ppm required by beef cows and legumes contain less than the 100 ppm required by dairy cows. Cobalt is essential for the synthesis of vitamin B_{12}, and all cattle fed mainly forages grown in New Brunswick should receive supplemental cobalt.

Comparison of calf-weaning programs. Calves fed whole milk at 10% of body weight were weaned abruptly when they were consuming 500 g/day (control) or 1000 g/day (delayed) of starter or were gradually weaned with increasing starter consumption up to 1500 g/day. Calves were weaned at 27 ± 1.9 (control), 54.5 ± 7.1 (delayed), and 44.0 ± 3.3 (gradual) days of age.

The delayed-weaning group consumed 137% more milk than the control group and gained 14% more weight by 84 days of age. The gradual weaning group consumed 45% more milk but did not gain any more weight than did the control group.

At weaning, both the control and delayed groups experienced a weight loss that required from 5 to 8 days to regain. The gradually weaned group did not change their growth rate after weaning.

Ideally, it is desirable to wean calves gradually from milk because there appears to be less trauma associated with the process. Practically, it would be difficult for producers to keep track of every calf on a gradual weaning program. Abrupt weaning is not harmful to calves, unless they do not begin to increase their solid feed consumption soon after birth. Delayed weaning is only of value if one is being severely penalized for producing over-quota milk, and an alternative means of marketing the milk is needed or calves will not consume solid feed.

Rumen development. Calves slaughtered at 3, 10, 20, 30, and 60 days of age had their rumens removed. The ability of rumen epithelium to use butyrate to produce ketone bodies was measured.

The production of ketone bodies was virtually nonexistent in the epithelium of newborn (3-day-old) calves. At 10 and 20 days of age increase ketogenesis was measured, but the levels were variable. By 60 days the epithelium could synthesize ketones at rates approaching that of mature tissue. The rates at 30 days were 40–60% of the 60-day rates. Calves fed only milk to 60 days

of age showed rates of ketogenesis similar to 15-day-old calves fed conventionally.

It was also noted that ketogenesis required butyrate as the substrate. Ketogenesis was greater when all three volatile fatty acids were in the incubation medium than when butyrate was used alone. The presence of ammonia or urea increased ketogenesis even more. The trends established relative to calf age were the same for all combinations of volatile fatty acids, urea, and ammonia provided that they were ketogenic (i.e., contained butyrate).

This suggests that the ability of the rumen epithelium to synthesize ketone bodies in early weaned calves (approximately 30 days of age) should not be a limiting factor to calf growth. However, one must consider other parameters such as feed digestibility, rumen capacity, and feed palatability.

Hay preservation with urea. The addition of preservatives to moist hay represents an alternative to the necessity of drying hay to the required moisture level (18%) needed for satisfactory conservation of big round bales. Anhydrous ammonia successfully preserves moist hay but it is not readily available and is potentially dangerous to handle. Urea breaks down to ammonia in the presence of ureases in moist hay and therefore it could replace anhydrous ammonia.

Three levels of urea (0, 2.4, and 4.6% on an as-is weight basis) were applied to big round bales at two moisture levels (approximately 23 and 29%). The bales were stored uncovered, one layer high in an open-front pole barn. The hay baled at the low and high moisture levels reached, respectively, a maximum temperature of 49.3 and 55.1°C. The maximum temperatures and heat damage to the proteins in the bales treated with 0, 2.4, and 4.6% urea were, respectively, 54.6, 52.9, and 49.3°C and 16.6, 17.6, and 13.6%. Dry-matter losses averaged 9.4% and were not affected by the levels of moisture and urea.

Although the addition of urea did moderate the temperature rise and heat damage of the proteins, it did not prevent the development of mold in the hay. Most bales, irrespective of the experimental treatments, were moldy and dusty at feeding.

ENGINEERING, HORTICULTURE, AND SOILS

A foam-padded elevator for a potato harvester. An experimental elevator was developed for elevating potatoes from the main digging bed of a potato harvester to a height suitable for loading into a bulk truck. Unidirectional flow of the potatoes through the harvester was considered essential in order to minimize tuber injury. The elevator was designed to be compatible with the prototype potato harvester described in earlier reports.

The principal feature of the elevator is a foam cylinder with an outside diameter of 1400 mm. The foam material is covered with a Lycra fiber to provide a protective surface from moisture and abrasion. Potatoes from two rows are fed from the clod rollers across an interfacing roller to two rubberized potato digger conveyors of 42 mm pitch and 762 mm width. These conveyors travel horizontally to the base of the foam elevator and around its circumference riding on the plywood rings. The digger chains remain in contact with the rings for 165 degrees.

When operating, the potatoes are lightly compressed between the digger chains and the foam at the base of the cylinder and are elevated to the top of the cylinder where the digger chains separate from the cylinder. The potatoes are then removed from the foam surface by two flat polyester belts at a point 15 degrees past the vertical, and the potatoes are then conveyed to a standard loading conveyor for loading into a bulk container.

The experimental elevator achieved satisfactory performance when tested under field conditions. The cylindrical elevator at a surface speed setting of 0.45 m/s easily handled all of the potatoes from the harvester operating at 3.0 km/h. The tubers fed smoothly both into and out of the elevator. Damage tests indicated that there was no significant increase in tuber injury between entering and leaving the elevator.

Effect of tree spacing on selected apple scion–rootstocks. The McIntosh (Mac) cultivar (Summerland strain) when grown on Malling 26 (M26), Beautiful Arcade (BA), Malling 106 (M106), and Ottawa No.5 (O5) rootstocks plus spur McIntosh (Greenslade strain) on BA at tree densities of 230, 447, and 838 trees per hectare produced moderate yields during 1985, the 15th year of growth. Highest yields were produced by Mac–O5, with an average of 42.9 t/ha over all spacings. Mac–BA and Mac–M106 produced similar average yields of 34.4 and 34.5 t/ha, respectively. Spur Mac–BA produced 30.3 t/ha, and Mac–M26 produced 19.1 t/ha. The accumulated yields since the start of fruiting in 1976 shows a similar pattern, with Mac–O5 and Mac–BA having the best yields per hectare followed by Mac–M106 and spur Mac–BA. Mac–M26 had the lowest accumulated yield.

Although Mac–M26, Mac–M106, and Mac–05 produced the best total yields per hectare at the close spacing (2.4 m × 4.9 m), Mac–BA

and spur Mac–BA performed best at the medium spacing (3.6 m × 6.1 m). No cultivar–rootstock combination produced highest yields at the wide spacing (5.5 m × 7.9 m).

In comparing the amount of Fancy grade fruit produced at the three spacings, it was found that Mac–O5, Mac–M106, and Mac–M26 produced the greatest percentage of Fancy fruit at the close spacing, despite heavy grade-out in the Mac–O5 and Mac–M106. The greatest percentage of Fancy fruit produced by Mac–BA and spur Mac–BA was found at the medium density.

Control of the blueberry leaftier. Leaftier, *Croesia curvalana* (Kft) of lowbush blueberry can cause severe damage to the fruit buds as well as to the foliage. Frequent burning as a pruning practice normally keeps the insect under control. However, with the move to less frequent burning and toward mowing to prune blueberry plants, leaftier damage can be expected to increase.

One spray of permithrin (Ambush ® 50EC) or fenvalerate (Belmark ® 30EC) with active ingredient (a.i.) at 0.07 kg/ha applied with a tractor-mounted automatic mist blower provided very good control of the adult stage when applied in July 1984. No larvae were found in the fruit buds in the treated plots during the spring of 1985.

Performance of recently introduced strawberry cultivars under several storage conditions. The keeping quality of four recently introduced strawberry cultivars, Cornwallis, Kent, Honeoye, and Glooscap, as well as Redcoat, was compared under storage conditions of 2, 10, and 20°C. Fruit was examined after 1, 2, 3, 4, and 8 days of storage. Strawberries held at 2 and 10°C performed similarly and remained bright for 2 days, whereas those held at room temperature (20°C) became dull within 24 h. Redcoat had the highest quality, in terms of marketable berries, under most storage conditions, and Honeoye was the least marketable.

Extending the shelf-life of strawberries. Three levels of sulfur dioxide gas released from Quick Release Grape Guard® sheets into closed containers of strawberries and held at 2°C appeared to have kept Micmac fruit in better condition than the control for up to 8 days. A similar trial with the cultivar Kent showed no obvious difference between fruit treated with SO_2 and untreated control fruit. After 8 days of storage the Kent cultivar showed some mold growth on the fruit, whereas Micmac showed none.

Deep tillage and incorporating organic amendments increase forage production. Soils with shallow topsoil (<50 cm) underlain by restricting layers or strata, such as dense local tills or geologic stratification of parent materials, occupy approximately 50% of the total arable lands in New Brunswick and are rated as the most serious soil constraint in crop production. With the objective of alleviating this constraint, experiments on subsoiling to a depth of 70 cm, with or without incorporating organic amendments (manure, sawdust, and peat moss at a rate of 22.4 t/ha), were established in 1980. Dry-matter yields of corn and alfalfa were used as a performance indicator. Average yields of corn (1981–1985 inclusive) show that an increase of 23, 39, 36, and 104% were found for the subsoiling, subsoiling plus peat, subsoiling plus sawdust, and subsoiling plus manure over the control, respectively. High average yield of the manure treatment is attributed solely to the high yield of 1981 (426% of the control), which is believed to result from the nutrient content of the manure. Similarly, average yields of alfalfa (1982–1985 inclusive) were 17.8, 46.1, 22.5, and 49.5% higher than the control for subsoiling, subsoiling plus peat, subsoiling plus sawdust, and subsoiling plus manure, respectively. These results provide concrete evidence that loosening of subsoil, with or without incorporating organic amendments, increases forage crop production under dense subsoil conditions. Additional measurements on thermal and moisture responses of various treatments suggest that higher soil temperature and more favorable moisture conditions are the contributing factors for increasing yield.

Tile drainage performance on a New Brunswick interval silty loam soil. Assessment of drainage system performance under various soil conditions is a major component of soil engineering research at Fredericton.

Over a period of 3 years, measurements of water table fluctuations were made and climatic data were recorded, both before and after the installation of an experimental subsurface drainage network on a flat, poorly drained Interval Silty Loam soil. Drain spacings of 12 and 24 m were installed at a constant depth of 0.85 m.

Water-table drawdown from the soil surface to 0.50 m below soil surface was decreased from a range of 6–10 days under the natural drainage condition to approximately 2 days after the installation of parallel subdrains. Similarly, the seasonal SEW_{30} value was decreased from 480 to 110 cm/day. Only the wide drain spacing functioned as theoretically anticipated. The effect of the wide and narrow systems on water table fluctuations and on drawdown was similar; the performance of the narrow spacing was impared because of chemical (iron ochre) deposits within the subdrain.

Field performance data and theories of appropriate steady and unsteady state flow were used to calculate field-effective values for conductivity (K) and for the saturated hydraulic conductivity-to-drainable porosity ratio (K:f) of the soil. It was shown that significant errors can occur in such calculations if the effects of evapotranspiration on water table drawdown are ignored.

FERME EXPÉRIMENTALE SÉNATEUR HERVÉ J. MICHAUD, BOUCTOUCHE (N.-B.)

Chou de Bruxelles. Le cultivar Jade Cross domine toujours dans les essais de cultivars de transformation. Par contre, les cultivars Captain Marvel et Prince Marvel se situent parmi les premiers quant au rendement et à la qualité. Dans les essais de cultivars pour le marché frais, Jade Cross se classe très bien quant au rendement, mais les choux en sont difficilement récoltables manuellement. Les choux de Predora et Titurel sont plus faciles à récolter manuellement, mais ces cultivars ont un rendement inférieur.

Laitue. Après des essais à deux sites au cours de deux années consécutives, la qualité et le calibre des plants n'ont pas été affectés par une augmentation de la densité des plants par unité de surface. En effet, aucune différence significative n'a été notée entre les espacements suivants: 71 cm × 36 cm, 53 cm × 36 cm et 36 cm × 36 cm. On peut donc doubler la densité des plants, ce qui représente des profits supérieurs pour les producteurs.

Fraises. Le cultivar Kent continue de se classer premier dans les essais de cultivars, tant durant la première année de récolte qu'à la seconde. Le cultivar Honeoye, introduit de l'État de New York, s'est classé deuxième pour le rendement au cours des mêmes essais.

Framboises. Une infestation de rouille jaune tardive, causée par *Pucciniastrum americanum* (Farl.) Arth., s'est manifestée en 1984 et 1985. Le cultivar Festival s'est avéré le plus sensible des cultivars sous essais. Un essai de fongicide a permis de démontrer que le Dyrene contrôle efficacement la maladie. Dans les parcelles traitées au Dyrene, 0,3 % des fruits étaient atteints par la rouille jaune tardive alors que 8,5 % des fruits l'étaient dans les parcelles témoins.

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Quebec Region
Région du Québec

J.-J. Jasmin

R. Rioux

R. Boulanger

Director General *Directeur général*
Acting Program Specialist *Spécialiste en programmes intérimaire*
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R. Rioux, B.A., B.Sc. (Agr.), M.Sc. (Agr.)
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PRÉFACE

La Région du Québec, créée en 1978, comprend quatre stations de recherches, trois fermes expérimentales et cinq sous-stations qui desservent l'agriculture du Québec. La région opère avec un budget de 41,7 millions de dollars et un effectif de 386 personnes dont 111 chercheurs.

Les activités reliées à la conservation et à l'amélioration des sols visent à approfondir nos connaissances pour obtenir une utilisation rationnelle des engrais azotés. Des recherches sont également en cours pour déterminer les besoins des plantes fourragères et des céréales au niveau de la fertilisation minérale en fonction du pH des sols et des régimes hydriques. On évalue aussi les risques et le niveau d'érosion qui affectent les différents types de sols de l'Estrie.

Les objectifs du programme en énergie visent à obtenir des souches de *Rhizobium meliloti* plus efficaces, à caractériser les dommages physiologiques causés par le froid et à mieux connaître le métabolisme d'assimilation de l'azote chez *Rhizobium*. On veut aussi identifier les principales espèces de champignons endomycorhizateurs spécifiques à la luzerne et au blé.

Des spécialistes en génétique, en physiologie de la reproduction, en alimentation et en viande participent aux programmes sur les bovins de boucherie et laitiers en vue d'augmenter le taux de reproduction des vaches et de diminuer les coûts de l'alimentation; deux critères qui affectent directement la productivité et la rentabilité des élevages. Nous avons maintenu notre collaboration au projet national d'amélioration génétique de la vache laitière.

Les travaux de recherches sur le porc consistent à évaluer la capacité de reproduction des truies qui ont des ovaires anatomiquement différents; nous avons poursuivi nos travaux sur le comportement des porcelets placés dans des conditions spécifiques d'élevage.

Nous tentons toujours d'augmenter la prolificité et le taux de désaisonnalisation des ovins par l'introduction de nouvelles sources génétiques (Romanov, Booroola et Coopworth) pour compléter le programme d'hybridation.

Le programme de recherches appliquées aux céréales vise, entre autres, à développer des lignées hâtives de maïs résistantes au complexe *Pyrale–Fusarium–Kabatiella*. La diversification de nos efforts de recherches s'est poursuivie avec l'amélioration du blé et du triticale, en plus de l'orge et de l'avoine et avec la mise au point de cultivars à rendement supérieur et résistants aux maladies les plus importantes.

La recherche dans le domaine des cultures fourragères vise surtout l'amélioration de la luzerne par l'obtention de génotypes supérieurs résistant aux organismes qui causent la pourriture racinaire et la flétrissure verticillienne. Nous avons progressé en identifiant des lignées de luzerne résistantes à ces organismes. Des travaux en vue d'augmenter la valeur alimentaire des graminées ont aussi été entrepris.

Les objectifs de la recherche en cultures maraîchères portent sur l'amélioration des crucifères, notamment la résistance à la hernie et la répression des ravageurs par le développement de programmes de lutte intégrée.

On cherche aussi à introduire la culture des fines herbes. La recherche sur les petits fruits est dirigée, entre autres, vers la production de cultivars de fraises aptes à la transformation et à la récolte mécanique et vers la sélection de framboisiers remontants. Les travaux de recherches sur les fruits de vergers portent sur l'amélioration et la fertilisation des pommiers ainsi que leur protection contre les ravageurs. Par ailleurs, on vise à déterminer les possibilités d'adaptation des plantes ornementales à différentes régions et à améliorer leur rusticité.

Dans le domaine de la technologie alimentaire, on cherche à améliorer l'entreposage à long terme, à développer des techniques d'évaluation de la qualité des protéines et à mettre au point des techniques de transformation plus efficaces. Le contrôle de la qualité des viandes et la biotechnologie des ferments lactiques présentent aussi des possibilités intéressantes.

Au cours de 1985, P.P. Lukosevicius, spécialiste en programmes, a pris sa retraite et R. Rioux a été nommé intérimaire à ce poste.

Le personnel de la Ferme expérimentale de La Pocatière est entré dans un nouveau bureau-laboratoire à la fin d'octobre 1985. À la Station de Lennoxville, on espère occuper les locaux en février 1986 et à St-Hyacinthe, en avril 1986.

On peut obtenir de plus amples renseignements sur nos programmes en s'adressant au Bureau régional, Direction générale de la recherche, Agriculture Canada, Complexe Guy Favreau, 200 boul. Dorchester ouest, Tour Est, Suite 1002-R, Montréal (Québec) H2Z 1Y3.

Jean-Jacques Jasmin
Directeur général

PREFACE

The Quebec Region, created in 1978, consists of four research stations, three experimental farms, and five substations, all of which serve Quebec agriculture. The region has an operating budget of $41.7 million and a staff of some 386 persons, including 111 research scientists.

Soil conservation and improvement activities are conducted with a view to rationalizing the use of nitrogen fertilizers. Efforts are also being made to determine the mineral fertilization requirements of forage and cereal crops based on the pH and moisture status of the soil. The risk and amount of erosion affecting the various types of soils in the Eastern Townships are also being evaluated.

The objectives of the energy program are to obtain more efficient strains of *Rhizobium meliloti*, to characterize physiological injury caused by cold and the metabolism of nitrogen assimilation in *Rhizobium*, and to determine the main species of endomycorrhizal fungi specific to alfalfa and wheat.

Experts in genetics, reproductive physiology, feeds, and meats participate in the beef and dairy cattle programs to improve the reproductive rate of cows and reduce feed costs, two factors that have a direct impact on livestock productivity and profitability. We are continuing to participate in the national dairy cattle breeding program.

The reproductive potential of sows with anatomically different ovaries is the focus of research work on swine, and we are continuing our research on the behavior of piglets placed in specific production conditions.

We are continuing our sheep crossbreeding program aimed at increasing prolificity and encouraging out-of-season lambing with the introduction of new breeds—Romanov, Booroola, and Coopworth.

One of the objectives of the cereal research program is to develop early lines of corn resistant to the borer–*Fusarium–Kabatiella* complex. We are continuing to diversify our research efforts with breeding work on wheat, triticale, barley, and oats, and with the development of higher-yielding cultivars resistant to major diseases.

The forage crop research program centers mainly on alfalfa breeding to obtain superior genotypes resistant to organisms that cause root rot and verticillium wilt. We have made progress in identifying strains of alfalfa resistant to these organisms. We are also working to improve the nutritional value of forage grasses.

The vegetable crop research program focuses primarily on the breeding of cole crops, especially for resistance to clubroot, and the development of integrated pest management programs. We are seeking to introduce herb production. Small fruit research is centered, among other things, on the production of strawberry cultivars suitable for mechanical harvesting and processing and the selection of multi-cropping raspberries. Tree fruit research focuses on breeding, fertilization, and protection against major pests. Efforts are being made to produce hardier ornamentals and to assess their adaptability in various regions.

Research on food technology is concerned with improving long-term storage and with developing techniques for assessing protein quality and improving processing methods. Other interesting areas of study include meat-quality control and lactic ferment biotechnology.

When Dr. P.P. Lukosevicius, program specialist, retired in 1985, R. Rioux took over from him on an acting basis.

The employees at the La Pocatière Experimental Farm began working in their new office and laboratory complex in late October 1985. We hope to move into our new premises at the Lennoxville Research Station by February 1986 and at the St. Hyacinthe Centre by April 1986.

Additional information on our programs may be obtained by contacting the Quebec Regional Office, Research Branch, Agriculture Canada, Guy Favreau Complex, 200 Dorchester Boulevard West, East Tower, Suite 1002-R, Montreal, Que. H2Z 1Y3.

Jean-Jacques Jasmin
Director General

Centre de recherches alimentaires Saint-Hyacinthe, Québec

PERSONNEL PROFESSIONNEL

Administration

R.R. Riel, B.Sc.A., M.Sc., Ph.D.	Directeur
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J. Proulx[12]	Agent d'information

Biotechnologie

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Industrie laitière

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D. Roy[5], B.Sc.(Vivres), M.Sc.	Bioréacteurs
B. Lee[4], B.Sc., M.Sc., Ph.D.	Génie génétique
D. St-Gelais[6], B.Sc., M.Sc.	Produits laitiers

Industrie carnée

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J.P. Piette[8], Ing., M.Sc.	Produits carnés
C. Zarkadas, B.Sc., M.Sc., Ph.D.	Biochimie musculaire

Industrie végétale

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G. Doyon[10], B.Sc.(Vivres), M.Sc.	Conservation
K. Lapsley[11], B.Sc., M.Sc.	Produits végétaux
J.C. Willemot[12], B.Sc., M.Sc., Ph.D.	Physiologie

Génie alimentaire

C. Passey, BE, ME, D.Sc., MBA	Chef de section; génie alimentaire
C. Toupin, B.Sc.(Vivres), Ph.D.	Transferts thermiques

Arômes et extraction

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J. Bélanger[12], B.Sc., M.Sc., Ph.D.	Extraction

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INTRODUCTION

En 1985, le Centre de recherches alimentaires de Saint-Hyacinthe est en voie de construction. Au cours de l'année, le nombre de cadre passe de 15 à 21, mais 11 d'entre eux sont en congé de formation, 5 sont affectés à l'administration du projet de construction et d'organisation et 3 sont des recrues de 1985. Par conséquent, ceci ne laisse que deux chercheurs qui sont affectés à plein temps à des activités de recherches du Centre.

En dépit des ressources limitées, le personnel du Centre est présent sur la scène scientifique avec une contribution de quelque 20 communications scientifiques. De plus, plusieurs travaux du Dr Lee sont incorporés dans «Advances in Meat Sciences». Dans les cadres du génie alimentaire et du secteur analytique, quelques appareils et instruments sont déjà sous évaluation dans d'autres laboratoires publics et dans l'industrie.

On peut obtenir des renseignements additionnels sur les activités du Centre en s'adressant au Centre de recherches alimentaires, Agriculture Canada, Saint-Hyacinthe, Québec J2S 4Z4.

René R. Riel
Directeur

BIOTECHNOLOGIE—LAIT

Des systèmes enzymatiques ont été utilisés avec succès et avec une bonne reproductibilité pour la différenciation de quelque 40 souches de ferments lactiques. Le système APIZYM (19 enzymes) ainsi que l'arginine dihydrolase et la citratase ont été particulièrement efficaces dans ce domaine. On a aussi développé une méthodologie nouvelle et un milieu sélectif pour la séparation des streptocoques lactiques d'avec les streptocoques fécaux à l'aide de la butyrate estérase sans inhibition. Ces développements peuvent trouver des applications pratiques en industrie fromagère comme d'ailleurs dans d'autres procédés de fermentation.

Dans le domaine du génie génétique, nous avons réussi à identifier et à transformer à partir d'un plasmide de *Escherichia coli* le gène codant pour la glucoamylase isoenzyme de *S. diastaticus*. Les travaux en cours visent le transfert de ce gène dans un nouvel hôte utilisé en industrie alimentaire. Voilà une application de la biotechnologie dans le processus d'amélioration génétique des streptocoques lactiques ou d'autres micro-organismes d'intérêt industriel.

VIANDES

Dans le but d'être en mesure de quantifier les protéines musculaires dans un mélange de protéines animales et végétales, une étude a été menée sur les niveaux de méthyle-histidine et d'hydroxylysine dans une série de tissus en provenance de boeufs, de porcs et de volailles de sexes et d'âges différents.

Des méthodes peu coûteuses, à haute résolution, haute sensitivité et haute reproductibilité ont été mises au point pour la détermination de la myosine et de l'actine dans les viandes. Ces méthodes sont basées sur la détermination de la méthyle-histidine, de l'hydroxylysine, de la desmosine et de l'isodesmosine par chromatographie à une seule colonne. Elles permettent aussi de déterminer d'autres acides aminés basiques méthylés et de suivre les changements métaboliques dans les tissus contractiles et connectifs sous différentes observations.

Une autre méthode rapide et sensible a aussi été développée pour déterminer le collagène et l'élastine dans les tissus carnés en se basant sur les niveaux d'hydroxylysine et de desmosine, permettant également de suivre les changements métaboliques du collagène et de l'élastine dans des systèmes biologiques.

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Station de recherches, Lennoxville, Québec

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INTRODUCTION

Les travaux de la Station de recherches de Lennoxville sont orientés vers la solution de problèmes importants dans les productions laitière, bovine, ovine et porcine, les plantes fourragères et les sols. Des recherches fondamentales et appliquées veulent contribuer à augmenter l'efficacité des productions animales et partant, leur rentabilité. Un nouvel édifice de bureaux et laboratoires a été complété au début de l'année 1986. Ces installations modernes et le retour de chercheurs présentement aux études ou en stage de formation permettront d'accélérer les travaux dans des domaines de pointe.

On peut obtenir des renseignements plus complets en écrivant directement aux chercheurs à l'adresse suivante: Station de recherches, Direction générale de la recherche, Agriculture Canada, C.P. 90, 2000 route 108 est, Lennoxville, Québec, J1M 1Z3.

J.C. St-Pierre
Directeur

PRODUCTION ANIMALE

Bovins laitiers

La progestérone et la prostaglandine en relation avec le premier oestrus et la conception chez la vache allaitante. Les niveaux de prostaglandines $F_2\alpha$ (PG) et de progestérone (P_4) de 81 vaches appartenant à trois génotypes (Hereford, Holstein et Hereford × Holstein) ont été utilisés dans une étude visant à élucider des facteurs favorisant une reprise hâtive de l'activité ovarienne postpartum. Les prises de sang étaient faites deux fois par semaine à partir du vêlage jusqu'au premier oestrus. Les niveaux de PG et de P_4 ont été reliés aux intervalles vêlage–premier oestrus (IVE) et vêlage–conception (IVC). Le PG a diminué graduellement durant les 2 semaines qui ont suivi le vêlage. Le temps pour atteindre le niveau de base n'était pas relié aux IVE et IVC. Dix vaches avaient un IVE égal ou de moins de 20 jours, aucune d'entre elles avait une montée de P_4 ou de PG avant l'oestrus. Leur IVC était en moyenne de 53,4 jours. Parmi les 51 vaches avec des IVE entre 20 et 60 jours, seulement six n'avaient aucune élévation de P_4 précédant l'oestrus et 20 avaient une élévation de PG associée avec une baisse de P_4. Il n'y avait aucune différence dans le profil hormonal des vaches avec un IVE de 40 ou de 60 jours. Le IVC était semblable chez ces deux groupes (57,5 contre 61,5 jours). Chez les 19 vaches avec un IVE d'une durée de plus de 60 jours, 13 avaient au moins deux élévations courtes et régulières de P_4 avant l'oestrus. Le IVC était de 101 jours. Il y avait dans ce groupe un plus grand nombre de vaches avec un P_4 élevé entre le jour 20 et le jour 40 que dans le groupe ayant un IVE entre 40 et 60 jours. Cette différence indique que le délai dans l'apparition du premier oestrus dans ce groupe n'est pas relié au manque d'activité ovarienne comme cela semble l'être chez les vaches ayant un IVE entre 40 et 60 jours.

L'influence du génotype du veau sur les performances reproductrices de la génisse de race Holstein après le vêlage. Les performances reproductrices de génisses de race Holstein (n = 21) ayant donné naissance à des veaux Holstein × Holstein, Holstein × Brahmanne ou Holstein × Angus ont été évaluées après le vêlage. Les concentrations de base ainsi que la libération de prolactine (PRL) et de l'hormone lutéinisante (LH) après une injection combinée de thyréolibérine (TRH) et de lutéolibérine (GnRH) au jour 10 après le vêlage n'ont pas été influencées par le génotype du foetus porté par la génisse de race Holstein pendant la gestation. Par contre, la proportion de génisses de race Holstein ayant montré une élévation de progestérone de plus de 1 ng/mL (et possiblement une ovulation) dans les 9 jours suivant l'injection de GnRH-TRH était inférieure chez les génisses ayant eu un veau Holstein × Brahmanne (2/7) que chez celles ayant eu un veau Holstein × Holstein (5/7) ou Holstein × Angus (7/7). L'involution utérine était moins rapide (de 20 à 30 %) chez les génisses de race Holstein ayant eu un veau Holstein × Angus que chez celles ayant eu un veau Holstein × Holstein ou Holstein × Brahmanne. Des observations similaires ont été faites pour l'involution du cervix. Il existait une corrélation positive entre les concentrations moyennes de 15-keto-13,14-dihydro-prostaglandine $F_2\alpha$ mesurées pendant les 15 premiers jours après le vêlage et le diamètre des cornes utérines (r = 0,32) ou du cervix (r = 0,36). Les résultats de cette expérience démontrent que le génotype du foetus, associé au taureau de la saillie, influence l'activité ovarienne et l'involution utérine de la génisse de race Holstein après le vêlage. L'activité de la glande pituitaire de ces mêmes génisses, en terme de libération de LH et de PRL,

n'a pas été influencée par le génotype du foetus qu'elles ont porté pendant la gestation.

L'influence du génotype du foetus sur les changements hormonaux de la génisse de race Holstein en période péripartum. Au moment de l'insémination, des génisses de race Holstein (n = 21) ont été réparties en trois groupes et ont été inséminées artificiellement par des taureaux de race Holstein, Brahmanne ou Angus. Des échantillons sanguins ont été prélevés quotidiennement pendant les 20 derniers jours prépartum et pendant les 15 premiers jours postpartum. Les concentrations plasmatiques de progestérone, de sulfate d'oestrone et de 15-keto-13,14-dihydroprostaglandine $F_2\alpha$ (PGFM) ont été déterminées.

La durée de la gestation était plus longue chez les génisses ayant eu un veau Holstein × Brahmanne que chez celles qui étaient porteuses d'un veau Holstein × Holstein ou Holstein × Angus (285 contre 278,7, 279,0 jours). Les veaux issus du croisement Holstein × Angus avaient des poids inférieurs à la naissance à ceux des veaux issus des croisements Holstein × Holstein ou Holstein × Brahmanne (30,6 contre 36,1, 43,4 kg). Enfin, quoique les différences n'aient pas été significatives en raison du petit nombre d'animaux, les productions laitière et de gras des vaches inséminées par un taureau de race Brahmanne tendaient à être inférieures (9,1 % et 6,9 % respectivement) à celles des vaches inséminées par un taureau de race Holstein ou Angus.

Avant le vêlage, les concentrations de progestérone étaient plus basses (environ 1 ng/mL) chez les génisses porteuses d'un foetus Holstein × Angus que chez les génisses des deux autres groupes. Les concentrations de sulfate d'oestrone étaient également inférieures chez les génisses porteuses d'un foetus Holstein × Angus et l'augmentation des concentrations de sulfate d'oestrone observée avant le vêlage était beaucoup plus marquée chez les génisses porteuses d'un foetus Holstein × Brahmanne. Les différences observées en période prépartum ont aussi été observées en période postpartum alors que les concentrations de PGFM étaient plus basses chez les génisses ayant donné naissance à un veau Holstein × Angus. Il existait une corrélation positive entre le poids du veau à la naissance et les concentrations moyennes de sulfate d'oestrone prépartum (r = 0,64) et de PGFM postpartum (r = 0,56).

Les résultats de cette expérience démontrent que les différents génotypes des foetus, associés au taureau de la saillie, influencent les concentrations hormonales de la génisse avant et après le vêlage. Ces changements peuvent avoir un effet sur la croissance du foetus et sur les caractères de production de la vache.

Bovins de boucherie

Digestibilité et ingestion volontaire de fourrages servis sous forme de foin ou d'ensilage aux bouvillons. Trente-six bouvillons de type de boucherie d'un poids moyen de 334 kg ont été utilisés dans le but d'évaluer la valeur alimentaire de la luzerne, de la fléole et d'un mélange de trèfle rouge–fléole–pâturin. Les différents fourrages étaient servis ad libitum sous forme de foin ou d'ensilage préfané. Les résultats ont montré que le contenu en unités nutritives totales de tous les fourrages était semblable. Le mode de conservation n'a eu aucun effet significatif sur la consommation de matière sèche. L'ingestion de luzerne a été la plus élevée et celle du mélange, la plus faible. L'ingestion de matière sèche a été hautement corrélée avec le contenu en lignocellulose. La digestibilité de la matière sèche et celle de l'énergie étaient semblables pour les six traitements. La digestibilité de la protéine de luzerne était supérieure à celle de la fléole et du mélange alors que l'inverse a été observé pour la fibre brute. La digestibilité de la fibre brute et celle de la protéine ont été respectivement de cinq unités supérieures et de trois unités inférieures pour l'ensilage comparativement au foin. La digestibilité des constituants cellulaires a été supérieure pour la luzerne et inférieure pour la fléole. La digestibilité des parois cellulaires a été respectivement de 59,5, 57,5 et 47,4 % pour la fléole, le mélange et la luzerne.

Porcs

L'importance de l'acide folique dans la nutrition de la truie gestante. La concentration de folates sériques a été mesurée dans le sérum de 105 truies distribuées au hasard en sept groupes de 15 animaux. Chacun des groupes représentait un moment du cycle de reproduction soit le sevrage, la saillie, 15, 30, 60, 90 et 110 jours de gestation. Les résultats ont montré une baisse biphasique des folates sériques à la saillie et à 60 jours de gestation. Il a ensuite été démontré que cette chute des folates sériques pouvait être modérée par une injection intramusculaire d'acide folique. Dans une expérience subséquente, 209 truies ont été distribuées selon un dispositif expérimental en tiroir 2 × 2. On a mesuré l'effet d'injections intramusculaires d'acide folique et d'un flushing entre le sevrage et la saillie sur les performances de reproduction des truies. Les injections d'acide folique ont eu un effet significatif sur le nombre de porcelets nés ($P \leq 0,04$) et nés vivants ($P \leq 0,03$). Les truies recevant le traitement combiné acide folique et flushing ont donné naissance à 12,0 porcelets nés vivants par portée contre 10,5 chez les truies ne recevant aucun traitement. Un apport supplémentaire d'acide fo-

lique pendant la gestation pourrait donc accroître sensiblement les performances de reproduction des truies.

Moutons

Influence du groupe génétique sur la qualité de la laine des brebis de race Finnoise, DLS et croisées. Pendant 3 ans, nous avons prélevé la fibre de laine sur 2 cm^2 de peau de l'épaule de 273 jeunes brebis de 1 an nées à la Ferme expérimentale de La Pocatière. Les jeunes brebis représentaient neuf groupes génétiques, soit un groupe de Finnois, un groupe de DLS (une population de 1/2 Dorset, 1/4 Leicester, 1/4 Suffolk) et sept combinaisons s'échelonnant de 1/8 à 7/8 de race Finnoise. Les traits étudiés étaient: le pourcentage de laine après nettoyage, la longueur, la densité et le diamètre de la fibre. La toison brute (ou avant nettoyage) (PTB) des 273 brebis et d'un groupe additionnel de 90 brebis, a été pesée lors de la première tonte. Le PTB a été pesé tous les ans jusqu'à la 5e tonte. Le PTB des Finnois était de 2,3 kg chez les jeunes brebis et de 2,0 kg chez les brebis plus âgées, tandis que, pour les DLS, il était de 2,3 et 2,8 kg respectivement. Les PTB des brebis croisées étaient supérieurs à la moyenne des PTB des races parentales, les meilleurs étant ceux des croisements 4/8F et 5/8F. Chez certains croisements, le PTB excédait celui de la meilleure race parentale. De plus, le PTB augmentait par rapport au pourcentage de Finnois d'une façon linéaire à la seconde tonte et de façon quadratique pour les tontes suivantes. Comparativement aux DLS, les brebis Finnoises avaient plus de fibre (1 950 contre 1 551/cm^2), la longueur des fibres était plus grande (19,1 contre 15,8 cm) et plus variée (SD = 4,66 contre 2,96 cm), le diamètre des fibres était plus fin (20,5 contre 25,5 µm) et plus uniforme (SD = 4,8 contre 5,9 µm). La majorité des croisements ont montré une hétérose positive plus particulièrement en ce qui concerne le pourcentage de laine et la longueur de la fibre et de la mèche. L'hétérose la plus élevée se manifestait le plus souvent chez le croisement 4/8F.

Rôle de l'acide gamma-aminobutyrique dans le contrôle hypothalamique de la prise alimentaire des moutons. Dix-neuf moutons ont été utilisés dans le but de vérifier si des neurones sensibles à l'acide gamma-aminobutyrique (GABA) sont impliqués dans le contrôle hypothalamique de la prise alimentaire. Des injections de pentobarbital dans les aires préoptique et paraventriculaire ont provoqué la faim chez des moutons rassasiés. Des injections de GABA dans les mêmes sites ont eu un effet variable, probablement parce que le GABA est capté rapidement de la fente synaptique par les cellules nerveuses et gliales environnantes. Dans des expériences subséquentes, on a utilisé le muscimol, une substance mimétique du GABA possédant une plus grande affinité avec les récepteurs du GABA que le GABA lui-même. La courbe dose–réponse obtenue avec le muscimol est cubique lorsque celui-ci est injecté à des doses de 0 à 0,750 nmol; la plus forte prise alimentaire a été mesurée après l'injection de 0,5 nmol de muscimol. La réponse au muscimol a été bloquée par des injections de deux antagonistes du GABA, la picrotoxine et la bicuculline mais la picrotoxine a été plus efficace. Les résultats semblent indiquer que des neurones sensibles au GABA, situés principalement dans les régions préoptique, paraventriculaire, ventromédiane et antérieure de l'hypothalamus, jouent un rôle important dans le contrôle de la prise alimentaire des moutons.

Qualité des viandes

Effet de la stimulation électrique sur la maturation et la qualité des carcasses. Des expériences ont été entreprises afin d'étudier les effets de la stimulation électrique à bas voltage (45 V) sur les carcasses de veaux de race Holstein et sur les carcasses de moutons Romanov. Nous avons testé des dosages de cathepsine D en utilisant des échantillons provenant de carcasses de taurillons et de bouvillons Hereford soumis à l'électrostimulation à haut voltage (600 V). Les résultats préliminaires démontrent que la baisse post-mortem du pH est accélérée par la stimulation électrique. Cette baisse n'est cependant pas aussi évidente pour les carcasses de moutons. La stimulation électrique à bas voltage accentue la libération de la cathepsine D dans le longissimus dorsi des carcasses de veaux et les analyses préliminaires d'échantillons provenant des carcasses de taurillons et de bouvillons Hereford semblent indiquer la même tendance. Il semblerait que l'acidification hâtive du muscle favoriserait la libération des enzymes lysosomales causant ainsi un attendrissement de la viande. Paradoxalement, les tests de dégustation sur la 12e côte des carcasses de veaux démontrent que la stimulation électrique à bas voltage durcit la viande. Il importe donc de définir les conditions d'entreposage des carcasses et de relier ces conditions aux effets bénéfiques ou non de l'électrostimulation.

Production végétale et sols

Influence de la diète sur la teneur en fer du lisier de porc. Deux systèmes d'alimentation ont été comparés avec des porcs en période d'engraissement, l'un où la moulée sèche était servie avec libre accès à l'eau par l'entremise de tétines,

l'autre où 30 % de la moulée était remplacée par du lactosérum nature sans aucun autre approvisionnement en eau. Les porcs ont été répartis selon l'âge (croissance: de 35 à 65 kg et finition: de 65 à 100 kg) et le sexe. Le lisier a été accumulé dans deux fosses, une fosse placée le long du mur des chambres d'élevage (fosse extérieure) et l'autre, le long de l'allée centrale (fosse intérieure). Après 8 semaines, des échantillons de lisier ont été prélevés pour l'analyse du fer total.

Lorsqu'on a comparé l'effet de la diète seulement, on n'a observé aucune différence dans la teneur en fer du lisier. Les porcs en croissance recevant la diète liquide ont produit un lisier plus riche en fer que les porcs recevant la diète sèche. L'inverse a été observé chez les porcs en finition. On n'a pas observé de différence dans la concentration en fer du lisier des porcs recevant la diète liquide lorsque l'on compare les sexes. Les castrats recevant la diète sèche ont cependant produit un lisier plus concentré en fer que les femelles. Il n'y a pas eu de différence entre la concentration en fer du lisier des porcs en croissance quel que soit le sexe mais, en finition, les castrats ont produit du lisier plus riche en fer. Le lisier de la fosse intérieure était beaucoup plus riche en fer chez les porcs recevant la diète sèche, quel que soit l'âge des porcs. Le lisier de la fosse extérieure était plus riche en fer chez les porcs en croissance recevant la diète liquide alors qu'aucune différence n'a été observée entre le fumier des fosses provenant des porcs en finition qui reoivent la diète liquide.

L'enfouissement du fumier réduit l'érosion hydrique. Pendant 2 ans, nous avons mesuré, sur une pente de 12 %, le ruissellement ainsi que les pertes de sol et d'éléments nutritifs subis au cours de la saison végétative du maïs–ensilage suite à des applications automnales de fumier de bovin. Deux doses de fumier (30 (F1) et 120 (F2) t ha^{-1}) ont été appliquées sur un total de 12 parcelles d'érosion d'une superficie de 45 m^2 chacune, dont six ont été labourées. Le printemps suivant, nous avons semé le maïs dans le sens de la pente (59 000 plants/ha) selon les méthodes culturales habituelles. Nous avons noté des différences significatives ($P \leq 0,05$) entre les pertes de sol et d'eau selon la dose de fumier appliquée. Aucune différence n'a été observée entre les parcelles labourées et non labourées. Comparativement à la dose F1, la dose F2 a réduit le ruissellement de 59 % ainsi que la perte de sol érodé de 72 % (19,5 t ha^{-1}) et a amélioré l'interception de l'eau de pluie (84 % contre 61 %). La forte dose de fumier a augmenté de 41 % la capacité de rétention en eau du sol et a réduit les pertes d'éléments fertilisants (azote nitrique, phosphore, potassium, calcium, magnésium) entraînés au bas des parcelles. En augmentant la dose de fumier de 30 t à 120 t ha^{-1}, nous avons constaté que le phosphore total et le phosphore assimilable, les éléments les plus discutables en pollution des eaux, avaient été réduits de 36 et 61 % respectivement.

Effet des régimes hydriques sur la réponse au potassium de la luzerne et de la fléole des prés. Le but de cette expérience était de voir jusqu'à quel point la réponse au potassium était influencée par les régimes hydriques des sols. Nous avons semé, en serre, de la luzerne Saranac et de la fléole des prés Climax dans l'argile Sainte-Rosalie, le loam Greenboro et le loam sableux Danby soumis à trois régimes hydriques: 1. Optimal, 2. Sec, 3. Très sec. Nous avons appliqué du potassium aux doses suivantes: 0, 50, 100 et 150 kg de potassium à l'hectare. Les rendements de luzerne ont augmenté quadratiquement avec les doses de potassium sur les sols d'humidité optimale. Aucune augmentation de rendements causée par les applications de potassium n'a été notée avec les autres régimes hydriques. Chez la fléole des prés, cultivée en régime hydrique optimal, on a enregistré une augmentation de rendement linéaire suite aux apports de potassium. En régime très sec, l'augmentation de rendement a été quadratique. L'eau a été utilisée plus efficacement en régime hydrique optimal qu'en régimes sec et très sec. L'efficacité d'utilisation de l'eau s'est accrue avec les doses de potassium appliqué dans le loam Greenboro et le loam sableux Danby. Elle est passée de 0,15 g de matière sèche produite par centimètre d'eau pour la dose 0 potassium, à 0,30 g de matière sèche par centimètre d'eau pour une application de 150 kg de potassium à l'hectare. Les deux espèces fourragères ont assimilé au moins deux fois plus de potassium en régime hydrique optimal qu'en régimes sec et très sec. Cependant, après l'expérience, on a retrouvé environ trois fois moins de potassium échangeable dans les sols soumis au régime hydrique optimal que dans ceux soumis aux régimes sec et très sec.

Influence des zones climatiques sur la qualité de la fléole des prés. L'objectif de la présente étude était d'évaluer le degré de variation apporté à la qualité des fourrages de fléole par divers facteurs climatiques et édaphiques. On visait aussi à déterminer si les résultats obtenus, lors des études d'utilisation et de qualité des fourrages, s'appliquaient aux diverses régions du Québec. Les déterminations de qualité et de teneur minérale ont porté sur huit cultivars de fléole des prés récoltés pendant 3 ans à quatre sites: Sainte-Anne-de-Bellevue (climat doux), La Pocatière et Lennoxville (climat intermédiaire) et Normandin (climat froid). Les pourcentages des

diverses composantes chimiques des cultivars de fléole de première coupe se chiffraient ainsi: digestibilité 63,8, protéines 9,1, phosphore 0,23, potassium 2,56, calcium 0,57 et magnésium 0,13. Les teneurs des mêmes composantes dosées dans le regain de fléole ont été évaluées à: 64,6, 9,9, 0,22, 2,17, 0,74 et 0,19 pour les mêmes éléments. Ces dernières valeurs sont basses à cause de la récolte tardive des fourrages. On a noté l'existence d'une corrélation significative entre les valeurs des composantes chimiques de la fléole et les facteurs cultivars, sites et années. Plus la teneur des composantes chimiques était élevée, moins les rendements étaient forts. Les effets des cultivars et du stade de maturité de la fléole sur les composantes chimiques, à l'exception du calcium et du magnésium à la première récolte, étaient significatifs. L'influence du site et de l'année de récolte s'est avérée très importante. La variation des composantes chimiques de la fléole était causée en grande partie par le site de production. Ceci était attribuable aux différences de température, d'humidité et de sols. La teneur des composantes du regain était aussi fortement influencée par l'année de production à cause des différences de température et de précipitation. Les actions entre le cultivar et le site ou le cultivar et l'année n'étaient pas significatives. Les valeurs relatives des cultivars n'ont donc pas varié selon les sites ou les années. Par contre, l'action entre le site et l'année était très significative. La comparaison de la teneur en composantes chimiques de la fléole des prés cultivée à plusieurs sites nécessiterait plusieurs années de récolte.

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INTRODUCTION

Les travaux de la Station de Sainte-Foy visent la solution de problèmes agricoles dans les régions du centre du Québec, du Bas Saint-Laurent, du Saguenay-Lac Saint-Jean et de l'Abitibi-Témiscamingue. Ils portent sur les productions fourragères, céréalières, ovines, bovines, horticoles telles la pomme de terre et les arbres fruitiers et ornementaux, ainsi que sur les sols.

Deux chercheures ont été engagées durant l'année pour travailler dans la région de l'Abitibi-Témiscamingue. Elles sont présentement à l'Université du Québec à Rouyn. La construction de l'édifice principal à la ferme expérimentale de La Pocatière est terminée. Il est possible d'obtenir des renseignements additionnels en écrivant aux chercheurs à l'adresse suivante: Station de recherches, Agriculture Canada, 2560 boulevard Hochelaga, Sainte-Foy, Québec, G1V 2J3.

S.J. Bourget
Directeur

LES PLANTES

Les plantes fourragères

Amélioration des légumineuses. Si les conditions climatiques de l'hiver 1984-1985 ont été favorables à la survie des légumineuses, elles ont, à l'inverse, été moins propices à la sélection de génotypes plus persistants. En conséquence, la sélection de génotypes soumis à une régie intensive de coupe automnale a dû être retardée d'au moins une année.

Les résultats préliminaires d'une étude sur la sélection pour le développement du système racinaire chez deux cultivars de luzerne démontrent une augmentation moyenne de près de 25 % pour un cycle de sélection. Ces résultats indiquent que la sélection semble possible.

L'évaluation de cultivars de luzerne pour le Québec s'est poursuivie en 1985 avec l'aide des stations coopérantes. Aucun nouveau cultivar ne sera ajouté à la liste des cultivars recommandés pour 1986.

Amélioration des graminées. Les résultats préliminaires d'une étude entreprise en 1983 sur l'héritabilité du rendement en matière sèche et de certaines propriétés physico-chimiques reliées à la qualité nutritive de la fléole des prés indiquent que les valeurs varient entre 0,40 et 0,50 dépendant des caractères étudiés. Par ailleurs, l'héritabilité de la digestibilité et de la teneur en protéine était de 0,52 et 0,24 respectivement après un cycle de sélection. Ces résultats laissent entrevoir la possibilité d'améliorer génétiquement la qualité nutritive de la fléole des prés.

Une pépinière de fléole des prés a été utilisée afin d'évaluer le regain, la croissance automnale, la résistance à la rouille de la tige et la maturité de cette espèce. Les résultats de 1985 indiquent une très grande variabilité génétique parmi les 2 400 génotypes. Cette étude démontre la possibilité de sélectionner des individus ayant un meilleur regain et une croissance automnale qui permettront d'étaler la période de récolte de la fléole des prés.

L'étude des effets de l'irrigation et de la fertilisation azotée sur le regain de la fléole des prés a été poursuivie. Cette étude vise à déterminer l'environnement optimal pour la sélection de génotypes ayant un potentiel de regain élevé. Afin de continuer les essais de sélection chez la fléole et de les commencer chez le brome, deux nouvelles pépinières ont été implantées en 1985. La pépinière de fléole compte actuellement 3 000 génotypes alors que celle de brome en compte 6 000.

Afin d'obtenir un port dressé, des feuilles larges et une faible croissance radiale des rhizomes, une sélection phénotypique a été pratiquée dans deux populations (200 génotypes par population) de chiendent hybride (*Agropyron repens* × *Agropyron spicatum*). De 40 % à 50 % des génotypes de ces populations ont été écartés. Les génotypes sélectionnés ont été croisés entre eux et la semence récoltée. La production de semence et le pouvoir germinatif seront déterminés. De plus, deux composites équilibrés seront formés et semés au printemps 1986 afin de comparer leur performance avec celle des espèces normalement recommandées dans l'est du Canada.

De la semence Syn-2 du cultivar expérimental de dactyle SF-8501 a été produite en 1985. Ce cultivar expérimental de dactyle, sélectionné pour la résistance au froid et le rendement, a été introduit dans les essais provinciaux d'évaluation du Conseil des productions végétales du Québec (C.P.V.Q.). Un nouveau semis devrait être effectué au printemps 1986.

Essais de cultivars de raygrass. L'évaluation de cultivars de raygrass annuel pour le Québec s'est poursuivie en 1985 avec l'aide des stations coopérantes. Les cultivars évalués se sont com-

portés de faon identique sous un régime de coupe pour le foin ou pour le pâturage. Cinq cultivars de raygrass, Aubade, Barmultra, Barspectra, Lemtal et Maris Ledger, sont maintenant recommandés au Québec.

Pathologie. Un inventaire de la pourriture phytophthoréenne de la luzerne au Québec a permis de mesurer l'étendue de cette maladie et d'isoler le champignon responsable. Le pouvoir pathogène du *Phytophthora megasperma* f. sp. *medicaginis* et son appartenance au type à petites spores ont été établis. Un programme de sélection génétique a déjà produit trois populations expérimentales résistantes. Parmi les cultivars utilisés au Québec, Apolo, Agate et Dekalb 120 sont résistants alors que Vernal, Iroquois et Apica sont sensibles.

Malgré l'absence de la verticilliose de la luzerne au Québec, cette maladie présente toujours un danger potentiel pour les luzernières. Deux cycles de sélection ont permis d'élever de 20 % le niveau de résistance de deux cultivars populaires, ce qui les situe à un degré supérieur au cultivar Trumpetor considéré comme moyennement résistant.

Une forte proportion des bactéries endoracinaires chez la luzerne appartient aux genres *Pseudomonas* et *Erwinia*. Parmi les isolats testés, 48 % ont provoqué des nécroses ou une pourriture des tissus végétaux. Trois isolats étaient très pathogènes. Les bactéries présentes dans la racine ne proviennent pas des graines mais plutôt du sol rhizosphérique et elles pénètrent par des blessures qu'ont subies les racines et les tiges. Les nodules racinaires abritent également des bactéries qui ne sont pas des *Rhizobium*; des *Pseudomonas* ont été isolées dans 42 % des nodules. Une partie des isolats bactériens obtenus de la rhizosphère et de l'intérieur de la racine sont glaçogènes, c'est-à-dire qu'ils favorisent la formation de glace par nucléation hétérogène.

Des essais de lutte contre la coulure des graminées chez la fléole des prés ont révélé que l'usage des pesticides peut réduire le pourcentage de coulure au champ. Des applications de pesticides durant la période de l'émergence des épis diminuent le nombre d'épis coulés et augmentent le rendement en semence.

Malherbologie. Les résultats des inventaires de mauvaises herbes effectués dans les régions de l'Abitibi-Témiscamingue en 1982 et de l'Outaouais en 1983 ont été analysés en profondeur. Ils révèlent que la fléole des prés et le trèfle rouge sont les espèces fourragères les plus importantes dans ces deux régions. Au niveau des mauvaises herbes, le chiendent est sans contredit l'espèce dominante; il est présent dans plus de 90 % des champs dans les deux régions et cause des infestations dans les champs de tout âge. Le pissenlit, la vesce jargeau et le plantain majeur sont aussi des espèces importantes dans les deux régions. Cependant, le pissenlit et la vesce jargeau dominent principalement les vieux champs. Le pâturin des prés, la renoncule âcre, le fraisier des champs, la marguerite blanche et l'achillée millefeuilles sont également des espèces très importantes dans la région de l'Abitibi-Témiscamingue. Il faut ajouter à cette liste des espèces moins fréquentes, telle l'agrostide blanche qui peut occasionner des infestations dans les deux régions, ainsi que la fétuque rouge, l'épervière orangée, la renoncule rampante et certains carex qui peuvent entraîner des infestations dans la région de l'Abitibi-Témiscamingue. L'étude agronomique découlant des mêmes relevés a démontré que 90 % des prairies des deux régions sont établies à l'aide d'une plante-abri associée à un mélange de graminées et de légumineuses. En Abitibi-Témiscamingue, les herbicides ne sont pratiquement pas utilisés alors qu'environ 30 % des prairies de l'Outaouais sont traitées à l'aide d'un herbicide agissant contre les mauvaises herbes à feuilles larges. D'autre part, 40 % et 75 % des prairies de l'Outaouais et de l'Abitibi-Témiscamingue ne reçoivent pas de fertilisant.

Les derniers résultats obtenus au cours de l'étude visant à déterminer l'impact des populations de mauvaises herbes sur l'établissement de la fléole des prés confirment que les mauvaises herbes causent des pertes substantielles lors de l'implantation de cette espèce fourragère et au cours de la première année de production. L'effet négatif des mauvaises herbes s'atténue cependant avec le temps puisqu'en deuxième année de production, les pertes causées par la présence de mauvaises herbes pendant la période d'implantation sont moins importantes.

Récolte et conservation. L'effet de la largeur des andains sur le séchage du foin à quatre stades de maturité chez la fléole et le brome a été mesuré. Deux types d'andain, soit des andains larges de 1,71 m, soit des andains étroits de 1,12 m, ont été formés derrière une faucheuse-conditionneuse de 2,67 m de largeur. Aux stades gonflement et début épiaison, le foin en andains larges pouvait être récolté et placé dans le séchoir à foin au cours de la troisième journée tandis que le foin en andains étroits requérait une quatrième journée de séchage sous des conditions climatiques favorables. Aux stades floraison et grenaison, deux bonnes journées de séchage suffisaient; le foin séchait aussi rapidement en andains étroits qu'en andains larges. Le foin mûr était relativement sec à la fauche (59 % d'humidité le 25 juillet); ses fortes tiges maintenaient des andains

bien structurés et bien ventilés, peu importe si les andains étaient larges ou étroits. Au contraire, le foin jeune était très humide à la fauche (81 % d'humidité le 13 juin); étant très feuillu, il se tassait, formait des andains compacts et séchait lentement. Un foin jeune tire donc plus d'avantages à être laissé en andains larges qu'un foin mature.

Un modèle mathématique des chaînes fourragères a été adapté aux conditions du Québec. Des simulations sur 10 ans avec les données climatiques de la ville de Québec montrent l'intérêt de nouvelles méthodes d'ensilage, notamment le silo-meule et l'ensilage de grosses balles rondes, même pour des petites fermes laitières possédant une quarantaine de vaches. Ces méthodes d'ensilage exigent peu d'investissement. En revanche, les recouvrements plastiques et les conservateurs d'ensilage peuvent représenter un déboursé annuel important. Si on réussit à réduire les coûts du plastique et des additifs, tout en maintenant la qualité des fourrages, on peut prévoir un intérêt grandissant pour ces deux méthodes d'ensilage. De nombreux agriculteurs, tentés de passer du foin à l'ensilage, y trouveront une option plus viable que l'ensilage traditionnel en silo-tour requérant de lourds investissements.

Une étude entreprise en 1984 sur les silos-meules a été poursuivie en 1985. Trois meules ont été fabriquées, la première avec de l'ensilage coupe-directe et sans traitement, la deuxième avec de l'ensilage coupe-directe traitée à l'acide formique, et la troisième avec de l'ensilage préfané pendant environ 4 h au champ. Sous une bâche de plastique de 30 m par 12 m, on a entreposé entre 28 et 38 t de matière sèche de graminées fourragères, surtout de la fléole. Des moutons et des vaches laitières ont consommé plus d'ensilage préfané que d'ensilage coupe-directe. La production de lait était légèrement plus élevée avec l'ensilage préfané. L'ajout d'acide formique ne semble pas nécessaire avec les graminées si l'on ensile un fourrage légèrement fané.

Les céréales.

Amélioration. Depuis 1982, nos efforts en amélioration portent sur quatre espèces de céréales de printemps, soit l'orge, l'avoine, le blé et le triticale. En 1985, 32 % de nos efforts portaient sur l'orge, 25 % sur l'avoine, 22 % sur le blé et 21 % sur le triticale. Nous avons donc intensifié l'amélioration et l'évaluation du blé et du triticale. En 1986, nous espérons faire porter nos efforts sur les quatre espèces.

En 1985, quelque 5 686 nouvelles lignées de toutes espèces ont été évaluées pour leur rendement et qualités agronomiques dont 2 830 l'étaient pour une première année. L'amélioration de l'orge produit présentement des génotypes très intéressants notamment pour leur très haut potentiel de rendement et leur paille forte; 125 lignées d'orge sont plus productives que les cultivars témoins. Dans l'avoine, trois lignées en dernière année d'essais d'homologation continuent à bien se comporter en plus de leur tolérance au virus de la jaunisse nanisante de l'orge (VJNO); la lignée Q.O.191.70 fera l'objet d'une demande d'homologation auprès du comité des céréales des provinces maritimes. Dans le blé, les lignées importées du Centre international pour l'amélioration du maïs et du blé (CIMMYT) et évaluées pour leur réaction au VJNO sont présentement en essais avancés de rendement. Ces lignées hâtives de blé sont caractérisées par une insensibilité à la photopériode, une paille plutôt courte, un rendement similaire au cultivar Columbus mais d'une qualité panifiable nettement inférieure à ce dernier cultivar. Quant au triticale, des lignées importées de CIMMYT ayant une réaction tolérante au VJNO sont présentement évaluées. La qualité du grain de ces lignées de triticale est médiocre et leur rendement est plutôt bas, trop bas pour en faire une solution de rechange intéressante pour l'agriculteur. Ce matériel importé est largement utilisé en croisement afin de transférer les gènes d'insensibilité à la photopériode, de hâtivité et de tolérance au VJNO. Les descendants de ces croisements sont sévèrement sélectionnés pour éviter les défauts du grain et pour une adaptation à nos conditions de croissance.

En 1985, la Station de Sainte-Foy homologuait un nouveau cultivar d'avoine, Marion, spécialement adapté aux provinces maritimes et à l'Ontario. Marion est très hâtif et possède de gros grains lourds; le poids du grain à l'hectolitre est également très élevé. En plus de sa hâtivité, Marion donne un rendement très élevé dans toutes les provinces maritimes et en Ontario. Toutefois, sa paille est longue et moins forte que d'autres cultivars à paille plus courte. Dans les provinces maritimes, les cultivars d'avoine très hâtifs, Cabot et Fundy, étaient cultivés en rotation avec les pommes de terre. Les producteurs préféraient ces cultivars car ils leur permettaient de terminer la récolte des céréales avant d'entreprendre la récolte principale des pommes de terre. Dorénavant, Marion pourra remplacer avantageusement ces cultivars tout en donnant 12 % et 18 % plus de rendement que Cabot et Fundy respectivement.

Pathologie. Le projet d'hybridation intergénérique a donné des lignées d'addition de blé d'automne plus résistant au VJNO que les blés conventionnels au niveau BC4. De nouveaux hybrides ont été synthétisés: 50 blé × *Thinopyrum* (=*Agropyron*) *ponticum*, 30 blé ×

T. intermedium, 500 blé × *Leymus angustus*, 10 blé × *L. mollis*, 10 blé × *L. giganteus*, 10 blé × (*Elytrigia repens* × *Pseudoroegneria spicata*), 25 blé × *Elytrigia repens*, 300 blé × triticale, 65 blé × seigle (= triticales 8x). Les triticales 8x, déjà doublés à la colchicine, contiennent des gènes d'immunité à la fusariose de l'épi.

Plusieurs cultivars résistant au VJNO ont été découverts dans le cadre du projet soutenu par le Centre de recherche et développement international (CRDI). Chez le blé de printemps, le dérivé intergénérique Long Miai 10 et le blé brésilien IAS-20 semblent prometteurs. Chez le blé d'automne, les dérivés intergénériques Elmo et Riebesel possèdent une résistance très héritable. Un grand nombre d'orges et d'avoines résistantes ont été identifiées; certaines sont destinées à devenir des cultivars adaptés aux conditions du Québec. Chez le blé dur (*Triticum durum*), les progrès sont lents; l'hybridation interspécifique avec *Triticum aestivum* semble être une solution pour augmenter la résistance au VJNO.

L'effet des engrais azotés appliqués sous forme organique d'urée ou de nitrate d'ammoniaque aux doses de 0, 40, 80, 120 et 160 kg/ha sur la rhynchosporiose de l'orge de printemps a été étudié sur deux types de sol pendant 2 ans. Une forte corrélation positive et significative entre la dose d'azote et l'intensité de la rhynchosporiose a été notée au cours des 2 années. Bien que l'intensité absolue de l'attaque était plus prononcée sur le loam sableux que sur sol argileux, l'influence de l'azote s'est manifestée de la même manière sur les deux types de sol. L'intensité de la maladie était à peu près équivalente dans les parcelles fertilisées à l'urée ou au nitrate d'ammoniaque.

L'énergie: fixation d'azote et endomycorhizes

Fixation d'azote à basse température. Une population de 48 souches de *Rhizobium* isolées des nodosités de trois légumineuses arctiques endémiques à la Péninsule de Melville (68° 32′ N, 83° 19′ W) dans les Territoires du Nord-Ouest, *Astragalus alpinus* (11), *Oxytropis maydelliana* (19) et *Oxytropis arctobia* (18), a été caractérisée. Les études physiologiques à 25 °C et 5 °C démontrent que ces souches de *Rhizobium* sont adaptées à un environnement froid. De plus, les études en symbiose avec le sainfoin démontrent une bonne efficacité de fixation d'azote à basse température lorsque cette plante est nodulée par des souches arctiques. Des études physiologiques avec *Oxytropis maydelliana* nodulé ont révélé que la nitrogénase est très active jusqu'à 5 °C et que l'activité augmente jusqu'à 30 °C où elle cesse brusquement; entre 5 °C et 10 °C, l'activité enzymatique relative (Q_{10}) est de 1,8 et elle descend à 1,3 de 10 °C à 20 °C; en comparaison, la luzerne a une activité nitrogénasique relative plus faible jusqu'à 15 °C et la valeur de Q_{10} est de 1,4 entre 15 °C et 25 °C. En général, l'activité de la nitrogénase *in situ* chez *Oxytropis maydelliana* ressemble à celle observée chez les légumineuses tempérées et elle est influencée par les mêmes facteurs environnementaux. Cependant, l'activité est maintenue durant toute la saison végétative à de faibles températures, ce qui indique une adaptation aux conditions nordiques.

Inoculation de la luzerne au champ. Durant 3 années consécutives, la luzerne nouvellement implantée sur l'argile Kamouraska et sur le loam Saint-André a été inoculée avec des doses variables de *Rhizobium meliloti*. Durant la sécheresse sévère de l'été 1983, la luzerne ayant reçu une dose de *Rhizobium* 1000 fois supérieure à la dose recommandée (10^3 cellules de *Rhizobium* par grain) a persisté et donné des rendements très élevés, grâce à son association avec le *Rhizobium*. Pour compétitionner favorablement la population naturelle des *Rhizobium* au champ, une dose de 10^5 cellules de *Rhizobium* par grain est requise sur l'argile Kamouraska. L'effet des fortes doses d'inoculants persistent durant 3 ans sur le loam Saint-André, alors qu'ils disparaissent après 2 ans sur l'argile Kamouraska.

Inoculants commerciaux. En collaboration avec la Direction de la production et de l'inspection des aliments dans le cadre de son programme sur les inoculants des légumineuses, et en conformité avec les règlements de la loi sur les fertilisants, 37 inoculants commerciaux à base de *Rhizobium* et 10 échantillons de graines préinoculées ont été analysés. Le nombre de *Rhizobium* infectieux et spécifiques présents dans les échantillons est énuméré selon la méthode officielle, développée à Sainte-Foy, basée sur l'infectivité des plantes inoculées et l'évaluation de la nodulation après 3 semaines de croissance.

Les inoculants pour le lotier, la luzerne et les trèfles ont un taux de satisfaction aux normes légales de 100 %, 96 % et 60 % respectivement. La qualité pour les graines préinoculées est faible avec seulement 60 % de satisfaction, ce qui laisse place pour l'amélioration de ce procédé.

Banque de Rhizobium. Nous maintenons à Sainte-Foy une bibliothèque de *Rhizobium* ayant des propriétés et des capacités différentes pour satisfaire les besoins de la recherche et pour constituer une réserve pour les usagers commerciaux. Nous nous appliquons particulièrement à préserver la diversité biologique et l'authenticité de la réserve génétique. Ainsi nous avons en banque des souches spécifiques pour plus de 20 légumineuses agricoles, en plus d'une collection impor-

tante de souches adaptées aux conditions nordiques. La collection a été entièrement révisée pour en assurer la pureté et elle a été mise sous conservation selon deux modes différents, l'un dans l'azote liquide et l'autre dans un surgélateur à –80 °C. Un catalogue avec fiche descriptive de chaque souche a aussi été préparé.

Endomycorhizes. À partir de cultures monosporales de champignons endomycorhiziens, provenant de luzernières ou de plantes sauvages du Québec, 32 nouvelles souches ont été isolées. Toutes ces souches sont en multiplication et l'identification des espèces est en cours. Une souche a déjà été identifiée, il s'agit du *Glomus mosseae*, dont c'est la première observation au Québec.

L'efficacité comparative de cette espèce sur la luzerne sera vérifiée dès qu'une quantité suffisante d'inoculant endomycorhizien sera disponible. Des modifications ont été apportées à la méthode de production de l'inoculant endomycorhizien. D'une part, un changement au niveau de la grille de fertilisation nous permet d'obtenir une colonisation plus rapide ainsi qu'un rendement en biomasse végétale deux fois supérieur dans un même laps de temps par rapport à la méthode antérieure. D'autre part, dorénavant tous les plants utilisés dans différentes expériences seront précolonisés en faisant les semis à proximité de plants âgés ayant un système racinaire déjà fortement colonisé par un champignon endomycorhizien. Cette nouvelle méthode permet d'éliminer la pratique traditionnelle d'inoculation qui consistait à utiliser des segments de racines colonisées. Ainsi, les risques de contaminations par des saprophytes et surtout des micro-organismes pathogènes sont beaucoup moindres, d'où un inoculant endomycorhizien de meilleure qualité. Cette méthode de précolonisation nous assure que l'endophyte est bien installé dans le système racinaire de la plante-hôte au moment où on met en marche une culture.

La survie à l'hiver

Comportement des plantes au cours de l'hiver. Les légumineuses, les graminées et les céréales se sont mieux endurcies à La Pocatière qu'à Saint-Hyacinthe durant l'automne et l'hiver 1984-1985, à l'exception du cultivar de trèfle rouge Lakeland qui a atteint la plus faible tolérance au gel (TL_{50}) des espèces à l'essai. Malgré une tolérance au gel égale à celle des cultivars de luzerne Apica et Vernal, le cultivar de blé Frederick est celui qui a le moins bien survécu, soit 24 % et 44 % respectivement à Saint-Hyacinthe et La Pocatière. Au milieu de mars, la mortalité dans les parcelles de blé était déjà supérieure à 50 %. La mortalité a également été très élevée dans les parcelles de trèfle, atteignant 57 % à La Pocatière et 24 % à Saint-Hyacinthe. Les cultivars de fléole des prés Climax, de seigle Puma et de brome Beacon ont atteint une tolérance au gel de –36 °C, soit la meilleure des espèces à l'essai. Les pourcentages ont également été élevés pour la fléole des prés et le brome, soit environ 95 %, et légèrement moindre pour le seigle avec 82 % à La Pocatière et 90 % à Saint-Hyacinthe. Avec une tolérance au gel inférieure, soit –27,7 °C à La Pocatière et –21,3 °C à Saint-Hyacinthe, le cultivar de lotier Léo a montré les meilleurs pourcentages de survie, soit 95 % et 100 % respectivement aux deux endroits.

Dosage de l'acide abscissique. L'action physiologique de l'acide abscissique (ABA) se retrouve toujours associée à des situations de stress ou d'inhibition de croissance et pourrait jouer un rôle déterminant dans les phénomènes physiologiques et biochimiques conduisant à l'acclimatation des plantes au froid. Une étude a été entreprise afin de déterminer, à l'aide d'un système de dosage radio-immunologique, les variations des niveaux d'ABA se retrouvant dans les tissus végétaux de deux cultivars de blé, différant par leur rusticité, lors d'une exposition au froid. Les résultats préliminaires indiquent la présence d'accumulation importantes d'ABA dans les feuilles et les collets. Toutefois, des différences majeures dans les niveaux d'ABA existent entre les deux cultivars, le plus résistant possédant des quantités d'ABA très supérieures à l'autre. S'il devient possible de corréler les niveaux des régulateurs endogènes de croissance avec la rusticité et l'endurcissement au froid, nous disposerons alors d'un outil extrêmement utile pour la sélection et l'amélioration de cultivars.

La synthèse de protéines. À la suite d'un traitement d'endurcissement au froid de 2 semaines, le TL_{50} augmente, en moyenne, de –4,4 °C à –16,1 °C chez le cultivar de blé Kharkov (résistant au froid) et de –3,8 °C à –9,4 °C chez le cultivar de blé Champlain (sensible au froid). L'étude électrophorétique effectuée à la suite de ce traitement montre que, au niveau des collets, plusieurs protéines spécifiques apparaissent chez le cultivar Kharkov. Chez le cultivar Champlain, on observe aussi la synthèse d'une dizaine de nouvelles protéines. Cependant, même si quelques-unes des protéines nouvellement synthétisées sont communes aux deux cultivars, la plupart d'entre elles diffèrent par leur point isoélectrique et leur poids moléculaire. La même étude comparative effectuée au niveau des parties aériennes ne révèle pas la présence de différences majeures à la suite du traitement chez les cultivars étudiés.

Évaluation de cultivars. Une méthode très efficace et peu coûteuse qui permet la sélection de cultivars de légumineuses et de céréales d'hiver en fonction de leur résistance au froid a été mise au point dans des serres de plastique. À l'aide de tables dont la température est contrôlée, des régimes alternés de gel-dégel sont appliqués. Ainsi, au cours de l'hiver 1983–1984, Champlain, un cultivar de blé sensible au froid, a péri après un seul cycle de gel-dégel tandis que Cougar, un cultivar de seigle résistant, a survécu après quatre cycles. Le blé Kharkov et le triticale OAC Wintri ont été sérieusement endommagés après deux cycles. Cette méthode a permis également de démontrer que le cultivar de luzerne Apica, développé à Sainte-Foy, était plus rustique que le cultivar Caliverde; les cultivars Saranac et Iroquois avaient une rusticité intermédiaire.

Estimation statistique du TL_{50}. La détermination des TL_{50} présente des problèmes d'analyse statistique particuliers parce que les TL_{50} obtenus pour chaque cellule du plan expérimental n'ont pas toutes la même précision. Différents modèles ont été utilisés et les résultats obtenus ont été comparés. Le modèle le mieux adapté considère le logit empirique du nombre de plants survivants comme fonction des différents facteurs qui définissent le plan expérimental et de la température de gel. L'égalité du coefficient du terme «température» d'une cellule à l'autre peut être testée. Des estimations du TL_{50} et leurs intervalles de confiance pour chaque traitement sont ainsi obtenus.

LES SOLS

La fertilité

Indice d'efficacité physiologique de l'azote chez l'orge. Les résultats obtenus montrent que dans nos conditions expérimentales, l'indice d'efficacité physiologique (IEP) de l'azote de divers cultivars d'orge varie entre 23,9 et 66,3 g de grain par gramme d'azote absorbé. Les valeurs les plus élevées sont obtenues avec une faible dose d'azote qui est utilisée surtout pour la formation de grains aux dépens de la formation d'organes végétatifs et de réserves.

Toutefois, à un niveau élevé d'azote, une proportion plus grande de cet élément est utilisée pour la formation des organes végétatifs et pour le stockage, et par conséquent l'IEP ainsi que l'indice de récolte diminuent. Les résultats montrent également que l'IEP est plus élevé chez les cultivars plus productifs quoique les différences soient moins évidentes avec de fortes doses d'azote; la supériorité des cultivars productifs dans la valorisation de l'azote se manifeste par un moindre stockage d'azote dans les grains et dans la paille et une meilleure utilisation de l'azote disponible. Les cultivars productifs et à haute efficacité physiologique, Sophie et Bruce, avaient une teneur en azote moins élevée que les cultivars moins productifs, Bonanza et Perth. Ces résultats suggèrent que l'IEP de l'azote absorbé est sous la dépendance de deux facteurs principaux, soit la quantité d'azote absorbé et les caractéristiques génétiques du cultivar d'orge. Des corrélations élevées entre le rendement en grain des cultivars d'orge et leur IEP de l'azote absorbé suggèrent que cette variable pourrait jouer un rôle de premier ordre dans le processus d'amélioration génétique de cette céréale, processus par lequel il faudrait améliorer simultanément l'efficacité de l'absorption de l'azote et son utilisation par la plante.

Magnésium et bore chez la luzerne. Une expérience portant sur l'effet de cinq doses de magnésium et de bore sur les rendements de cinq cultivars de luzerne a été effectuée en serre. Seul le cultivar Saranac a bien répondu aux apports de magnésium, le rendement maximum (82,6 g/pot) ayant été obtenu à la dose maximum de magnésium (240 mg/pot). La réponse aux applications de bore a été meilleure. Le rendement maximum (85,4 g/pot) a été obtenu avec le cultivar Dekalb–120 à la dose de 1,25 mg/pot de bore.

Effet d'un résidu de cartonnerie sur la productivité de l'orge. L'effet de cinq mélanges sol–résidu a été étudié en serre. Le témoin (sans résidu) a donné le moins bon rendement total (19,9 g/pot) tandis que le traitement contenant 100 % de résidu a donné le meilleur rendement (40,1 g/pot). Les rendements en grains ont suivi la même tendance, passant de 9,8 g/pot avec le témoin à 16,7 g/pot avec le milieu composé exclusivement de résidu de cartonnerie.

La pédogenèse

Arénisation des schistes. Au Québec, il y a environ 15 000 ha de sols développés sur matériaux calcaires et qualifiés de résiduels ou quasi-résiduels par les pédologues. Des profils ont été échantillonnés dans un contexte de dépôts glaciaires du piedmont appalachien pour étudier la formation de ces sols. Les dépôts meubles ne dépassent généralement pas 1 m d'épaisseur. Des essais de désagrégation des schistes dans H_2O et HCl dilué ont montré que l'arénisation des schistes est lié à la dissolution des carbonates. Ce processus est plus actif dans les sols bien à modérément bien drainés. Les schistes sont donc inexistants et en l'absence de matériaux allochtones déposés par les glaciers, ce qui est

concevable dans une aire assez étendue, les sols peuvent avoir une apparence de sols résiduels. Dans de tels profils et sous les conditions climatiques du Québec, il y a translocation vers les horizons B de particules fines et de complexes organométalliques, de sorte que pour les deux profils étudiés dans des situations de drainage modérément bon, un profil était classé dans l'ordre podzolique et l'autre dans l'ordre luvisolique.

Les sols de l'Anse. Une étude est en cours pour évaluer les propriétés des sols de l'Anse, formés sur les dépôts récents du fleuve Saint-Laurent, dans leur aire d'extension. Une partie de ces sols a été récupérée pour l'agriculture et un système de drainage y a été installé. À ce moment, les sulfures contenus dans les dépôts ont été oxydés et les sols sont généralement très acides. Il y a formation de jarosite qui peut être ultérieurement détruite. Les quantités de soufre (S) retrouvées dans les profils ont considérablement diminué par rapport aux valeurs mesurées dans les sédiments non drainés et incultes. Dans un cas, les valeurs de S sont souvent inférieures à 0,75 % de S alors qu'elles sont supérieures à cette valeur pour les sédiments non cultivés.

Physique et productivité

Fragments grossiers schisteux. Au Québec, plusieurs séries de sols contiennent des quantités parfois élevées de fragments grossiers schisteux. Il a été de montré que ces fragments grossiers pouvaient contribuer de façon importante à la rétention des éléments nutritifs pour les plantes. Deux essais ont été menés en aire de propagation pour évaluer l'effet de ces fragments grossiers sur la rétention de l'eau et la productivité des sols. Les sols naturels ont été comparés à ceux dans lesquels les fragments grossiers ont été soit enlevés, soit remplacés par une quantité équivalente de graviers inertes. La plante-témoin était la luzerne. Dans le premier essai, les arrosages ont été réduits après la quatrième coupe, et après la première coupe dans le deuxième essai. Les rendements de luzerne les plus élevés ont été généralement obtenus avec les mélanges sol–fragments grossiers. Les mélanges sol–gravier se classaient seconds dans le premier essai et ont donné les plus petits rendements dans le deuxième essai. Il semble que les fragments grossiers contribuent à améliorer la structure du sol dans les pots et permettent une meilleure implantation de la luzerne. De plus, les fragments poreux contribuent à retenir l'eau pour les plantes tandis que sous des conditions de stress hydrique, les mélanges sol–gravier permettent une évacuation trop rapide de l'eau dans les pots.

FERME EXPÉRIMENTALE, LA POCATIÈRE

Les plantes fourragères

Essais de cultivars. Plusieurs lignées et cultivars de différentes espèces fourragères annuelles et vivaces sont évalués à chaque année. L'évaluation des cultivars de luzerne CW62, CW69, CW6306, Pickstar, Ottawa 78-1 et Ottawa 78-2 a été arrêtée. Les cultivars de trèfle rouge Hungaropoli et de dactyle Orion sont retirés de la liste des recommandations pour le Québec. L'analyse des résultats a permis d'ajouter à cette liste les cultivars de dactyle Kay et Juno et les cultivars de raygrass annuel Lemtal, Maris Ledger, Barmultra (type italien), Aubade et Barspectra (type westerwold).

Semence du trèfle rouge. Les cultivars de trèfle rouge Arlington et Florex ont été ensemencés en 1983 et en 1984 sur deux types de sol, le loam graveleux Saint-André et l'argile Kamouraska. La semence de cette espèce a été récoltée sur le regain l'année suivant l'implantation. Les résultats préliminaires montrent que le cultivar Florex rend plus de semence que le cultivar Arlington et ce, quel que soit le type de sol. De plus, une corrélation positive entre les rendements en semence et la précipitation durant les mois de production (juillet et août) a été notée. De plus hauts rendements en semence ont été obtenus sur le sol Saint-André l'année où les précipitations ont été abondantes et régulières. Toutefois, sous des conditions de sécheresse, les cultivars ont été plus productifs sur le sol Kamouraska.

Fertilisation azotée. La digestibilité des fourrages est un facteur très important dans l'alimentation des ruminants. Une étude a été entreprise afin d'évaluer l'effet de la fertilisation azotée sur la digestibilité de la luzerne et de la fléole des prés semées en monocultures et en mélanges. L'azote a été appliqué sous forme de nitrate d'ammoniaque à des doses variant entre 0 et 160 kg/ha. Les résultats montrent que la fertilisation azotée n'a que peu ou pas influencé la digestibilité de la matière sèche de ces espèces fourragères et ce, quelle que soit la dose utilisée.

La pomme de terre

Amélioration. L'amélioration génétique de la pomme de terre s'est poursuivie à La Pocatière. Il y a eu pratiquement 20 000 parcelles de pomme de terre en 1985. Une centaine de croisements ont été réalisés. Des lignées produites en 1984 (12 500) ont été évaluées au champ et 8,0 % de celles-ci ont été sélectionnées. Les lignées sélec-

tionnées à Frédéricton (856) et à La Pocatière (1 036) ont été évaluées sur deux sols, Saint-André et l'Anse, au stade de 4 buttes. La sélection aux champs a permis de conserver 37,0 % et 24,6 % de ces lignées pour les évaluations de rendement, teneur en matière sèche, cuisson à l'eau, croustille et qualités diverses des tubercules. Les 112 lignées sélectionnées en 1984 au stade de 4 buttes ont été évaluées pour la première année en parcelles aléatoires sur trois sols différents, Saint-André, l'Anse et Saint-Pacôme et 60 % de ces lignées ont été retenues. L'épuration de ces lignées est actuellement en cours.

Pour la seconde année, un essai de tamisage a eu lieu sur trois stations, Lennoxville, Normandin et La Pocatière. Cet essai a été composé de 47 lignées LP84. La sélection de ces lignées d'après les tests de laboratoire et les analyses statistiques permettront d'inclure les meilleures lignées dans le réseau d'essais régionaux en 1986. Dix lignées LP80, LP81 et LP82 ont été épurées et intégrées dans le réseau d'essais régionaux suite à l'essai de tamisage.

Parcelles de démonstration. Des parcelles de démonstration ont été faites en collaboration avec le Centre de certification et d'épuration des pommes de terre avec des cultivars homologués au Canada et ailleurs, et certaines lignées adaptées aux conditions du Québec. Ces parcelles servaient à l'entraînement des élagueurs et des professionnels à reconnaître les cultivars.

Cultures fruitière et ornementale

Arbres fruitiers. Tous les cultivars de prunier, sauf Green Gage, ont donné une récolte en 1985. Toutefois, les pruniers n'ont produit que 30 % (35 minots) du rendement obtenu en 1984; il y a eu infestation de tétraniques et de pucerons en fin de saison. Par contre le rendement des cultivars de poirier a été satisfaisant cette année (Claps, 5 minots; Nenie, 8 minots; Phyleson, 12 minots).

Arbres et arbustes ornementaux. L'évaluation d'arbres et d'arbustes ornementaux du réseau d'essais provinciaux s'est poursuivie en 1985. De nouveaux arbres et arbustes (1 008) ont été transplantés à La Pocatière cette année et 87 % des transplantations effectuées en 1984 ont survécu l'hiver.

FERME EXPÉRIMENTALE, NORMANDIN

Les céréales

L'amélioration du blé de printemps. L'objectif majeur du programme d'amélioration génétique du blé de printemps est le développement de lignées hâtives ayant un potentiel de rendement élevé. Ces travaux permettent d'étendre l'aire de culture de cette espèce aux régions périphériques du Québec, notamment dans les régions du moyen nord. Le développement de lignées de blé de type 3M est également un objectif de ce programme. Depuis 1982, près de 350 croisements ont été réalisés. En 1985, plus de 200 populations en disjonction (F2, F3 et F4) et au-delà de 6 000 épis-lignées ont été semés servant de source à la sélection de matériel génétique. De plus, six lignées de ce programme ont été évaluées dans l'essai coopératif Maritimes–Québec des blés de printemps.

Les bovins

Le préconditionnement des veaux d'embouche. Les résultats de différents travaux sur le sevrage et la vaccination pré-vente sont controversés et semblent être liés fortement à l'environnement. Une comparaison qui regroupait un total de 498 sujets mâles castrés provenant de quatre régions différentes du Québec a été effectuée en 1982 et en 1983. La vaccination intra-musculaire contre la rhinotrachéite infectieuse bovine, la parainfluenza du type III et la méningo-encéphalite thrombo-embolique infectieuse a été appliquée à tous les sujets. Les résultats obtenus montrent que chez les naisseurs, les sujets vaccinés à la ferme ont eu des gains de poids similaires aux sujets vaccinés à l'encan. Les sujets sevrés 26 jours avant les ventes à l'encan ont gagné 3,9 kg de plus que les sujets sevrés au moment de l'expédition vers les lieux de vente à l'encan. Toutefois, les sujets sevrés 26 jours avant les ventes ont perdu 3,3 kg de plus dans le transport et durant les manipulations de la vente. Durant les deux premiers mois d'engraissement, les sujets séparés de leur mère au moment de l'expédition ont gagné plus de poids que les sujets sevrés 26 jours avant les ventes. Par la suite, tout avantage avait cepen-

dant disparu même si la tendance est demeurée en faveur de ces mêmes sujets pour une période allant jusqu'à 146 jours en engraissement. Cette étude révèle également que les finisseurs feraient plus d'économie en achetant des veaux non sevrés et vaccinés à la ferme en comparaison avec des sujets également non sevrés mais vaccinés sur les lieux de vente. Par contre, sans transfert de fond lors de la transaction, les éleveurs de vaches–veaux ne retrouveraient pas d'avantage pécunier à vacciner à la ferme.

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Départs

L.J. Coulombe, B.A., B.Sc.(Agr.), M.Sc., Ph.D. À la retraite, 16 décembre 1985	Phytopathologie
M. Dupré, B.A., B.Sc.(Agr.) À la retraite, 29 mai 1985	Protection
R. Thériault, B.Sc.(Agr. Eng.), Doc. Ing. À l'Université Laval, 5 juillet 1985	Mécanisation

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INTRODUCTION

La Station de recherches de Saint-Jean conduit un programme élaboré de recherche et de développement orienté vers les plantes maraîchères, fruitières et oléagineuses ainsi que sur le maïs grain. La recherche est de portée multidisciplinaire et embrasse le génie génétique, l'amélioration, la régie, le génie ainsi que la protection et la malherbologie. On porte un intérêt tout particulier à la lutte intégrée contre les dangers qui menacent la carotte, le céleri et les fruits afin d'aider l'industrie à diminuer les coûts de production.

Les travaux de fertilisation du tabac, d'amélioration du maïs grain en vue d'agrandir ses aires de production et la régie des plantes ornementales sont poursuivis à la ferme expérimentale de l'Assomption.

Les résultats des recherches exposés ici sont un hommage rendu à notre personnel et ont pour but de donner un aperçu des activités de l'année qui vient de s'écouler. Pour de plus amples informations, veuillez vous adresser à: Station de recherches, Direction générale de la recherche, Agriculture Canada, C.P. 457, Saint-Jean-sur-Richelieu, Québec, Canada. J3B 6Z8.

C.B. Aubé
Directeur

CULTURES MARAÎCHÈRES

Méthodes d'extraction des nématodes

Les nématodes phytoparasites sont des ravageurs importants dans les cultures maraîchères du Québec, principalement dans les sols légers comme les sables, les loam-sableux et les sols organiques. Pour dépister ces micro-organismes, nous procédons par analyse d'un échantillon de sol provenant de la rhizosphère d'un plant endommagé. Il existe présentement plusieurs méthodes pour extraire les nématodes du sol.

Nous avons comparé notre méthode usuelle, l'assiette de Baerman, avec la méthode de Coolen reconnue comme étant plus efficace pour l'extraction des nématodes du genre *Meloidogyne*.

L'assiette de Baerman est avant tout simple et peu coûteuse et permet de récupérer les nématodes vivants. Un échantillon de sol est déposé dans une assiette sur un filtre maintenu humide. Chaque échantillon prend environ 5 minutes à préparer, mais il faudra attendre 7 jours d'extraction avant de pouvoir faire l'analyse.

La méthode de Coolen extrait les nématodes morts et vivants par un procédé de mixage et de centrifugation dans des solutés à densités spécifiques. Les organismes sont ensuite récupérés sur un filtre à mailles très fines. Cette technique nécessite environ 45 min de travail pour une extraction seulement.

Avec un sol minéral, la méthode de l'assiette de Baerman s'est avérée plus efficace. Par contre, la méthode de Coolen a permis de récupérer 5 fois plus de *Meloidogyne* à partir d'un sol organique.

À cause de sa sélectivité et de sa rapidité à fournir des résultats, la technique de Coolen pourra avantageusement être utilisée en sols organiques.

Cycle évolutif du bident penché et du bident feuillu

Lors de l'inventaire des mauvaises herbes dans les champs de carottes en sols organiques en 1982, le bident penché, *Bidens cernua* L., avait une fréquence d'apparition de 70 %, alors qu'un autre bident, *Bidens vulgata* Greene, avait une fréquence variant de 6 à 10 %. Des plants de bident (*B. cernua* et *B. frondosa* L.) ont été transplantés au champ le 24 mai 1985 et leur cycle évolutif a été étudié. *Bidens frondosa* ou bident feuillu a été choisi car il est similaire au *B. vulgata*.

Le bident feuillu est plus sensible au vent: la tige principale et les branches sont facilement brisées par le vent. Par contre, le bident penché est beaucoup plus résistant car les branches à la base de la plante développent des racines aux entre-noeuds aidant ainsi la plante à bien s'ancrer dans le sol. Le bident penché a un nombre important de fleurs à nectar odorant qui attirent les abeilles et les taons.

Distribution et développement saisonnier de la mouche de la carotte au Québec

La mouche de la carotte, *Psila rosae* (F.), est un ravageur sporadique de la carotte au Québec mais qui peut causer jusqu'à 25 % de dommages dans certains champs. On connaît peu de choses sur le développement saisonnier de cet insecte ni sur sa distribution dans les régions productrices de carottes au Québec.

Une étude a été réalisée en utilisant des pièges englués de couleur jaune pour capturer les adultes

de la mouche de la carotte. Des pièges ont été placés en 1983 et 1984 dans les principales régions productrices de carottes au Québec. Ces pièges étaient disposés par groupes de trois, espacés de 2 m, à 125 cm du sol et à 2 m à l'intérieur des champs. Afin de déterminer le développement saisonnier de cet insecte, des pièges ont aussi été placés de 1982 à 1985 à la Ferme expérimentale de Sainte-Clotilde et chez un producteur à Sherrington.

Les pièges placés à Alma, Beauport, l'Assomption, l'Ange-Gardien (Rouville) et Lotbinière ont capturé des mouches de la carotte. Seuls les pièges placés à Nicolet n'ont pas capturé cet insecte. Ce ravageur est donc présent dans l'ensemble des régions productrices de la carotte au Québec. De plus, cet insecte a deux générations par année au Québec et les périodes de vol sont bien distinctes.

Dans les champs étudiés, on a observé très peu de dommages de la première génération mais par contre, la deuxième génération peut causer jusqu'à 36 % de dommages surtout dans les semis récoltés en octobre et plus tard. La date de semis ne semble pas affecter le pourcentage de dommages causés par la mouche de la carotte à la récolte.

Pollinisation du fraisier

On a poursuivi des études pour identifier chez un groupe de huit cultivars de fraisiers, les plus visités par les abeilles et les autres insectes pollinisateurs. Le but est d'employer de tels cultivars comme parents dans un programme d'amélioration génétique visant à la production de fruits exempts de toute malformation causée par une mauvaise pollinisation. La fréquence des visites des abeilles et des autres pollinisateurs a été mesurée pendant la floraison sur deux mètres de rang et pour quatre répétitions par cultivar.

On a observé qu'il y a des différences notables entre les fréquences des visites de pollinisateurs chez les cultivars étudiés. Pour les abeilles, mais pas pour les autres insectes pollinisateurs, les fréquences des visites de 1984 et de 1985 étaient corrélées ($r = 0,72$; significatif à $P = 0,04$). En général, les visites des abeilles ont été plus nombreuses en 1985 qu'en 1984, alors que le contraire s'est produit pour les autres insectes pollinisateurs. Ceci peut être expliqué par une compétition entre ces deux catégories d'insectes.

Nouveaux groseilliers

Stanbridge. Les parents de ce groseillier sont inconnus. Étant donné cependant que le cultivar Stanbridge a été évalué dans un groupe de sélections exemptes d'épines, il est possiblement apparenté aux cultivars Spinefree et Captivator.

Il produit un buisson très vigoureux, érigé, plutôt haut et dont les tiges sont dépourvues d'épines. Lorsque taillés adéquatement, les buissons de ce cultivar peuvent se prêter à la cueillette mécanisée. À l'instar de Captivator, son feuillage et ses fruits se sont montrés résistants au mildiou et aux autres principales maladies, de sorte que des traitements très limités peuvent le maintenir en santé pendant toute la saison de végétation.

Au point de vue productivité, Stanbridge se compare avantageusement aux autres cultivars commerciaux de l'est du Canada. Le calibre de son fruit est plutôt petit mais étant donné sa grande productivité et l'absence d'épines sur ses tiges, il est de cueillette facile et rapide. Les groseilles de Stanbridge sont attrayantes et d'un goût excellent. Elles sont particulièrement recherchées pour la confiserie parce qu'elles restent vertes à maturité.

Sébastien. Les parents de ce groseillier sont inconnus. Cependant, étant donné que le cultivar Sébastien a été évalué dans un groupe de sélections exemptes d'épines, il est possiblement apparenté aux cultivars Spinefree et Captivator.

Il pousse en buissons vigoureux, semi-érigés. Ses tiges ne portent que peu d'épines courtes, peu incommodantes pour la cueillette. Le feuillage et les fruits de Sébastien sont légèrement sensibles au mildiou dont la répression peut se faire facilement.

La productivité de Sébastien est comparable à celle des cultivars Captivator et Pixwell. Ses fruits sont de meilleur calibre que ceux de Pixwell. Contrairement à ce dernier, les tiges sont presque dépourvues d'épines. Les fruits de Sébastien sont excellents et rouges à maturité. La récolte est hâtive.

Biologie de la tordeuse du fraisier au Québec

Au cours de la dernière décennie, on a fréquemment mentionné la présence de la tordeuse *Olethreutes olivaceana* (Fern.) (Lepidoptera: Tortricidae) dans les fraisières du sud-ouest du Québec. Les chenilles de ce lépidoptère s'attaquent au feuillage mais, jusqu'à présent, elles n'ont apparemment pas été retrouvées à des niveaux de populations risquant de compromettre cette culture. L'impact réel des populations de cet insecte sur le rendement est méconnu. Afin d'élaborer des stratégies de lutte efficace, nous avons effectué des études sur la biologie de cette tordeuse. C'est la première fois que la biologie de cette espèce est étudiée.

Les larves ont été collectionnées en 1977, 1978, 1979 et 1983 dans des fraisières de première et deuxième années non-traitées aux insecticides.

Les élevages ont été effectués en insectarium; chaque larve a été élevée individuellement et nourrie de feuilles de fraisiers, lesquelles étaient changées au besoin. Les adultes ont été transférés dans des récipients de 1 L contenant des solutions d'eau et une feuille de fraisier en guise de substrat de ponte.

Au printemps, on trouve les larves enroulées dans une feuille. Le stade de chrysalide s'effectue également dans une feuille enroulée. L'émergence des adultes s'échelonne de la mi-juin au début de juillet. L'enroulement des feuilles cause probablement une baisse de rendement mais cette baisse n'a pas été à ce jour quantifiée.

La période de ponte a commencé au début de juillet et a atteint son sommet à la mi-juillet. En insectarium, le taux d'éclosion des oeufs est de 95 %. La mesure des capsules céphaliques a permis l'identification de cinq stades larvaires. *Olethreutes olivaceana* passe l'hiver dans les débris du sol sous forme de troisième et quatrième stades larvaires. Cette tordeuse a donc une génération par année sous nos conditions.

TABAC

Lutte contre le tabac jaune grisé

La manifestation de ce désordre physiologique, sur les feuilles de plants cultivés en serre dans des pots contenant du sol avec antécédents de tabac grisé, a été réduite significativement par des amendements de chaux (0, 858, 1 716 kg/ha) ou de fumier (0, 4,1, 8,2 t/ha) et éliminée par l'apport combiné de ces deux amendements. Une fumure à base de 2-12-16T, à des doses de 613, 1 226 et 1 839 kg/ha n'a pas fait diminuer l'incidence des symptômes. Ceux-ci ont été en corrélation positive avec la teneur en Ca, Mg, Mn et Fe des feuilles, mais en corrélation négative avec le pH du sol. Une corrélation partielle a démontré que pour prédire l'incidence du tabac grisé, la teneur en Fe des feuilles est la variable la plus importante à considérer.

Croissance du tabac jaune grisé et normal

Des plants de tabac grisé provenant de trois fermes tabacoles ont produit des feuilles dont le poids sec était en moyenne inférieur de 3 452 kg/ha, en regard de tabac sain, pour chacune des cueillettes effectuées au cours de 2 ans. La surface foliaire du tabac affecté était également moindre. Cependant, il n'y a pas eu de différence entre les deux types de tabac quant au taux de croissance relative et au taux net d'assimilation. Le taux de croissance du tabac grisé était plus faible dans la période qui a suivi la transplantation au champ (1er juin) et le premier échantillonnage (26 juin). Bien que la surface foliaire ait été moindre dans le tabac grisé, le rapport poids sec:surface foliaire était comparable à celui du tabac normal. La perte de revenus chez les producteurs n'est pas seulement causée par une qualité inférieure du tabac grisé, mais aussi par un rendement inférieur.

Fertilisation du tabac jaune

Les engrais azotés utilisés sous forme d'urée, de nitrate d'ammoniaque, de sulfate d'ammoniaque ou de phosphate d'ammoniaque ont eu un effet comparable sur le rendement, la qualité et la maturité du tabac cultivé sur un loam sableux. L'indice de qualité a cependant été moindre sur un sol sablonneux. L'azote fournie sous forme de nitrate de potasse a causé une réduction non significative du rendement et de la qualité. Quant aux sources de phosphore, le superphosphate simple a été comparable au triple phosphate par rapport aux paramètres évalués. Le rendement a augmenté, au détriment de la qualité, avec l'accroissement des taux de fertilisation; une formulation équivalente à 25N-75P-165K/ha est recommandable.

HORTICULTURE ORNEMENTALE

Lutte contre des agents phytopathogènes

La population de *Fusarium oxysporum* f.sp. *radicis-lycopersici* Jarvis et Shoemaker et la nécrose des racines de *Lycopersicon esculentum* Mill. c. Vendor n'ont pas été affectées par une augmentation du phosphore (P) disponible dans le substrat (argile montmorillonite calcinée), ni par une teneur plus élevée en P des racines et du feuillage. L'augmentation du taux de P dans le milieu de culture a cependant entraîné une diminution de la colonisation racinaire par *Glomus intraradices* Schenk et Smith. La présence seule du *Glomus* a résulté en une diminution significative ($P = 0,05$) de la population du *Fusarium* (2 299 à 604) et de la nécrose des racines (46 % à 29 %), quel que soit le niveau de P disponible ou que le champignon soit localisé à proximité du système racinaire mycorhizé ou dispersé dans le sol.

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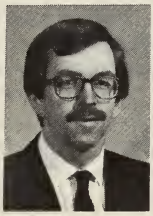
Ontario Region
Région de l'Ontario

J.J. Cartier



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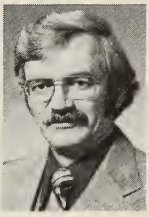

D.G. Proctor

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PREFACE

The Ontario Region comprises nine responsibility centers: the research stations of Harrow, Delhi, Vineland, and Ottawa; the London and the Animal research centers; and the experimental farms at Smithfield, Kapuskasing, and Thunder Bay. All have specific mandates that address current and anticipated problems of concern to the agri-food industry. Regional staff totals about 850, of which about 170 are professionals. The total regional budget is approximately $40 million.

The Harrow Research Station has one of the most diverse research programs in the region. Its program features field crops such as corn, soybeans, winter wheat, and field beans, and to a lesser extent burley tobacco, as well as horticultural crops such as tree fruits and vegetables, including greenhouse crops. Emphasis is placed on improving integrated pest management technologies for the control of weeds, diseases, and insects. In response to increased priority on soil conservation, Harrow will be responsible for the technology evaluation and development subprogram of the federal–provincial southwestern Ontario soil and water quality enhancement program.

The Delhi Research Station provides research support to the flue-cured tobacco industry in Ontario, Quebec, and the Maritimes. A research program on alternative crops for tobacco soils is also under way and a master plan to assist this transition is being developed.

Integrated pest management for orchard and vegetable crops, grapes, and ornamentals is the focus of research at the Vineland Research Station. To reduce the use of chemical pesticides while maintaining crop productivity and produce quality has required a strong multidisciplinary approach that maximizes the use of biotic factors and is integrated with provincial initiatives. The station also maintains a virus-free nuclear stock repository of strawberries, raspberries, and tree fruits.

The Ottawa Research Station conducts breeding programs in cereals, forages, soybeans, and some ornamentals, from which new improved cultivars or hybrids are produced. Supportive research is provided in plant pathology, physiology, entomology, cytogenetics, and grain quality. A center of excellence has been established in biotechnology to support plant-improvement programs of the future. Significant success has been achieved in embryogenesis from protoplasts, somatic hybridization, and other areas, including mammalian gene transfer to plants, in cooperation with the Animal Research Centre.

The Animal Research Centre at Ottawa conducts research in nutrition, physiology, management, breeding, product quality, disease resistance, and genetics in beef and dairy cattle, swine, poultry, and sheep; animal waste management; and food safety and nutrition. The center strives mainly toward improving the productive efficiency of intensively housed and managed livestock and poultry. Increased emphasis is placed on the introduction of the most up-to-date biotechnology methods to animal research. Mycotoxin research is providing sound guidelines on contamination tolerance in feeds.

The London Research Centre concentrates on integrated pest management. Research is directed toward reducing the dependence of the agri-food industry on chemical pesticides and toward assuring that human health and environmental safety are not adversely affected by pesticide use. Present facilities are being upgraded to ensure continued efficiency.

The Smithfield Experimental Farm program features breeding of apples and tomatoes, orchard and vegetable crop management, and some processing research. The Kapuskasing Experimental Farm works with the Animal Research Centre and the Ottawa Research Station, and its facilities are being improved with two new buildings. Animal research aims at improving beef production systems for northern Ontario and western Quebec using adapted, locally produced feeds and novel storage approaches. Feed supplement research has produced significant increases in rate of weight gain. The Thunder Bay Experimental Farm evaluates adaptation of forage, grain, and horticultural crops to the area and produces virus-free potato tubers.

Detailed information on the various programs may be obtained by writing to the establishments concerned or by addressing inquiries to Ontario Region Headquarters, Research Branch, Agriculture Canada, Central Experimental Farm, Ottawa, Ont. K1A 0C6.

J.J. Cartier
Director General

PRÉFACE

La Région de l'Ontario comprend neuf centres de responsabilité, à savoir les stations de recherches de Harrow, Delhi, Vineland et Ottawa, les centres de recherches zootechniques et de London, et les fermes expérimentales de Smithfield, Kapuskasing et Thunder Bay. Tous ont des mandats particuliers qui visent à résoudre les problèmes courants et prévus dans le secteur agro-alimentaire. Les effectifs régionaux d'environ 850 employés, dont environ 170 sont des professionnels, utilisent un budget régional total d'environ 40 millions de dollars.

La Station de recherches de Harrow compte l'un des programmes de recherches les plus diversifiés de la Région. Ce programme porte sur les grandes cultures comme le maïs, le soja, le blé d'hiver et le haricot et, dans une moindre mesure, sur le tabac jaune, et sur les cultures horticoles comme les fruits de verger et les légumes, y compris les cultures de serre. Les chercheurs mettent l'accent sur l'amélioration des technologies de lutte antiparasitaire intégrée dans la lutte contre les mauvaises herbes, les maladies et les ravageurs. Face à une plus grande priorité accordée à la conservation des sols, la station sera chargée du sous-programme de mise au point et d'évaluation de la technologie dans le cadre du programme fédéral-provincial d'amélioration de la qualité des sols et de l'eau du sud-ouest de l'Ontario.

La Station de Delhi prête son concours au secteur du tabac jaune de l'Ontario, du Québec et des Maritimes. Un programme de recherches sur des cultures de remplacement pour les sols à tabac est également en cours et un plan-cadre est actuellement élaboré pour aider à faire la transition.

Les recherches effectuées à la Station de Vineland portent principalement sur la lutte antiparasitaire intégrée dans les cultures fruitières et légumières, vinicoles et ornementales. Pour réduire l'utilisation des pesticides chimiques tout en maintenant la productivité des cultures et la qualité des produits, il a fallu une démarche pluridisciplinaire qui maximise l'utilisation de facteurs biotiques et qui est intégrée à des projets provinciaux. La station exploite en outre une banque de matériel souche de fraisiers, de framboisiers et d'arbres fruitiers exempts de virus.

À la Station de recherches d'Ottawa, les chercheurs exécutent des programmes de sélection des plantes vivant sur les céréales, les cultures fourragères, le soja et quelques plantes ornementales permettant de produire de nouveaux cultivars ou hybrides améliorés. La station collabore également à des recherches sur la phytopathologie, la physiologie, l'entomologie, la cytogénétique et la qualité des céréales. Un centre d'excellence a été établi en biotechnologie pour appuyer les programmes d'amélioration des plantes de l'avenir. Des succès importants ont déjà été remportés dans le domaine de l'embryogenèse à partir de protoplastes, de l'hybridation de cellules somatiques, et dans d'autres disciplines, y compris le transfert de gènes de mammifères à des plantes, en collaboration avec le Centre de recherches zootechniques.

Les travaux effectués au Centre de recherches zootechniques à Ottawa portent sur la nutrition, la physiologie, la gestion, la reproduction, la qualité du produit, la résistance aux maladies, la génétique des bovins à viande et à lait, des porcs, de la volaille et des moutons, la gestion des déchets animaux, ainsi que la sécurité des aliments et la nutrition. Le Centre cherche principalement à améliorer la productivité du bétail et de la volaille en régime d'élevage et de gestion intensifs. Les travaux mettent l'accent sur l'introduction des plus récentes méthodes biotechnologiques appliquées à la recherche zootechnique. En outre, les recherches sur les mycotoxines fournissent des jalons importants sur la tolérance à la contamination dans les aliments du bétail.

Le Centre de recherches de London concentre ses efforts sur la lutte antiparasitaire intégrée visant à réduire la dépendance du secteur agro-alimentaire envers les pesticides chimiques et à assurer que leur utilisation ne nuise pas à la santé de l'homme ni à la sécurité de l'environnement. Les installations sont actuellement rénovées pour maintenir le même niveau d'efficience.

Le programme de recherches de la Ferme expérimentale de Smithfield porte sur la sélection des pommes et des tomates, la gestion des cultures fruitières et légumières, et la transformation des produits. La Ferme expérimentale de Kapuskasing dont les installations sont actuellement améliorées grâce à l'addition de deux nouveaux bâtiments, collabore avec le Centre de recherches zootechniques et la Station de recherches d'Ottawa à améliorer les systèmes de production de bovins de boucherie dans le nord de l'Ontario et l'ouest du Québec en utilisant des aliments du bétail adaptés aux conditions locales et produits sur place, ainsi que de nouvelles méthodes de conservation. Les recherches sur les compléments alimentaires ont permis d'augmenter sensiblement le taux de gain de poids. La Ferme expérimentale de Thunder Bay évalue l'adaptation locale de certaines plantes fourragères, céréalières et horticoles, et produit des tubercules de pommes de terre exempts de virus.

Pour obtenir de plus amples renseignements sur les divers programmes, on peut écrire aux établissements concernés ou s'adresser à l'Administration centrale de la Région de l'Ontario, Direction générale de la recherche, Agriculture Canada, Ferme expérimentale centrale, Ottawa (Ont.) K1A 0C6.

J.J. Cartier
Directeur général

Animal Research Centre, Ottawa, Ontario

PROFESSIONAL STAFF

Administration

R.S. Gowe, B.S.A., M.S., Ph.D., F.P.S.A.	Director
J.I. Elliot, B.S.A., M.Sc., Ph.D.	Deputy Director
D.A. Leger, B.Sc.	Assistant to the Director
D.A. Schmid, B.A.	Chief, Administration and resources
L.M.B. Babin,[1] B.A.	Administrative Officer; Personnel
R.D. Howey[2]	Acting Administrative Officer; Finance

Scientific Support

K.G. Hilson,[3] B.Sc., M.Sc.	Project Manager; Computer services
D.L. Brewin[3]	Programmer–Analyst
D. Campbell[3]	Programmer–Analyst
B.J. McKelvey	Programmer–Analyst
H.M. Mucha[3]	Programmer–Analyst
T.D. Osterhout	Programmer
K.E. Hartin, D.V.M.	Veterinarian
J.P. Miska,[4] B.A., B.L.S.	Library services

Biotechnology

J.S. Gavora, Ing., C.Sc.	Program Chairperson; Disease resistance genetics
D.E. Bernon,[5] B.Sc.(Agr.), M.Sc., Ph.D.	Cellular, molecular, and quantitative genetics
A.J. Hackett, D.V.M., M.Sc., Ph.D.	Embryo transfer, female reproductive physiology
G.J. Marcus, B.A., Ph.D.	Maternal–embryonic physiological interactions
J. Nagai, B.Sc., D.Agr.	Embryo manipulation, quantitative genetics
M.P. Sabour, B.Sc., Ph.D.	Molecular and cellular genetics
R.M. Teather, B.Sc., Ph.D.	Genetic manipulation of rumen bacteria

Animal Waste Utilization Program

N.K. Patni, B.Ch.E., M.Sc., Ph.D.	Program Chairperson; Livestock waste utilization, farm pollution abatement

Dairy and Beef Cattle Nutrition Program

M. Ivan, Ing., M.Sc., Ph.D.	Program Chairperson; Nutrition and metabolism of trace minerals
A.S. Atwal, B.Sc., M.Sc., Ph.D.	Forage evaluation and nutrition
J.D. Erfle, B.S.A., M.Sc., Ph.D.	Rumen metabolism and nutrition
M. Hidiroglou, D.V.M., Dip. Nutr.	Vitamin and trace mineral nutrition
K.J. Jenkins, B.S.A., M.Sc., Ph.D.	Calf nutrition
J.R. Lessard,[6] B.A., B.S.A., M.S., Ph.D.	Forage conservation and nutrition
S. Mahadevan, B.Sc., M.Sc., Ph.D.	Rumen metabolism and nutrition
F.D. Sauer, D.V.M., M.S., Ph.D.	Rumen metabolism and nutrition
D.M. Veira, B.Sc., M.Sc., Ph.D.	Ruminant nutrition

Dairy Cattle Breeding and Production Program

A.J. Lee, B.Sc.(Agr.), Ph.D.	Program Chairperson; Dairy cattle breeding and production—statistical methodology and breeding strategies
T.R. Batra, B.V.Sc., M.V.Sc., M.Sc., Ph.D.	Dairy cattle breeding—field data analyses, disease resistance
C.Y. Lin, B.S., M.S., Ph.D.	Dairy cattle breeding—multi-trait mixed model sire and cow evaluation methods
A.J. McAllister, B.S., M.S., Ph.D.	Dairy cattle breeding and production—selection for lifetime performance and use of crossbreeding

Swine Production Program

D.W. Friend, B.Sc., M.Sc., Ph.D.	Program Chairperson; Sow and piglet nutrition
J.I. Elliot, B.S.A., M.Sc., Ph.D.	Sow nutrition, artificial rearing
A. Fortin, B.Sc.(Agr.), Ph.D.	Carcass evaluation—swine, poultry, sheep, cattle
D.G. Fraser, B.A., Ph.D.	Animal behavior—swine, sheep, cattle

Poultry Breeding Program

A.A. Grunder, B.S.A., M.Sc., Ph.D.	Program Chairperson; Eggshell quality genetics, broiler breeding, goose breeding and management
J.R. Chambers, B.Sc., M.Sc., Ph.D.	Broiler breeding and management
R.W. Fairfull, B.Sc., M.Sc., Ph.D.	Egg stock breeding and management
R.S. Gowe, B.S.A., M.S., Ph.D., F.P.S.A.	Egg stock breeding and management
C.P.W. Tsang, B.Sc., M.Sc., Ph.D.	Physiology—eggshell quality and egg production

Poultry Nutrition Program

I.R. Sibbald, B.Sc.(Agr.), M.Sc., Ph.D., D.Sc.	Program Chairperson; Avian energetics and feedingstuff evaluation
N.A.G. Cave,[7] B.Sc., M.Sc., Ph.D.	Amino acids and proteins, broiler breeder nutrition and management
R.M.G. Hamilton, B.Sc.(Agr.), M.Sc., Ph.D.	Nutrition and physiology—eggshell quality, mycotoxins

Sheep Production Program

L. Ainsworth, B.Sc., M.Sc., Ph.D.	Program Chairperson; Female reproductive physiology
P.S. Fiser, B.Sc., M.Sc., Ph.D.	Cryopreservation, male reproductive physiology
D.P. Heaney, B.S., M.S., Ph.D.	Nutrition and intensive management
G.A. Langford, B.Sc., M.Sc., Ph.D.	Male reproductive physiology
J.N.B. Shrestha, B.V.Sc.A.H., M.S., Ph.D.	Breeding and intensive production—applied quantitative genetics

Animal Feed Safety and Nutrition Program

H.L. Trenholm, B.Sc., Ph.D.	Program Chairperson; Mycotoxins, toxicology
M.H. Akhtar, B.Sc., M.Sc., Ph.D.	Pesticide metabolism and residues
L.M. Coté,[8] B.Sc., M.Sc.	Biochemical toxicology, mycotoxins
E.R. Farnworth,[9] B.Sc., M.Sc., Ph.D.	Lipid nutrition and metabolism
J.K.G. Kramer, B.Sc., M.Sc., Ph.D.	Lipid chemistry and biochemistry
D.B. Prelusky, B.Sc.(Pharm.), Ph.D.	Mycotoxin metabolism, toxicology

Departure

G.R. Ford[10] Transferred to Food Production and Inspection Branch, 2 August 1985	Administrative Officer; Personnel

VISITING SCIENTISTS

L.B. Frando, B.Sc. Department of Anatomy and Reproductive Biology, University of Hawaii, Manoa, Hawaii; National Institutes of Health (U.S.) research fellowship	Follicular growth and ovulation
G.P. Hazlewood, Ph.D. Institute of Animal Physiology, Babraham, Cambridge, England; Organization for Economic Cooperation and Development research fellowship	Cloning of cellulase genes
J. Wang, B.Sc. Y. Wang, B.Sc. Oil and Fat Bureau, Ministry of Commerce, Beijing, China; Food and Agriculture Organization training fellowship	Research and processing of oils and fats

Natural Sciences and Engineering Research Council (Can.) postdoctorate fellows

L.L. Charmley, B.Sc., Ph.D., 1985–1986	Copper and other trace mineral metabolism
B.C. Foster, B.Sc., Ph.D., 1984–1986	Toxicology of mycotoxin-contaminated grains
R. Gopinath, B.Sc., M.Sc., Ph.D., 1984–1986	Urea metabolism in ruminants
J.E. Irwin, B.Sc., Ph.D., 1985–1986	Gene cloning in rumen bacteria
C.A. Kelleher, B.Sc., Ph.D., 1983–1985	Mineral metabolism
J.F. Patience, B.Sc.(Agr.), M.Sc., Ph.D., 1985–1986	Swine nutrition
B. Pawluczuk, B.Sc., M.Sc., Ph.D., 1985–1986	Carcass quality measurement in geese
K.H. Ponzilius, B.Sc., M.Sc., Ph.D., 1984–1986	Embryo splitting and manipulation
J.P. Rushen, B.Sc., Ph.D., 1985–1986	Behavior of swine and sheep in intensive husbandry systems

Graduate students

H.V. Petit, Bacc., M.Sc.	Calf nutrition
J.C. Segura, C.Ing.	Poultry genetics

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[1]Appointed 4 October 1985.
[2]Acting Administrative Officer, Finance, from 5 August 1985.
[3]Seconded from Systems and Consulting Directorate, Finance and Administration Branch.
[4]Seconded from Libraries Division, Finance and Administration Branch.
[5]On transfer of work at the Cellular Genetics Laboratory, National Institute for Research in Agriculture (I.N.R.A.), Toulouse, France, from 29 November 1984 to 1 December 1985.
[6]Seconded to Research Branch, Program Coordination Directorate, since 1 November 1981.
[7]On transfer of work at the Small Animal Breeding Institute, Belgium Ministry of Agriculture, Merelbeke, Belgium, from 1 August 1984 to 1 August 1985.
[8]On education leave at the University of Illinois, Urbana, Ill., as of 21 June 1982 for an indefinite period.
[9]On transfer of work at the Pig Husbandry Department, National Institute for Research in Agriculture (I.N.R.A.), Saint Gilles, France, from 15 August 1984 to 5 August 1985.
[10]Acting Administrative Officer, Finance, from 1 January 1985 to 2 August 1985.

INTRODUCTION

The Animal Research Centre (ARC) is the main location in Canada for breeding and genetics research with dairy cattle, sheep, and poultry. It also has major research programs in biotechnology and in the nutrition of dairy and beef cattle, poultry, swine, and sheep. In addition, studies are under way in the following areas: animal waste utilization and management; dietary utilization of fats and oils; reproductive physiology; trace mineral and vitamin requirements of sheep and cattle; animal behavior in intensive production systems; carcass evaluation; ruminant digestive physiology; pesticide metabolism and residues; and the effects and metabolism of toxic contaminants in animal feeds. There are nine multidisciplinary research program teams composed of scientists with a broad range of scientific knowledge. Both applied and basic studies, directly related to the solution of practical problems, are made by these teams. The major goal of ARC is the resolution of the numerous problems associated with improving the productive efficiency of intensively housed and managed livestock and poultry.

In 1985 research in the new program area of biotechnology expanded with the outfitting of further laboratory space to accommodate proposed projects in tissue culture, cell manipulation, and DNA manipulation for application to studies on genetic resistance to disease. This will support work already in progress in embryo manipulation, genetic engineering of rumen bacteria, and use of tissue culture techniques and hormone assay technology to develop early prediction methods for measuring the potential milk production of dairy cattle.

The effective transfer of research results from the laboratory to the farmer–user continues to receive priority. Research data were published in over 80 scientific and over 55 technical articles. The number of scientific staff members invited to international symposia and conferences remains high. Representative was the visit by Douglas Veira to Venezuela as a member of a technical mission on cattle production and of Jan Gavora to Australia to present data on genetic resistance to disease in poultry. Among over 200 visitors to the research farm, the center was especially honored by the ministerial representatives of the Arab Organization for Agricultural Development, as well as by senior delegations from the USSR, Hungary, Romania, and the People's Republic of China.

The Animal Research Centre continued extensive cooperative research and development programs in Venezuela, Brazil, the Philippines, and Cuba in the areas of dairy cattle and poultry breeding and dairy cattle production research. Under these international programs, visits to sites by several ARC scientists provided opportunities to evaluate national and local needs and to make training and technology transfer more effective.

National and international recognition of excellence in research continued to be received by members of the ARC scientific staff. The Agricultural Institute of Canada presented David Heaney with the certificate of merit of the Canadian Society of Animal Science for his outstanding contribution in the area of sheep production and nutrition. For the second time in 2 years, the institute also gave the co-op feeds young scientist award to an ARC researcher. Douglas Veira received this award for significant studies on beef production and nutrition at ARC and at Kapuskasing Experimental Farm.

The Professional Institute of the Public Service of Canada honored Kenneth Jenkins and Michel Hidiroglou by jointly awarding them the 1985 gold medal for their fundamental research in selenium nutrition and metabolism. This scientific team has made major contributions to the prevention of selenium-responsive disorders that occur in all classes of livestock around the world. The ARC selenium studies have now been recognized by seven awards from three countries.

Major international recognition was also given to the poultry research program. Jan Gavora and Lloyd Spencer of the Animal Diseases Research Institute were presented with the Tom Newman Memorial Award for their cooperative research on disease resistance genetics, with particular reference to control of Marek's disease and lymphoid leukosis. The awarding agency, the British Poultry Breeding and Hatcheries Association, cited their discoveries as being of "great fundamental importance to the poultry industry." This is the third time that ARC researchers have received this honor.

Capital construction and development at the research farm continued with a project to link together structurally two adult sheep buildings. The link will expand holding and operational space for research in the sheep production program. It also will allow proper entry procedures to protect the minimal disease sheep population. Phase I of the major construction for the office–laboratory building was completed. This phase consisted of preliminary site preparation and servicing, an essential step before the main building is erected.

This annual review highlights research for 1985. Some advances that were particularly noteworthy were as follows: a series of synthetic genes have been synthesized and successfully cloned into

Escherichia coli, opening the door for the movement of new genetic material into rumen bacteria; hydrogen sulfide gas was determined to be the main manure gas hazard when under-the-floor slurry pits in livestock barns were agitated or emptied; a major enzyme in the production of methane in the rumen was studied and its mode of action clarified; concentrate feeding for growing dairy heifers can be reduced by judicious use of forage combinations; interrelationships that determine biological availability of liposoluble vitamins in the ruminant were identified; rupturing the cysts of cattle with cystic ovarian disease did not affect subsequent reproductive performance; the breeding of heifers at an early age, coupled with a proper management program, may increase profit for the dairy industry; the usefulness of electronic grading probes for swine has been demonstrated; extensive data have been analyzed to evaluate selection and crossbreeding for dairy cattle, sheep and egg laying, and meat-type poultry; the effectiveness of large-scale programs for eradicating the lymphoid leukosis virus was examined; further research with naked oats indicated their potential as a feed ingredient for poultry; a major block of data is now available on the true available amino acids in poultry feedstuffs; low-cost protein sources, such as soyflour, can replace part of the high cost of milk products in milk replacer formulations for intensively reared lambs; procedures were further improved for using frozen–thawed ram semen, providing greater fertility for sheep that are artificially inseminated; additional data confirmed that vomitoxin residues in feedstuffs are not transmitted through edible animal products such as eggs or milk; the metabolic pathway of the pesticide cypermethrin was determined in poultry; a chick embryo-toxicity bioassay was developed to aid in the identification of toxic compounds in grains and feeds.

Detailed information on the research accomplishments, methodology, and results can be obtained from the publications listed at the end of this report. Reprints of the publications and copies of the report are available on request from the Animal Research Centre, Headquarters Building, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R.S. Gowe
Director

BIOTECHNOLOGY

Genetic engineering of rumen bacteria

Gene-cloning techniques are being applied to rumen bacteria with the objective of increasing the efficiency of feed utilization in the rumen. It is known that rumen bacteria are a major protein source for ruminants. Normally that protein does not contain sufficient amounts of amino acids such as lysine and methionine. As a result, producers include costly concentrates in the rations of high-producing livestock. Genetic changes to improve the nutritional value of rumen bacterial protein would have a far reaching impact. To achieve this goal, a series of synthetic genes have been designed, synthesized, and successfully cloned into *Escherichia coli*. Cloning vectors have been developed that will serve for the introduction of the synthetic genes into rumen bacteria. To examine the regulation of gene expression in rumen bacteria so that effective use of the synthetic genes in them can be achieved, rumen bacterial genes involved in fiber degradation were cloned into *E. coli*.

Since fiber degradation may itself be a limiting factor in ruminant nutrition, the understanding of the expression of these genes can be also applied directly to improving rumen function. Gene banks from the fiber-degrading bacteria *Bacterioides succinogenes*, *Ruminocccus flavefaciens*, and *Butyrivibrio fibrisolvens* have been prepared, and genes specifying the enzymes β-(1–4)-glucanases (cellulases) and β-(1–4), (1–3) glucanases (involved in the degradation of cereal gums) have been identified and characterized. In addition to applications in ruminant nutrition, these cloned genes, or the enzymes they specify, have potential use in other areas of animal nutrition and in industrial utilization of cellulosic wastes.

Embryo manipulation

A new dairy cattle breeding project that integrates conventional procedures such as selection and mating with new techniques including superovulation and embryo splitting has been designed in cooperation with the dairy cattle breeding and production program. Manipulation of genetically superior embryos will lead to substantially faster genetic improvement compared with conventional breeding procedures. Basic principles and technology for embryo transfer are initially developed with mice for later application to dairy cattle.

Heterosis is the difference between performance of crossbred offspring and the average performance of the two parental strains. To exam-

ine heterosis for survival, embryos of mouse strains ICR, C57BL, and their first-generation cross (F_1) were surgically or nonsurgically transferred to each of ICR, C57BL, and F_1 recipients. Embryo survival was generally higher in crossbred recipients and ranged from 0% for C57BL recipients to 35% for ICR and F_1-cross recipients. Crossbred embryos had lower survival than those from pure strains, and the size of heterosis ranged from –8% in ICR recipients to –38% in C57BL recipients. The merit of F_1 cross as recipients varied, depending on the type of embryos used for transfer. Survival rates for surgical and nonsurgical transfer of ICR embryos to ICR recipients were 47.4 and 11.3%, respectively.

Mouse embryos from a random-bred population were bisected microsurgically and transferred surgically. Twins and singletons were born, but success rates were not high, amounting to 4 and 20%, respectively. These twins and singletons were later mated to produce another generation of embryos that are expected to be more viable when treated microsurgically.

Dairy cows, mostly 2 years old, were superovulated with 22–40 mg of follicle-stimulating hormone and 50 mg of prostaglandin $F_2\alpha$. Embryos were bisected, and procedures were developed for micromanipulation and nonsurgical transfer to recipient cows.

Cellular and molecular genetics of livestock

The cellular and molecular genetic research proposed for the program stems from previous ARC work in disease resistance genetics and livestock breeding. Laboratory facilities for this research have been designated, and renovations to accommodate the work have started. Some aspects of the new research involve lymphoid leukosis of chickens, which is caused by a retrovirus. Besides the exogenous lymphoid leukosis virus (LLV) that can integrate DNA, homologous to viral RNA in the genome of infected chickens, there are endogenous proviral genes (*ev* genes) that reside permanently in the chicken genome and can produce an endogenous virus or parts thereof. Some of the 21 known *ev* genes interfere with the bird's ability to mount immune response against LLV. Other possible effects of these genes on productivity and survival need further investigation. Studies conducted in collaboration with the Animal Diseases Research Institute in Nepean, Ont., and the United States Department of Agriculture Regional Poultry Research Laboratory in East Lansing, Mich., showed that the frequency of birds that produced the complete endogenous virus was only 1% among 293 hens of three strains free of the exogenous LLV. However, the group-specific antigen, a component of the endogenous virus, was found in blood or feather pulp of these strains, with frequencies ranging from 43 to 100%. Thus *ev* genes that produce viral components, rather than the complete endogenous virus, are expected to be found when DNA samples are analyzed.

UTILIZATION OF ANIMAL WASTE

Hazardous manure gases

Gas levels of manure were studied in normally ventilated dairy cattle and sheep barns with under-the-floor slurry pits or gutter-scraper systems and in outdoor tanks for slurry storage. When stored slurry was undisturbed, barn concentrations of hydrogen sulfide (H_2S), ammonia, carbon dioxide (CO_2), and methane were mostly within the generally recommended safe limits. However, when the slurry was disturbed, such as during mixing and agitation, H_2S was the main gas hazard in manure. Continuous measurement of H_2S in the barns revealed short-term (about 2–15 min) excursions of up to seven times the time-weighted average threshold limit value (TLV) of 10 ppm. Temporal as well as spatial variation in H_2S concentrations was observed. Concentration peaks substantially above the TLV may go undetected when indicator-type gas detector tubes are used, unless gas concentrations are measured precisely when the peaks of short duration occur. Potentially dangerous concentrations of H_2S (25–100 times the TLV) and CO_2 (up to 3% by volume) were measured in the air above slurries being mixed in outdoor, covered concrete tanks. Concentration of H_2S tended to increase with increased slurry turbulence and temperature.

Effect of manure-cropped systems on soil, crop, and water quality

The long-term effect of various methods of slurry application on crop yield and quality, on the quality of shallow groundwater, and on physical and chemical properties of the soil, continues to be investigated. Slurry applications are made by plowdown in the fall and discing, injection, and sidedressing in the spring. Two additional treatments consisted of a control and a chemical fertilizer application. Groundwater quality has not been substantially different for the various methods of manure application. Nitrate–nitrogen concentration in groundwater has ranged from 15 to 40 mg/L for all treatments. After 3 years of treatments, concentration of nitrate tended to be lowest in the controls and highest in the chemical fertilizer treatment.

Bacterial quality of runoff

Previous data on the bacterial quality of runoff from manured and nonmanured cropland were reevaluated in light of the recently revised (1983) recommended limits for bacterial concentrations in surface water to be used for contact recreation in Canada. The recommended criteria can often be met if the applied manure is incorporated immediately into the soil and the land is relatively level. However, the criteria for bacterial quality are unlikely to be met under prolonged wet weather conditions, especially when runnoff is severe, irrespective of manuring or cropping activity. The fecal coliform group appears to be a better indicator of fecal contamination of runoff from manured land than the fecal streptococcus group.

DAIRY AND BEEF CATTLE NUTRITION

Prevention of methane production in the rumen

The production of methane (CH_4) by rumen bacteria accounts for approximately a 10% loss of gross energy intake. A significant increase in efficiency of energy utilization is obtained when CH_4 production is inhibited. As the intermediates in CH_4 formation become known, specific inhibitors are being designed and tested. The structure of tetrahydromethanopterin (H_4MPT), the principal carbon carrier in methanogenesis, was confirmed by proton and ^{13}C nuclear magnetic resonance techniques. The role of H_4MPT in the transfer of methyl-groups from H_4MPT to coenzyme M (CoM) and then to CH_4 was established by following the kinetics of radioactive carbon transfer from $^{14}CO_2$ to $^{14}CH_4$. The large protein complex that synthesizes CH_4 from CO_2 and H_2 was isolated from methanobacteria and shown to contain a new enzyme, tetrahydromethanopterin methyltransferase, which catalyzes the transfer of methyl-groups from H_4MPT to CoM. In addition, the protein complex contains the enzyme methyl-CoM reductase, which catalyzes the terminal step in methane production. This enzyme is inhibited by a number of substituted CoM analogs, which may be useful in inhibiting methane synthesis in the rumen.

Supplementation of high-moisture grass silage

At the Kapuskasing Experimental Farm male beef calves, initially weighing 250 kg, were fed for 112 days either of two grass silages alone, or supplemented with barley or fish meal at 500 g per head per day. The silages, which were made from primary growth, were direct-cut, treated with formic acid, and stored in horizontal silos. Both silages were well preserved with similar levels of cell wall contents (50%) and organic acids (7%), but produced significantly different rates of liveweight gain (0.86 versus 1.28 kg/day). The only compositional differences that appeared to be related to the difference in growth rate were a lower crude protein content (15.0 versus 19.3%) and a higher level of soluble sugars (7.68 versus 3.74%) in the better of the two silages, respectively. Studies with nylon bags indicated no differences in rates of dry matter or fiber digestion; however, the rate of nitrogen degradation was slower in the low crude protein silage.

Fish-meal supplementation of the silages resulted in substantial increases in growth rate and feed efficiency, which ranged from 20 to 50%, without increasing intake. Addition of barley had no effect. Improvements in liveweight gain between the two silages alone and resulting from fish-meal supplementation were also observed for carcass gain, indicating that changes in gut fill were not the cause of the differences in animal performance.

These findings suggest that when high-moisture, high-nitrogen grass silages are fed to young, growing beef cattle, the first limiting nutrient is probably undegradable protein in the rumen. It is also clear that traditional feeding standards do not apply to these feeds and that more definitive methods are needed to determine protein quality in silages.

Interrelationships among liposoluble vitamins

Using sheep as pilot animals, plasma levels of vitamins A and E showed a transitory decrease following administration of a single massive dose of 5×10^6 international units of vitamin D_3. A large dose of vitamin E (100 mg/kg body weight) reduced plasma retinol (vitamin A) concentrations within 72 h but thereafter returned quickly to near pretreatment levels. The results suggest that in sheep a single massive dose of one of the liposoluble vitamins may impair the utilization of other fat-soluble vitamins.

Vitamin E kinetics

The kinetics of a physiological dose of radiotocopherol administered to sheep was studied using intravenous, oral (capsules), intraruminal, or intramuscular methods of administration. The study indicated that the bioavailability of vitamin E ranked in the following order: intravenous > intramuscular > oral > intraruminal. However, the rate of elimination ranked in the following order: intravenous > oral > intraruminal > intra-

muscular. The kinetic study showed that the intravenous route was best fitted to a three-compartment model, whereas the other routes exhibited a good fit for either one- or two-compartment models.

Forage evaluation

Alfalfa hay baled at 18–31% moisture content (MC) as large round bales showed self-heating. Maximum temperatures ranged from 57.4 to 85°C and were related to initial MC. Deterioration in quality evidenced by an increase in acid detergent insoluble nitrogen (ADI-N) was highly related to the maximum temperature and cumulative degree-days above a reference point of 65°C during the initial 12-week storage. On the other hand, an increase in neutral detergent fiber nitrogen (NDF-N) was highly related to the initial-into-storage MC and cumulative degree-days above a reference point of 35°C. The difference between NDF-N and ADI-N may relate to the rumen by-pass protein.

Application at the recommended level of a commercial mold inhibitor, Hay Treet,® or an equivalent amount of propionic acid to hay baled at 25% MC proved ineffective. Even a concentration of propionic acid that was 10 times higher (0.3% by weight) was of limited value. In the higher treatment, the content of neutral and acid detergent fiber and cellulose was significiantly ($P < 0.05$) lower than with the Hay Treet treatment, and energy digestibility was significantly ($P < 0.05$) higher than with Hay Treet or untreated conrols. Hay baled at 18% MC was significantly ($P < 0.05$) higher in dry matter digestibility (63 versus 59%), energy (61 versus 57%), and crude protein (73 versus 65%) than that baled at 25% when both hays were treated with 0.3% propionic acid.

For rapidly growing heifers between 238 and 350 days of age, concentrate feeding can be reduced from 25 to 15% of the total ration dry matter (DM) by judicious use of forage combinations. A forage diet of hay, haylage, formic-acid-treated alfalfa silage, and corn silage (15:15:30:40 DM basis), supplemented with 25% concentrate, was compared with formic-acid-treated alfalfa silage and corn silage (56:44 DM basis) supplemented with 10% concentrate. Both rations were fed to appetite and resulted in similar average daily gains (0.87 versus 0.88 kg); body weights (299.3 versus 303.5 kg), heart girths (150 versus 151.4 cm), and wither heights (113.2 versus 113.9 cm) at 350 days of age.

Calf milk replacers and essential fatty acids

The calf is born with very low stores of the essential fatty acids (EFA) (linoleic, linolenic, and arachidonic). Many of the fats used in calf milk replacers have low levels of EFA and so susceptiblity to EFA deficiency might be expected. The calf is essentially monogastric until weaned at 6–8 weeks. Depriving monogastric animals of EFA characteristically causes reduced growth rate, scaly dermatitis, pigmentation changes in the skin, and impaired reproduction.

A 6-week study with calves starting at 3 days of age compared the effects of low or adequate EFA in milk replacers on performance, feed utilization, and fatty acid profiles in blood plasma, heart, and liver. None of the calves fed the low EFA diet developed any of the external signs of deficiency seen in monogastric animals. Supplementation of the basal diet of hydrogenated coconut oil with linoleic acid, or both linoleic and linolenic acids, had no influence on weight gains, feed efficiency, or digestibility of lipids, nitrogen, and dry matter. Low EFA intake decreased the resistance of erythrocytes to lysis. In blood and tissue lipids there was a marked reduction of linoleic acid and an elevation of trienoic acid (20: *n*–9), palmitoleic acid, and the ratio of trienoic acid to arachidonic acid, all of which confirm low EFA status.

It was concluded that the newborn calf does not show poorer performance when fed a low-EFA liquid diet to weaning age. However, it does develop the characteristic biochemical signs of EFA deficiency. Although EFA level in milk replacer may not be a practical concern, intake may be more important for longer term consumption (over 3 months with vealer calves) or where stresses are present such as infectious diseases or high environmental temperatures, conditions known to be affected adversely by low EFA intakes.

Copper (Cu) toxicity

The sheep flock was reestablished in 1980 by a hysterectomy procedure. An outbreak of chronic Cu toxicity 10–12 months later caused a high rate of mortality. The toxicity was controlled by decreasing the dietary concentration of Cu from 10–14 to 5–8 μg/g DM and adding molybdenum and sulfur supplements. It was later determined that the flock remained protozoa-free after repopulation. Since the dietary regime was not changed after hysterectomy, experiments determined the association between the absence of rumen protozoa and Cu toxicity.

Two groups of rams were fed a corn-silage-based diet containing soybean meal and copper chloride for 184 days. Copper concentration in the diet was 14–16 μg/g DM. A normal population of rumen protozoa was established in one group, and the other was maintained without pro-

tozoa. The sheep with protozoa ate more feed and grew faster. In spite of higher feed and Cu intake, their livers contained 1.7 times less Cu than those of the protozoa-free sheep (962 versus 1684 μg/g DM, respectively). Based on the mean Cu concentration of 745 μg/g DM in the liver at the beginning of the experiment, the actual increase in Cu concentration was 4.3 times higher in the protozoa-free group than in the group with protozoa. When the total Cu in the liver was divided by the mean daily DM intake, the ratio was 38–50% higher in the protozoa-free sheep than in the others, strongly suggesting a higher rate of Cu absorption in the protozoa-free sheep. This was further supported by observations that with a dietary Cu concentration of 10–14 μg/g DM before 1980, Cu concentration in the liver was only 300–400 μg/g DM as compared with 745 μg/g DM at the beginning of the experiment, despite a much lower dietary Cu concentration of 5–8 μg/g DM.

It was concluded that rumen protozoa play an important role in the prevention of chronic Cu toxicity in sheep through a reduction in the availability and consequent lower hepatic accumulation of excess dietary Cu. Excessive levels of dietary components such as zinc and lipids may significantly decrease the protozoa population in the rumen, thereby decreasing the formation of copper sulfide and increasing Cu availability.

DAIRY CATTLE BREEDING AND PRODUCTION

National cooperative dairy cattle breeding project (NCDCBP)

Improving the efficiency of dairy production through enhanced lifetime performance is the objective of the long-term NCDCBP. The collection of comprehensive lifetime performance records provides the data base for developing optimum breeding strategies. The NCDCBP has several phases, and the ultimate evaluation of the research must await completion of all of them. The final phase of the NCDCBP is now under way. An assessment of genetic progress from collection of later lactation data for comparisons of lifetime performance of pureline and crossline genetic groups is continuing. Matings to corroborate measurements of genetic progress and to use in a new research project have been initiated using semen available from industry.

First-lactation yields of pure lines and various crossline groups have been compared. Records include pure lines, F_1's, second- and third-generation crossbreds, and backcrosses of F_1's to pure lines. Significant heterosis ($P < 0.05$) was evident for protein and fat yield and was nearly so ($P < 0.10$) for milk yield. Yields of F_1's, crossbreds of a later generation, and backcrosses were equivalent and were contrary to the theoretical decline expected in heterosis in later generations of crossbreds. No evidence was found of maternal heterosis or recombination effects.

A new research project to examine ways of using embryo transfer and manipulation technology in breeding programs in the most effective way possible has been developed in cooperation with the biotechnology program. Proposals have been discussed extensively with industry.

Efficiency of dairy heifer growth

Data from the NCDCBP were used to examine genetic and nongenetic effects on efficiency of heifer growth from 6 to 8 months of age. After adjustment to a common 6-month weight, Holstein H-line heifers grew faster than Ayrshire-based A-line heifers (51 versus 48 kg in 56 days). Crossbred C-line heifers were intermediate. Consumption of total digestible nutrients (TDN) from a fixed concentrate allotment and ad libitum roughage feeding was similar for all lines at 201 kg. There was a slightly better efficiency of growth of H-line than A-line heifers, with C lines again intermediate. However, differences were very small. Initial 6-month weight had a negligible correlation with gain, was closely associated with final 8-month weight, but was only moderately correlated with TDN consumption. Gain was lowly correlated with TDN consumption but highly correlated with gain per kilogram of TDN. Differences between research stations, reflecting forage sources and general husbandry, had major effects on initial weight, feed consumption, and growth but much more moderate effects on feed efficiency of growth. Heterotic and maternal effects were negligible. Feed consumption data for a more extended period (birth to 1 year of age) might reveal more information but would be extremely expensive to obtain. It appears that a simple, 8-week feeding trial from 6 to 8 months of age provides limited information beyond that provided by weights and weight gains. Voluntary consumption of roughage, probably closely related to forage quality, appears to be the most important factor in rate of gain and feed efficiency in growing dairy heifers. Bigger heifers eat more and grow more rapidly, particularly with good-quality roughage. Genetic effects not associated with size appear to be of limited importance.

Milk protein polymorphism

A study using 920 head of cattle in the H, A, and C lines of the NCDCBP determined the gene frequencies of genetic variants of milk proteins

and investigated the possible relationships of milk protein types to first-lactation milk, protein, and fat yields. The gene frequencies at the five milk protein loci studied were similar to those reported in the literature. Gene substitution at the α-casein locus showed the greatest effects on first-lactation yields compared with those at other milk protein loci. Unfortunately, the favorable B allele at this locus is almost fixed, a result of long-term selection for high milk production in dairy cattle. Although favorable alleles at β-casein, κ-casein, and β-lactoglobulin loci exerted smaller effects on first-lactation performance than those at the α-casein locus, their moderate frequencies in the current population can be raised to improve lactation yields through milk-protein typing. The combined contribution of the four milk protein loci to phenotypic variance in milk, protein, and fat yields was 8.9, 8.6, and 5.0%, respectively. It appears that associations between milk protein loci and first-lactation yields do exist and thus can be utilized as selection aids for genetic improvement. Lactation performance can be improved through milk protein typing by increasing the frequencies of the B allele at the α-casein locus, the A2 allele at the β-casein locus, and the B alleles at the κ-casein and β-lactoglobulin loci.

Production of early and late bred heifers

To study effects of age at first breeding on subsequent growth, production, and reproduction, 253 NCDCBP heifers were bred at the first heat after 350 days of age (*350* group), and 249 contemporary heifers were bred at the first heat after 462 days of age (*462* group). All heifers had similar feeding and management. The average age at first calving for the *350* and *462* group was 698 and 796 days, respectively. Station and line were significant sources of variation for heifer production traits. Heifers of the *350* group had lower milk, protein, and fat yields at both 168 and 308 days of first lactation than those of the *462* group. However, both breeding groups had similar number of days in milk, suggesting that early breeding reduced lactation yields by decreasing daily production rather than by decreasing the number of days in milk. Neither group differed significantly in yield per day of life to the completion of first lactation. The economic advantage of early over late breeding results from quicker return of income and a saving of rearing cost. Breeding heifers at the younger age, coupled with a proper rearing program, offers a promising approach to increase profit for the dairy industry.

Lactation curve models

Weekly milk yields of 2066 first-, 1407 second-, and 755 third-lactation pure-line and crossline cows from the NCDCBP were used to derive the coefficients of lactation curves by modified gamma and inverse polynomial functions. The inverse polynomial function provided a better fit to the lactation curves than the modified gamma function based on comparison of R^2 values. The presence of additive genetic variation for initial yield indicates that the lactation curve could be raised or lowered by selection, without changing its shape. The shape could not be changed through selection, since there were no significant breed additive effects or maternal effects for its coefficients. Most of the heterosis effects were not significant, indicating very little evidence of nonadditive genetic variation associated with the coefficients of lactation curve.

Extension factors for predicting 305-day protein yield

New extension factors for predicting 305-day protein yield from lactations in progress were estimated using multiplicative and nonlinear model methods. Complete lactation records were used, consisting of 8- or 9-month test-day milk weights and corresponding protein yields from record of performance (ROP) data. Extension factors were derived for the Ayrshire, Guernsey, Holstein, and Jersey breeds for two age groups and four seasons of calving. Multiplicative extension factors for protein yield were developed for interim use until reprogramming in the dairy system is done for the adoption of the nonlinear model method. The nonlinear model method was superior to the multiplicative method, both in terms of bias and standard error of prediction. The use of new extension factors for predicting 305-day protein yield has been adopted by the Canadian Milk Recording Board and will help to produce more accurate evaluations of sires and cows.

Cystic ovarian disease

Cystic ovarian disease is a serious cause of reproductive failure in dairy cattle. Various modes of action are available, such as waiting for self recovery; manually rupturing the cysts with or without drugs; administering hormones; or a combination of the above. It is a concern that rupture of cysts may cause hemorrhaging, resulting in ovarian adhesions or death. Of 1194 calvings in the Ottawa herd of the NCDCBP over 2 years, the incidence of cystic ovaries was 10%. Rupturing the cysts at first occurrence did not affect pregnancy rates, services per conception, or days open, and in no cases did it result in hemorrhaging. When care was exercised on rupturing cysts, there were no detrimental effects to the cow. In fact, this procedure is useful in the accurate diagnosis of cystic ovarian disease.

Relationships between steroid levels and lactation performance

If lactation performance could be predicted from circulatory steroid hormone levels, selection of heifers at an early age would be possible. At ARC new enzyme-linked immunosorbent assays for testosterone and estradiol have been developed which are simpler, safer, and more sensitive than radioimmunoassays. In a study of 99 NCDCBP heifers, androstenedione measured at 130 days of age was the steroid hormone most highly associated with subsequent lactation performance. However, it accounted for only 4% of the variation in milk yield. Progesterone, testosterone, estrone, and estradiol had even smaller relationship to subsequent performance. Hence prepubertal steroid levels appear to have limited practical value in predicting lactation performance.

SWINE PRODUCTION

Mycotoxins

Research is continuing on the effect on pig production of diets contaminated by mycotoxins such as deoxynivalenol (vomitoxin) and zearalenone, and on practicable techniques for reducing their toxicity. Results pertaining to pigs are included in the section entitled "Animal feed safety and nutrition."

Carcass evaluation

Research is developing methodology, based on color reflectance, for the objective identification in pork carcasses of quality deficiencies, such as pale, soft, exudative (PSE) tissue. Two electronic measuring probes were evaluated for their ability to identify PSE at the time of grading, i.e., within 1 h or at 24 h postmortem. Results suggest that identification of PSE pork based on colorimetry is poor at the time of grading and no better than 50% correct at 24 h postmortem. Further research will evaluate other existing grading probes and a recently developed fiber optic probe. Preliminary results from the latter show great promise.

In a cooperative study with a commercial abattoir the effect of preslaughter management on the quality of pork was investigated. The duration of transport, the time between unloading and slaughtering or the resting period, as well as the effect of temperature were the factors monitored. Initial results indicate that the resting period was critical for pigs transported for a short period of time.

Electronic grading of hog carcasses is scheduled to be implemented commercially on 1 April 1986. Studies assessed the operational efficiency of the Hennessy Grading Probe, the Destron PG-100, and the Fat-O-Meater probes and their impact on the Canadian grading system. Results showed that the introduction of electronic grading, together with the use of the probes, will improve the efficiency and accuracy of grading and will create minimal disruption to the grading system.

Behavior and welfare of pigs

Research is continuing on the use of two-level, free-access pens for fattening pigs. The design allows more efficient use of barn space, encourages good pen hygiene, and provides confined pigs with exercise. In earlier work, a small percentage of pigs had shown initial difficulty in adapting to the two-level design. A further experiment showed that these problems could be overcome by confining the animals on the upper level for a few days when they are first moved into the pen. Another experiment indicated that a modified design, intended for future commercial testing, gave good performance figures over the full growing–finishing period of 20–100 kg liveweight.

Tail-biting among pigs is a widespread behavioral problem causing considerable economic loss. The behavior is poorly understood and difficult to study because of its highly variable and sporadic occurrence. In two experiments, pigs were allowed to chew on canvas tail models that were either plain or impregnated with blood. The animals' responses were highly variable and ranged from indifference to persistent, vigorous chewing on the blood-covered models. The response to blood and the individual differences in its expression likely contribute to tail-biting among pigs and help to explain its variable occurrence.

POULTRY BREEDING

Selection and management studies in egg-laying chickens

Four Leghorn strains and their crosses [two-strain (F_1), three-strain, four-strain, and $F_1 \times F_1$ (F_2)] were assessed as part of a heterosis study. The fertility of the pure strains was similar to that of the two-strain cross, although hatchability in the latter was 7% higher. With a strain-cross dam, fertility improved by 4–6%, but a hybrid sire did not affect fertility. Hatchability with three-strain and four-strain embryos improved by 12% from that of the pure strain, and the improvement in F_2

crosses was similar in magnitude at 10%. The difference in hatchability between two-strain and three-strain, four-strain, and F_2 crosses may reflect in part maternal heterosis, namely, a two-strain-cross dam.

Three mathematical models of egg production curves, a gamma-type function, a compartmental model, and linear regression were compared for their ability to predict mean 50-week egg production from egg production records of 16, 20, and 24weeks. Using three Leghorn strains on both a hen-housed and survivor basis, all models were well suited to 50-week production, explaining 82% or more of the variation. However, their abilities varied in predicting 50-week egg production from part records of 16, 20, and 24 weeks. The gamma-type function was not as accurate as the linear and compartmental models, which were similar. Thus, when the model is intended to predict only full-record egg production from a part record, the linear model is the one of choice because of its simplicity and lower cost of utilization.

The relationship between early activity and feed efficiency was studied in three Leghorn strains. Feed conversion was measured from hatch to 27 days of age, and activity at 1, 2, and 4 weeks of age. Males were more active than females. Chicks of the more active strain consumed more feed and had poorer conversion than those of the least active strain. Ranking of strains on feed conversion to 27 days was similar to their ranking on feed consumed per unit of egg mass produced in previous generations.

Genetics of poultry meat production

Synthetic broiler dams were used for four generations to evaluate a selection program. Two lines were selected for high 28-day body weight, high 28–42-day feed efficiency, and, in pullets, hatching egg production to 40 weeks of age. Indices were used to combine individual and full- and half-sib information for the three traits. Progeny of the selected lines were 40 g heavier at 28 days and had a correlated 42-day body-weight increase of about 80 g compared with progeny of a control line. There was also evidence of a small improvement in feed efficiency and slight reduction in abdominal fatness, in spite of increased body size.

The adjustments of the feed consumption of age-constant broilers and the efficiency from 28 to 42 days for differences in body weight during the test were studied using two procedures. For procedure *1*, consumption and feed efficiency data were regressed on initial and final body weights to estimate consumption and feed efficiency as if all broilers had been the same weight during the test. These adjusted values fail to reflect differences resulting from variation in growth rate. The adjusted traits would be appropriate for selection programs where growth rate and one of these traits were being selected. For procedure *2*, data on individual consumption and feed efficiency were corrected by a two-stage regression to those ages at which the broiler attained average initial and final body weights of the population. These values, which are corrected for differences in body weight, retain those differences because of growth rate. The "true" consumption and feed efficiency values were obtained by interpolation within weekly values to adjust data to average initial and final weights of the population. This is an empirical procedure but is used in evaluating other methods. Correlation of estimates for broiler males adjusted by procedure *2* with other estimates (namely age constant), adjusted by procedure *1*, and "true" were 0.22, 0.63, and 0.95 for feed consumption and 0.84, 0.63, and 0.95 for feed efficiency, respectively. Correlations were similar for females. Therefore procedure *2*, which retains differences in growth rate, seems more appropriate for evaluating feed consumption and efficiency.

Carcass fatness

The role of fat in determining dressing percentages expressed as carcass weight excluding giblets as a percentage of fasted, live-body weight was examined. Samples of slow- and rapid-growing strains of broiler chickens were slaughtered at 2-week intervals between 1 and 17 weeks of age. Dressing analyses included either percentage of carcass fat or percentage of abdominal fat as covariates. Neither covariate was an important source of variation in dressing percentage unless abdominal fat was included as part of the carcass weight. In the latter case, regressions of dressing percentage on the covariates were positive. Generally, increases in dressing percentage associated with fatness appear to be a result of greater amounts of abdominal fat being left in the eviscerated carcasses of fatter broilers.

Genetic parameters of percentage of abdominal fat (AF) and very low density lipoproteins (VLDL) in the plasma were studied to assess the usefulness of plasma VLDL in selection programs to reduce broiler fatness. In the control strain and two selected strains studied, heritabilities of AF and VLDL were 0.52 and 0.33, respectively. The phenotypic and genetic correlations between AF and VLDL were 0.31 and 0.61, respectively. The high genetic correlation and moderate heritability supports the suggestion that AF can be reduced by selecting for low plasma VLDL.

Disease resistance genetics

Programs for eradicating large-scale lymphoid leukosis virus (LLV) were initiated in three flocks in 1984. In a Leghorn flock under relaxed selection, 8000 hens in individual cages were tested in 1984. The average incidence of test-positive hens was 10%, and it did not change significantly in 1985. Female progeny were raised in group cages of 75 individuals to 5 weeks, and 25 individuals thereafter. Results of tests for a virus-neutralizing antibody in 1985 supported the findings for group-specific antigen (GSA) and suggested that there was a spread of the virus within but not between the rearing cages. The second flock was a population of 1200 meat-type hens of two unselected control strains and six strains selected for rapid growth, housed in individual cages. In 1984, 8% were test-positive. The progeny were brooded and reared in large floor pens. Tests of the next generation detected GSA antigen in 15% of the females. The third flock consisted of 30 genetic groups of multiple breeds and production types reproduced without selection for production traits, except for seven inbred lines selected for high egg production. The incidence of LLV-infected hens was 15% in 1984, whereas in 1985 it was reduced to 5%. The housing of this flock was similar to that of the meat-type birds. There was no clear explanation for the success in the one flock and lack of success in the two others. As expected, exclusion of dams that tested positive for GSA from reproduction of the flocks did not eliminate all that were congenitally transmitting LLV. Differences among the three flocks in horizontal transmission of LLV may have accounted for the results obtained. The results were similar to those reported by others.

Management and genetics of geese

Geese exposed to 10 h of light and 14 h of darkness (10L:14D) generally lay more eggs with greater fertility than geese exposed to other light regimens. Instead of testing regimens with more than 10 h of light per day, an 8L:16D regimen was compared to the 10L:14D, starting in early February after housing the geese in December under 6L:18D. A synthetic strain was used; this strain was developed from a cross between three breeds (Chinese, Pilgrim, and Hungarian) and a strain of the Chinese breed, both under selection for fertile egg production and other economically important traits. During a 24-week test period, geese exposed to 10L:14D laid more eggs than those exposed to 8L:16D, 53 versus 46 eggs, respectively. Fertility of geese exposed to 10L:14D was also higher, 67 versus 56%, respectively. After a summer molt period, continuation of the light regimens did not result in significant production for either during a 2.5-month test.

Genetics of eggshell quality

Several methods of measuring eggshell quality have been developed and are assumed to be related to egg breakage under commercial conditions. A study determined which methods would be useful to the primary breeder as a selection tool for reducing egg breakage. The heritabilities of shell weight (SW) and specific gravity (SG) were medium at 0.25–0.42, whether measured at 42 weeks of age or at the end of the first laying year, at 68 weeks of age. On the other hand, heritabilities of nondestructive deformation (DFM), compression fracture strength (CFS), and percentage of intact eggs (PI) surviving from hen through the egg washing, candling, and grading were low at 0.03–0.24. Genetic correlations (ignoring sign) between PI and eggshell quality were somewhat higher at 42 (0.71–1.0) than at 68 (0.50–0.83) weeks of age, respectively. However, the genetic correlation between PI at 68 weeks of age and shell quality at 42 weeks of age was high for SW (0.61) but low for SG (0.09), DFM (–0.04), and CFS (0.09). Since breeders would prefer to select their birds at 42 weeks of age rather than at the end of the laying year, SW, the most expensive of the traits to measure, might be the most useful for genetic improvement of eggshell strength.

POULTRY NUTRITION

Feedstuff evaluation

The development of assays to measure bioavailable energy and amino acids in poultry feedstuffs has been completed; however, improvements continue to be sought. A recent improvement was the modification and adoption of a harness that makes possible the collection of excreta free from scales and feathers. The success of the assays is indicated by their use in more than 50 countries. Two hundred and twenty samples of feedstuffs were assayed for true metabolizable energy (TME_n) and for true available amino acids (TAAA). The data are being published. The bulletin will include details of assay methodology and a bibliography of 560 related publications. When published, the TAAA values will be the largest block of such data in the public domain.

Nutrient utilization

Research has focused on the utilization of the amino acid lysine. A surprising observation was

that L-lysine HCl, added to chick diets, was only 91.9 ± 3.6% bioavailable. Questions now arise because many published estimates of lysine requirements are based on the assumption that synthetic lysine is wholly available. An experiment estimated the effect of dietary lysine on chick carcass composition independent of energy intake. The lysine requirement for maximum bodyweight gain was 9.6 g/kg of diet containing 14.3 MJ of TME_n. Protein accretion continued to increase at higher concentrations of lysine. At a fixed TME_n intake, the gain of carcass energy as protein increased and that as fat tended to decrease as dietary lysine increased. At a fixed lysine intake, body weight, protein energy, and fat energy all increased with TME_n intake. The requirement of the chick for lysine varies among response criteria.

Use of naked oats by poultry

Adverse effects of naked oats, cultivar Tibor, on feed intake and weight gain of young chicks at 7–21 days of age, reported earlier, were improved by dietary supplementation of an enzyme to degrade oat glucan and by an antibiotic to control gut microflora. It appeared that low feed intake also resulted, in part, from low palatability because of the liberation of free fatty acids from grain lipids after diet preparation. Further improvements in weight gains and better feed efficiency were obtained by autoclaving and by tempering the naked oats at 30°C for 14 days. A minor problem of mineral availability for starter chicks was identified following dietary supplementation with a chelating agent. Differences in nutrient composition between naked oats of the 1984 and 1985 crop years resulted in small differences in feed efficiency.

Direct measurement of shell strength of hatching eggs

Results from a previous experiment to determine the suitability of the puncture test for measuring directly the strength of shell material of hatching eggs indicated that one or two puncture measurements increased and four measurements decreased the hatchability of eggs from White Leghorn and broiler hens compared with eggs that were not punctured. In a second experiment, puncturing eggs from either White Leghorn or commercial broiler breeder hens one, two, or four times had no significant ($P > 0.05$) effect on the hatchability from either genotype, the decrease in egg weight during the first 18 days of incubation, chick body weight at hatching, or growth during the first 21 days posthatching. The results from both experiments indicate that the puncture strength can be measured directly at one or two sites on the shells of hatching eggs from White Leghorn or broiler hens without influencing subsequent hatchability.

Relationships between laboratory measures of shell strength and breakage of eggs collected at a commercial grading station

Laboratory methods that measure eggshell strength are of value to the industry only if they relate closely to shell breakage under commercial conditions. Few data are available on this relationship for eggs from commercial operations. Correlations calculated from results on shell strength obtained from random samples of 60 eggs with intact shells and data on breakage for 35 shipments of eggs delivered to a commercial grading station indicated that measures of shell quality, such as shell weight, specific gravity, nondestructive deformation, and quasistatic compression fracture strength, do not reflect closely the breakage of eggs during commercial processing because of differences in the ages of the hens that laid the eggs.

SHEEP PRODUCTION

Studies using record of performance (ROP) data

Genetic and phenotypic parameters for daily gain and body weights of Suffolk and Dorset lambs were determined from field data supplied to the federal–provincial ROP program. The paternal half-sib estimates of heritability, computed from 19 400 Suffolk and 14 316 Dorset records, for daily gain from 50 to 100 days of age were 0.47 ± 0.04 and 0.50 ± 0.04, respectively. Corresponding estimates for lamb weights at 50 and 100 days were 0.46 ± 0.04 and 0.43 ± 0.04, respectively, for the Suffolk breed and 0.32 ± 0.03 and 0.47 ± 0.04, respectively, for Dorsets. Estimates of genetic and phenotypic correlations among the traits studied were high and ranged from 0.73 to 1.02. The results indicate that these parameter estimates can be used effectively to derive selection indices and predict breeding values for genetic improvement for daily gain and lamb weights for these breeds.

Development of specialized synthetic sire and dam strains

The paternal half-sib estimates of heritability for the two synthetic strains of dam (which contain from 40 to 50% Finnish Landrace ancestry)

for lamb weights at birth, weaning, 49, and 70 days of age ranged from 0.25 to 0.26. These estimates, based on 6078 lambs and 525 sires were for lambs raised artificially in a controlled environment. The levels suggest that genetic response to selection for lamb weight can be enhanced if lambs are raised artificially, independent of potential maternal effects and competition among litter mates for a fixed quantity of milk. The genetic and phenotypic correlations among the lamb weights ranged from 0.60 to 1.0 and from 0.51 to 0.93, respectively. The moderate to high correlations indicated that selection for body weight at one age should not have an adverse effect on body weight at other ages.

Intensive rearing of lambs

Continuing studies to evaluate and develop milk replacer (MR) formulations at lower cost have shown that lambs perform equally well when raised artificially from birth to 21 days of age on MR in which all the protein was provided by spray-dried milk products or on MR in which 33% of the milk protein was replaced by soyflour. Although postweaning weight gains were marginally lower among lambs from larger litters fed MR containing soyflour, it is evident that protein sources of lower cost can replace at least part of the high-cost milk products in MR formulations.

The teat-suckling behavior of lambs is being studied to reduce the time required to teach lambs to suckle independently in an artificial feeding system. Experiments have confirmed that lambs accept teats based principally on softness and length. A screening of eight commercially available teats has identified two designs that are more acceptable to the lambs than the teats now in use in the ARC system.

Reproductive physiology

Breeding ewe lambs. Data from 2776 ewe lambs were analyzed to evaluate the effects of breed–strain, season, age, and liveweight at breeding on the reproductive performance of lambs raised in a controlled environment. The lambs were bred at 6.5–7.5 months of age during January, May, or September by synchronization of the estrous cycle and exposure to rams at the synchronized and follow-up estrus. Least-square means for fertility and fecundity were 43% and 68%, respectively. These parameters were highest for lambs of the Finnish Landrace breed, intermediate for the two synthetic dam strains, and lowest for the synthetic sire strain and the Suffolk breed. Increased age and liveweight at the synchronized estrus had a significant and positive influence on reproductive performance. Moreover, reproductive performance was higher when lambs were bred in January rather than in May or September. Thus, breed, age, liveweight at breeding, and to a lesser extent season, can influence the lambing outcome of breeding ewe lambs raised in a controlled environment.

Artificial insemination. Procedures are being developed and improved to retain the survival and fertilizing capacity of frozen–thawed ram semen. Rapid cooling of semen from 30 to 15°C after extension in a Tris-fructose diluent had little or no effect on spermatozoa survival and motility before freezing or after freezing and thawing. However, rapid cooling of extended semen from 30 to 10, to 5, or to 0°C was accompanied by a progressive decrease in spermatozoa motility and percentage of intact acrosomes before freezing and a decrease in spermatozoa motility after freezing and thawing. The addition of egg yolk (20% v/v) to the Tris-fructose diluent had a beneficial effect on spermatozoa motility, particularly after the semen was cooled to 10 or 5°C. From a practical standpoint, initial dilution and rapid cooling of semen to 15°C will reduce the processing time for freezing semen. Also, the time of exposure of spermatozoa to high temperatures will be reduced, which could have a beneficial effect on lifespan and fertilizing capacity.

The routine processing for freezing and thawing ram semen has been modified as a result of recent studies. Semen to be frozen is extended initially in a Tris-buffered fructose-egg yolk diluent at 30°C and cooled slowly at 0.3°C/min to 5°C. It is then extended further by the gradual addition of a Tris-buffered diluent containing glycerol and a dextran-sugar combination. After transfer to 0.5 mL straws and equilibration at 5°C for a further 2 h, the semen is frozen using a programmable freezer at a rate of 20°C/min to –100°C before it is plunged into liquid nitrogen. Semen is thawed by immersing the straws in a water bath at 60°C for 8 s. In preliminary trials, the fertility of ewes inseminated with semen frozen and thawed as described was 72% compared to 40% for ewes inseminated with semen processed by the procedure currently in use.

Manipulation of photoperiod. Evaluation of the long-term effects of artificial photoperiods on testicular function of rams is continuing. These photoperiods alternated 4 months of short days (8 h of light and 16 h of darkness) with 1, 2, or 4 months of long days (16 h of light and 8 h of darkness) and continuous short days. Biweekly measurements of blood hormone levels (LH, FSH, prolactin, and testosterone), scrotal size, and semen parameters such as spermatozoa motility and concentration, seminal plasma fructose, and citric acid levels monitored the re-

sponses to the various photoperiods. Except for rams exposed to continuous short days, each parameter exhibited rhythmic cycles of maximum and minimum activity, which corresponded to the combined number of months of short and long days in a repeating photoperiod. However, the shorter the exposure to long days the less pronounced were the changes. In rams exposed to continuous short days the prolactin levels remained depressed, testosterone and FSH levels remained elevated, fluctuations in the scrotal size were minimal, and semen quality remained high. Moreover, there was no evidence to indicate that continuous exposure to short days were photorefractory. The results indicate that low levels of prolactin stimulate testicular function in rams, whereas high levels have an inhibitory effect.

ANIMAL FEED SAFETY AND NUTRITION

Fats and oils

On 28 January 1985 the United States Food and Drug Administration gave GRAS (generally recognized as safe) approval to canola oil with a maximum limit of 2% erucic acid. This action permits the use of canola oil in all U.S. food products and in those of many other countries that adopt the U.S. food regulations and standards. However, canola oil was restricted for use in infant formulas because of a lack of experimental data on canola oil consumption from birth to weaning. Studies are under way to evaluate the use of canola oil in infant formulas to possibly remove this restriction.

A method was developed to quantitate small amounts of complex lipid mixtures using the Iatroscan. Molecular species within a lipid class were found to separate on the chromarod. The technique of impregnation with $CuSO_4$ resulted in a uniform response, but the development solvents had to be modified to overcome metal binding to unsaturated lipids. The method gives reproducible and accurate results.

Studies have shown that dietary oils low in saturated fatty acids reduce saturates in the phospholipids of the hearts of rats within a period of 1week. Continuous exposure to such dietary oils for an extended period of time was highly correlated to increased incidence of myocardial necrosis. The results provided evidence that the incidence of heart lesions observed in rats is basically a nutritional problem. However, in humans low dietary saturates would be a desirable component in a mixed-fat diet, which is usually high in dietary saturates.

An experiment with swine determined the effect of maternal diet on fetal development, and fetal organ and body fat composition. Sows were fed diets containing either no added fat or a diet containing a fat high in saturated fatty acids or polyunsaturated fatty acids from day 57 of gestation. The type of diet did not affect sow growth or number of fetuses. The weight of fetal organs and their total fat content did not change when the sow's diet was changed. Most lipid components of fetal hearts, livers, lungs, and kidneys were unaffected by the maternal diet, although changes were noted as the fetuses developed in utero. The results suggested that the total lipid and lipid subclass composition of fetal organs is precisely fixed and that changes in maternal diet may not affect this composition.

Mycotoxins

Results of feeding trials using purified deoxynivalenol (DON) in a dose–response study indicated that swine are very sensitive to the toxin. Reduced feed intake and weight loss were the only serious toxic effects at DON levels of up to 20 mg/kg. The pigs eventually accepted low levels of DON in their feed, but required several weeks for adaptation to take place. The dose–response data for purified DON in swine diets demonstrated that toxicity observed at low concentrations of DON is probably due to the presence in the diet of other toxins acting alone or in combination with DON.

Radiotracers used to determine the metabolism of DON indicated that residues were not transmitted through milk of lactating sheep or to edible tissues of poultry. When DON was consumed at higher dietary levels of 20 mg/kg some accumulation in eggs from laying hens did occur. These egg residues rapidly decreased once the contaminated feed was removed. More than 75% of the DON was efficiently absorbed when fed to swine, but, as with sheep and poultry, systemic DON underwent rapid elimination from the animal.

The presence of a propionate-based feed preservative did not alter the toxicity of a swine diet containing corn inoculated with *Fusarium graminearum*. The data suggested that addition of the preservative improved the performance of swine offered control and DON-contaminated diets.

Results indicated that if *Fusarium* contaminated grain must be fed to swine the grain should be diluted or blended to give dietary DON levels of less than 2 mg/kg and supported with good management practices. When the diet of pigs was changed from a clean to a DON-contaminated diet, a 1–2 week period of adjustment was observed before pigs returned to normal per-

formance. However, when DON-contaminated diets were gradually introduced over several weeks, a much more prolonged recovery period resulted. This recovery period was observed in all feeding trials and was considered to be due to adaptation to contaminated feed. A double cross-over study has shown that the mechanism that operates in the recovery is not learned or memorized because reexposure to the contaminated diet resulted in a further period of reduced feed intake and weight loss. Although compensatory growth was evident when animals were fed clean grain, a constant switch between clean and contaminated grains reduced performance.

A chick embryo assay was established to test the relative toxicity of the trichothecene toxins found in Canadian grains. The assay will be used to identify the presence of other toxic metabolites in grains infected with *Fusarium*.

In a field study grain was inoculated with various endogenous species of *Fusarium* mold to determine if other toxic chemicals were produced by the mold. Moniliformin and Fusarin C were both formed, indicating that these toxins may also be endogenous in contaminated grain. Further analytical work on a sample of physically damaged corn in the field, which mimicked bird-damaged corn, identified the presence of nivalenol, DON, culmarin, and possibly other trichothecene toxins, such as T-2 and HT-2.

Pesticide metabolism

**Deltamethrin*. Initial studies as part of an industry–government cooperative project on the metabolic fate of deltamethrin in dairy cattle were completed. Lactating dairy cows were given an oral dose of 10 mg/kg body weight of ^{14}C-labeled *gem*-dimethyl or benzyl deltamethrin for 3 days. Analyses demonstrated that deltamethrin was poorly absorbed but that which was absorbed was extensively metabolized and excreted in the bile and urine with little accumulation in major edible tissues. Approximately 36–43% of the ^{14}C was eliminated within 24 h.

Cypermethrin. Studies in laying hens were completed on the fate of radiolabeled racemic cypermethrin, *cis* and *trans* isomers of 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid. The amount of individual compound dosed per hen per day was approximately 7.5 mg, equivalent to a consumption of about 75 mg/kg of feed, each day for 3 days. Radiocarbon was eliminated rapidly in excreta. Tissue residues were generally very low, with the exception of fat depots. The data indicate that proper use of cypermethrin in poultry production should not produce unwanted residues in eggs and edible tissues.

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INTRODUCTION

This report summarizes highlights of research carried out during 1985 at the London Research Centre in support of departmental objectives in environmental quality and crop protection. The center was established in 1951 to investigate the problems created by the introduction of synthetic organic pesticides. Present research programs reflect the current health and environmental concerns regarding the agricultural use of pesticides by concentrating research efforts in integrated pest management (IPM) and environmental toxicology.

The IPM objective comprises four research activities. The pest management activity is aimed at developing IPM procedures, including biological control, for agriculturally and economically important insect pests. Research on stored products is directed toward the investigation of environmental and insect resistance problems and the development of more efficient fumigation procedures leading to a minimum of pesticide residues. The third activity concerns research on alternative pest control strategies. Studies on insects are aimed at identifying specific areas for attack so that pest control in the future will not rely upon the use of broad-spectrum toxicants. Research on natural plant defense mechanisms in disease-resistant and susceptible agriculturally important crops has the objective of using natural defense mechanisms by biotechnology, chemical manipulation, or the breeding of resistant varieties. The last activity under the IPM objective concerns research on systemic fungicides. Studies are carried out on the efficacy of systemic fungicides and on the plant pathological, biochemical, biophysical, and structural parameters of fungicide activity and resistance.

Research on environmental toxicology has three areas of activity. The first deals with the effect of pesticides on nontarget soil invertebrates and agriculturally important soil microorganisms. The second is concerned with the determination of the behavior, persistence, and environmental fate of pesticides and their movement through the environment. The third is concerned with establishing the mode of action of growth regulators and toxicants by carrying out studies on insects and plants related to the vital processes of growth and development.

This report records only the highlights of our accomplishments for 1985; more detailed information can be obtained from the publication titles listed at the end of the report. Copies of the 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

Biological control of the onion maggot

Further progress was made on feasibility studies aimed at incorporating biological control using parasites and predators in an integrated pest management program.

Over 10 000 laboratory-reared, marked predatory adult beetles, *Aleochara bilineata* (AB), were released in onion fields at Thedford. Activity and dispersal behavior of the beetles were monitored twice-weekly over several weeks. The complex and large data set is currently undergoing statistical analysis.

Remarkably different collection patterns of another onion maggot dipteran predator, *Coenosia tigrina* (CT), at two different onion fields at Thedford suggested that certain species of annelid worms are highly preferred as hosts by larval CT. This would have a bearing on CT field distribution, and hence on its effectiveness for controlling onion maggot. Toxicology studies have also established that most insecticides are quite toxic to CT.

The feasibility of using *Entomophthora muscae* as a biological control agent for root maggots and house flies received further consideration. *Entomophthora muscae* is now being successfully cultured in vivo using a technique developed at the University of California; some progress is being made on the development of an in vitro culture method. Two hundred and twenty-five in vitro strains of *E. muscae* were isolated from London, Thedford, and California. Tests on the vigor and pathogenicity of the isolates indicated that 80% of the London strains showed good infectivity and 30% had quick infection capability. Optimum conditions of temperature and humidity for conidia germination were established.

Monitoring

Two versions of a new pheromone trap in Canada were evaluated against the currently used

sticky trap and the Hara funnel trap. The new Multipher® pheromone trap was shown to be more effective for the fall armyworm and the variegated cutworm and will now be introduced into the pest-alert program. These new traps, however, were not as effective as the standard sticky trap currently being used for the common armyworm and black cutworm.

The province-wide cornborer–cutworm monitoring program, run jointly with the Ontario Ministry of Agriculture and Food, provided weekly reports to extension specialists and processing-company field personnel. The inclusion of information on cutworms was timely and an important addition for the growers.

Monitoring of crucifer pests in rutabagas under grower conditions has proven feasible. Yellow pan traps baited with allylisothiocyanate (ASCN) pick up the beginning of the second and third generations of cabbage maggot, even when populations are low because of insecticide pressure. This allows the grower to better control the insect population. The procedure also monitors aphids, which may be important in the transmission of turnip mosaic virus from winter canola to rutabagas.

Resistance–enhanced microbial degradation

In 1985 increased emphasis was placed on research on enhanced microbial degradation, since erratic insecticide control or resistance problems may, in fact, be caused by this phenomenon.

Evidence was obtained indicating that microbial populations in the soil had developed the ability to rapidly degrade isofenphos, carbofuran, trimethacarb, and fensulfothion. Laboratory studies indicated that insecticide degradation in "active" soil was dependent on formulation and application rate, soil type, and climatic factors. Cooperative studies with the St. John's and Vineland research stations and Ohio State University indicated that the failure of recommended control measures for cabbage maggot, carrot rust fly, and turf insects (Japanese beetle, grubs) was due to enhanced degradation rather than to the development of insect resistance to some of these recommended insecticides.

Cabbage maggot from Newfoundland gave no indication of resistance development to fensulfothion, carbofuran, or chlorfenvinphos, but only the last is still providing effective control. Subsequent tests indicated that soils from farms where pupae were collected had adapted to fensulfothion or carbofuran but not to chlorfenvinphos. No evidence of organophosphorus or carbamate insecticide resistance was detected in carrot rust fly collected from the Holland Marsh in Ontario; soil adaptation to rapid degradation of carbofuran was demonstrated.

Tests on Colorado potato beetle (CPB) strains from Thedford Marsh in Ontario indicated resistance to pyrethroids, but not to carbofuran; a strain from eastern Ontario was susceptible to carbamate and pyrethroid insecticides. Laboratory experiments indicated that piperonyl butoxide had little effect on the toxicity of deltamethrin to insecticide-susceptible or insecticide-resistant CPB strains or on the toxicity of fenvalerate to the insecticide-susceptible strain. However, piperonyl butoxide had a marked effect on fenvalerate toxicity to pyrethroid-resistant CPB. No evidence of further development of organophosphorus (OP) resistance was detected in a Michigan onion maggot strain.

Evaluation of pesticides

Several experimental insecticides were evaluated in primary or secondary laboratory studies or in microplot field tests for spectrum of activity, toxicity, or persistence in soil. Three chemicals, DOWCO 429x, PP993, and SD208304 continued to show good to excellent potential as soil insecticides with moderate persistence in soil. A comprehensive 3-year study on persistence of corn root worm insecticides in soil was continued. Although persistence varied from year to year, e.g., chlorpyrifos residues remaining in soil after 8 weeks ranged from 4 to 9% of the initial application, retreatment of the same soil each year did not appear to be a factor affecting the persistence of terbufos, phorate, disulfoton, chlorpyrifos, or fonofos.

A study on temperature–toxicity effects on onion maggot (OM) was completed. In general, currently recommended OP insecticides showed slight positive temperature coefficients of toxicity. Pyrethroid insecticide toxicity was negatively correlated with temperature, with some materials being one-sixth as toxic at 32°C as compared with 15°C. Similar studies on parasites and predators are nearly complete.

Field microplot studies verified the effectiveness as seed dressings of the OP insecticides trichloronate, chlorfenvinphos, and fonofos, and the growth regulator cyromazine, for control of first-generation OM. Cyromazine and the OP insecticide SD208304 were also as effective as seed furrow granular treatments as was the recommended standard, chlorfenvinphos. Harvest assessment showed that control of second-generation OM damage by all of the above treatments was promising, particularly at the higher rate of application.

Laboratory experiments showed chlorfenvinphos 5G incorporated into organic soil to be quite safe to first-instar larval *Aleochara bilineata* (AB). All other tested insecticides (fonofos, chlorpyrifos, ethion, and PP993) were much more toxic to this parasitic stage of AB.

Crop loss studies

The final year's data were obtained on crop losses in processing tomatoes. Over 2 years, plots that received the complete pest control program yielded 50.7 t/ha. When no pesticide was used, yield was reduced by 43.6 t/ha—a loss of 84%. In the absence of herbicide, a 79% reduction attributable to weeds occurred, whereas in the fungicide-free plots a 19% reduction in yield could be attributed to diseases. In the 2 years of the study insects were not a problem, and no insecticides were used.

Insect rearing

A vigorous insect-rearing program is a vital component of integrated pest management research. Development of successful techniques for rearing potential biological control agents is a prerequisite for inundative field release. Many insecticide-resistant and insecticide-susceptible strains are maintained and made available to other laboratories.

Twenty-eight separate strains of insects representing 11 individual species were processed through the 1985 rearing program. Fully adequate numbers of insects were produced for a variety of experiments in microbiology, toxicology, economic entomology, and insect biology. The largest single requests were for 350 000 onion maggot (OM) and 225 000 house fly adults for continuing studies on *Entomophthora* by microbiology; 30 000 Colorado potato beetle (CPB) adults for toxicology; and 110 000 *Aleochara bilineata* (AB) adults for release in a small-scale integrated management program for OM on the Thedford–Grand Bend Marsh. Further improvements to the mass-rearing program for *Coenosia tigrina* (CT) permitted increased studies on the biology and toxicology of this important OM predator. Seven field cultures were received and successfully reared for resistance screening tests. Twenty-six separate shipments of insects were made to a variety of government, university, and commercial laboratories across the country as well as to England, the Netherlands, and the United States.

An 11-month study on long-term cold storage for AB showed that storage for up to 8 months is possible with >75% survival of diapausing larvae. The calculated threshold temperature for egg development in AB was 4.2°C; for development from larvae–pupae the temperature was 5.7°C. An attempt to determine the stimulus for oviposition in AB gave confusing results; more work will be done. Diapause induction studies in CT showed induction in newly hatched larvae, not eggs or parents. Temperatures <10°C produced more intense diapause; larvae survived for at least 2 weeks at –5°C and can be stored as long as 6 months at 1°C. The native earthworm, *Dendrodrilus rubidus*, was found to be a satisfactory host for CT. At 22°C, female CT produced an average of 16 eggs per female; average survival from egg to pupa was 45%. Increasing density in adult cages beyond eight females per 0.028 m^3 significantly reduced egg production.

STORED PRODUCTS

Investigations on the uptake and action of phosphine on the red flour beetle, *Tribolium castaneum*, have shown that in insects treated with $^3PH_3$ most of the radioactivity (98%) is found in the soluble fraction of the homogenate, with the mitochondrial and microsomal fractions containing negligible activity. Tests on the enzyme catalase showed that both bovine liver catalase and insect catalase were inhibited in vitro by phosphine. In vivo catalase activity in phosphine-treated insects was found to be inhibited up to 31% in susceptible insects, and there was no significant difference in enzyme activity between susceptible and resistant insects.

Studies on the isolation and identification of reaction products formed in commodities treated with methyl bromide ($^{14}CH_3Br$) were continued, with most attention directed toward the characterization of volatile substances resulting from alkali-induced decomposition. Methyl bromide readily methylated methionine, and when corn heated with methyl bromide was heated with 1 *N* NaOH, over 40% of the radioactivity could be removed by slow distillation. Some of this volatile fraction was determined to be dimethyl sulfide, but evidence was also obtained for the presence of other labeled substances. To help in the development of an understanding of the nature and source of these volatile materials from treated corn, [*methyl*-^{14}C]methionine sulfonium bromide and *S*-[*methyl*-^{14}C]cysteine have been prepared. The evidence accumulated to date indicates that methionine is a major site of methylation when corn is fumigated with CH_3Br.

Methodology was developed for the analysis of ethylene down to the picogram level using a portable gas chromatograph. This level of sensitivity enables studies to be carried out on ethylene production in stored apples.

ALTERNATIVE PEST CONTROL STRATEGIES

Plant diseases

Research in this area is directed toward obtaining an appreciation of the basic processes in plant–pathogen interactions in resistant and susceptible crops. The potential benefits of these studies would be the ability to activate the plants' natural defence mechanisms and to provide guidelines for breeding for genetic resistance.

Research aimed at examining specificity, recognition, and phytoalexin production in the soybean–*Phytophthora* system was continued. A study of the production of glyceollin isomers I, II, and III in roots, hypocotyls, cotyledons, and leaves of the soybean plant has been completed. Roots produce glyceollin I almost exclusively, and leaves produce mostly glyceollin III. Proportions were influenced by exposure to light and by the development of resistance and susceptibility. As all three isomers arise from a common precursor, the final two steps in their synthesis must be finely and separately controlled.

The glyceollin isomers were obtained in a highly purified form by HPLC and TLC separations (a new extinction coefficient was obtained for glyceollin I), and methods were developed for their bioassay in small quantities. The differential toxicity of the three isomers was established for the first time, glyceollin I being twice as toxic as the other isomers to growth of *Phytophthora*. The development of resistant strains was also demonstrated; however, these did not have enhanced pathogenicity.

The expression of resistance and susceptibility to *Phytophthora* in leaves has been studied further; however, attempts to develop an assay using a wide range of conditions and inoculation procedures have not been successful. This failure appears to be due primarily to variability between pathogen races, and although one race can be assayed at a time, it has not been possible to augment the procedure so that many races can be compared. Demonstration of major gene resistance in leaves and the production of glyceollin in response to fungal infection has not been achieved previously. Of particular interest was the finding that immature leaves, even on resistant plants, are susceptible. This provides an excellent experimental system for determining factors that they lack or that can be added to them for resistance to develop. A wide range of materials have been tested, including precursors of glyceollin, salts, amino acids, sugars, and hormones. Of all these compounds only glucose has been found to have any effect with regard to inducing resistance.

Twelve virulence mutants of *Pseudomonas syringae* pv. *tomato* were generated by transposition Tn*5* mutagenesis. Each mutant was the result of a unique single-site Tn*5* insertion into the genome of the pathogen. Physical and genetic tests indicated that these mutations were very stable, with secondary transposition occurring at an extremely low frequency. These mutants should be useful not only in the physical and genetic mapping but also in the cloning and sequencing of *P. syringae* pv. *tomato* pathogenicity genes.

A solid phase immunoassay was adapted for detection of bacterial and fungal antigens. The technique is rapid, inexpensive, sensitive, and can be performed with only minimal training. It has been used for serodiagnosis of plants infected with *Verticillium* wilt, as well as for the detection of bacterial pathogens in pear, tomato, and pepper.

Incubation of total DNA from a cycloheximide-resistant mutant of *Fusarium graminearum* producing zearalenone with protoplasts of a nonzearalenone-producing cycloheximide-susceptible isolate of *F. culmorum* resulted in some isolates of *F. culmorum* that produced zearalenone and were cycloheximide-resistant. The results suggest the transformation of *F. culmorum* by the genetic factors responsible for these traits from *F. graminearum*.

The biosynthesis of the bacterial toxin pyoluteorin has been clarified and has led incidentally to the isolation of a new, biologically active metabolite of a complex and apparently unprecedented structure. Further stress compounds have been obtained from eggplant, giving further support to the generalization that the bicarbocyclic stress compounds of the Solanaceae are either eudesmanes or are derived from eudesmanes by molecular rearrangements and that they contribute to a definition of the molecular locus at which normal metabolism is diverted to abnormal metabolism. Previously accepted concepts regarding the stereochemistry of the biosynthesis of the important cotton metabolite gossypol have been shown to be incorrect.

Insect pests

Research in this area is directed toward gaining an understanding of basic life processes peculiar to the insect so that methods of selective, specific control can be developed that do not rely upon broad-spectrum toxicants.

Work continued on the biochemical control mechanisms associated with the insect molt–

intermolt cycle. The major effort in this area during 1985 was on the development of improved methodology to isolate labile compounds. The objective was to separate and identify important components from crude tissue extracts. A new system of high performance liquid chromatography (HPLC) was used to effect these separations on the basis of ion exchange or molecular exclusion, or both. The main advantage of such a system is the speed with which the separation takes place, a very important parameter considering the extreme lability of the components of interest. During the course of this work a new sample-loading method was developed that was shown to increase the resolution of all ion exchange columns used in HPLC.

Studies showed that the postproline carboxypeptidase in cockroach hemolymph had a pH optimum of about 6.0 but was still capable of degrading proctolin up to at least pH 7.6. Other workers studying the inactivation of proctolin at pH 7.2 failed to observe the action of this enzyme because the tetrapeptide resulting from initial cleavage of proctolin was very rapidly degraded further in the absence of added inhibitors. Preliminary results indicate that a new proctolin analog, H-Arg-Phe(p-Me)-Leu-Pro-Thr, has high activity on the cockroach hindgut. Studies have confirmed the usefulness of Millipore Norganic resin for first-stage purification of pharmacologically active components from cockroach tissues.

ENVIRONMENTAL TOXICOLOGY

Environmental fate of pesticides

Work directed toward determining the movement and persistence of pesticides in the environment was continued. This was the second year of the field-leaching studies. The number of soil cores was increased from 36 to 96 and the types of apparatus were increased. This year both persistence and leaching data were obtained from the soil cores. Although amount of precipitation was less during the summer months, significant amounts of aldicarb sulfoxide and sulfone were leached through 75-cm soil cores. In contrast, metolachlor exhibited little movement and relatively short persistence in the soil cores. Laboratory adsorption, desorption, and persistence studies were completed for the herbicide alachlor. Again this year, granular chlorpyrifos exhibited unusual stability in the leaching soil core units. It is believed that the application technique (layered application 2.5 cm below the surface of the soil) may have minimized volatility losses and perhaps, for some unknown reason, may have inhibited microbial degradation. Further studies are planned to further investigate this anomaly.

Analytical methodology was developed for the analysis of four pyrethroid insecticides—permethrin, cypermethrin, fenvalerate, and deltamethrin in natural waters at the parts per trillion level (ppt, 1×10^{-12} g). This level was chosen because environmental toxicologists believe these materials may be toxic to certain aquatic organisms at this level. It was also believed that adequate methodology at this level did not exist. The work carried out demonstrated that analysis of permethrin, cypermethrin, fenvalerate, and deltamethrin at 1 ppt in natural water can be achieved. The amount of cleanup of the extracts that is required is related to the desired detection level. Analysis at 100 ppt could be done on raw water extract. Cleanup on Florisil permitted analysis at 10 ppt or lower, depending on the particular pyrethroid and the acceptable level of interference. Further cleanup by HPLC permitted interference-free analysis at 1 ppt and possibly lower, if required. Obviously, the lower the limit of detection required of the analyst, the more costly each analysis becomes. Requirements for a level of detection of the order of 1 ppt should be fully established before resources are committed.

Results from a study comparing the method of sampling currently in use for our field microplots with a more acceptable statistical procedure demonstrated that both methods gave identical results for disappearance curves over a 4-week period. The method currently used reduces the analytical cost by 50% at the expense of not providing a standard deviation.

Pesticide toxicity and mode of action

Research continued on the mode of action of the herbicide glyphosate. Certain phenolic compounds, such as 2,6-dihydroxyacetophenone, *p*-coumaric acid, caffeic acid, and ferulic acid, protected plants from glyphosate inhibition of growth to a varied degree, depending on the concentration of the chemicals and the plant species. The phenols also inhibited the metabolism of indoleacetic acid (IAA), particularly the formation of conjugates with L-aspartic acid and L-glutamic acid. These results support the hypothesis proposed in earlier reports that the effect of glyphosate on IAA metabolism is related to glyphosate-induced changes in the matabolism of phenolic compounds in plants. The promotion of IAA metabolism is an important link between the action of glyphosate in the shikimic acid pathway with subsequent inhibition of phenolic compound synthesis and certain observed symp-

toms such as the inhibition of growth, the promotion of lateral shoot development, the decrease of ethylene production, the promotion of senescence, as well as other responses known to be influenced by the hormone IAA.

A basic requirement of the effective use of pheromones in IPM is the development of an understanding of pheromone reception systems in insect antennae. Electrophysiological studies on antennal responses (EAG) of the European corn borer to pheromones continued. The EAG response is assumed to be the summation of bioelectrical activities generated by many olfactory receptor cells responding to odor stimulants. Most studies on bioelectrical activities have been at the level of the receptor unit in a sensillum rather than the summation aspects of EAG responses. Previous work here has led to the proposal of an equivalent circuit diagram, including a mechanism for generating the local EAG characteristics. During the past year, further support for the above proposal and mechanism was obtained. Studies of the variation of amplitude and shape of receptor activities under the influence of polarizing currents demonstrated that the EAG response amplitude evoked by a pheromone increased when the receptors were polarized by a current flowing through the receptor. As expected, the amplitude was reduced by a current flowing in the opposite direction.

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Departure

J.M. Elliot, B.S.A., M.S.A. Deceased 9 January 1986	Soil science

[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On work transfer to Ottawa Research Station.
[3]Provided by the Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers' Council.
[4]Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Delhi Research Station conducts a multidisciplinary research program in support of the flue-cured tobacco industry in Ontario, Quebec, and the Atlantic region. Basic research in genetics, chemistry, biochemistry, and physiology is conducted in support of mission-oriented research. Engineering research on energy utilization and mechanization is conducted by the Delhi Engineering Research Group (DERG), which is jointly funded by the Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers' Council. A new crops program is currently directed toward alternative or rotational crops for the sandy soils of the tobacco area.

Words cannot express our sense of loss with the passing of our good friend and fellow worker, Jim Elliot, on 9 January 1986. Jim was well known and respected for his work on tobacco nutrition and nematode control.

Reprints of research publications and copies of this report are available from the Research Station, Research Branch, Agriculture Canada, P.O. Box 186, Delhi, Ont. N4B 2W9.

P.W. Johnson
Director

TOBACCO PRODUCTION

Seedling production

Forking or clipping treatments in seedbeds reduced seedling size and weight but resulted in a higher proportion of root to shoot. Seedlings hardened in this way flowered up to 5 days earlier in the field and tended to have higher grade indices, yields, and crop returns than unhardened plants or plants hardened by water reduction only.

Muck top-dressed with about 0.75 cm of vermiculite resulted in a higher survival rate of seedlings than muck alone or muck mixed with different amounts of commercial peat-based media. The top dressing of vermiculite enhanced seed germination and reduced amount of loss of young seedlings from tipping-over.

Fertilization

The yield of flue-cured tobacco varied with fumigant nematicides applied 3 weeks prior to transplanting but not with the form of nitrogen applied at transplanting. Comparison of 100% urea-N, 100% NH_4^+-N, 75% NH_4^+-N plus 25% NO_3^--N and 50% NH_4^+-N plus 50% NO_3^--N as forms of nitrogen showed that the rate of nitrification in the soil was influenced by the type of fumigant nematicide only and not by the form of nitrogen. Fumigant nematicides slowed the conversion of soil NH_4^+-N to soil NO_3^--N for a 6-week period after transplanting. Chloropicrin-containing fumigant nematicides had the greatest effect and produced higher tobacco yields, regardless of nitrogen form.

A field experiment was conducted in 1981 and 1982 on Fox loamy sand to study the effects of various proportions of ammonium (NH_4^+) and nitrate (NO_3^-) fertilizer on selected agronomic and chemical characteristics of flue-cured tobacco. Five forms of fertilizer N consisting of 100% NH_4^+, 75% NH_4^+ + 25% NO_3^-, 50% NH_4^+ + 50% NO_3^-, 25% NH_4^+ + 75% NO_3^-, and 100% NO_3^- were applied at 33.6 kg/ha. Increasing the proportion of NO_3^- in the fertilizer decreased yield, value, and reducing sugars in cured leaves, but increased organic acids, phenolic constituents, total N, and total alkaloids in cured leaves. The proportion of NH_4^+ in the N fertilizer had no effect on leaf pigments, duvatrienediols, fatty acids, phytosterols, surface waxes, hexane extracts, grade index, or maturity index. In general, differences were quite small, possibly because of the moderate amounts of rainfall in each year of the study.

Harvesting

Mechanically harvested plots yielded less than hand-harvested plots because of loss of leaf material during the harvesting operation. This loss represented about 8.5% of the leaf material. Mechanically harvested plots cured in bulk bins also lost more weight in curing than hand-harvested plots cured in bulk racks. The ratio of green weight to cured weight was 7.26 for the mechanically harvested plots and 6.04 for the hand-harvested plots. This represents a loss of about 435 kg/ha. Hand-harvested plots also had a higher grade index after curing and a lower percentage of trashy material.

GENETICS AND PLANT BREEDING

Inheritance of tobacco polyphenols

Genetic analyses of major phenolic constituents of flue-cured tobacco (*Nicotiana tabacum*

L.), utilizing Griffing's method II model II and Hayman's W^r–V^r graphic analysis on a five-parent diallel set excluding reciprocals, were conducted in a replicated randomized block design over a 2-year period at the Delhi Research Station. The analysis of variance for general and specific combining ability and W^r–V^r graphic analysis indicated genetic control for these phenolics. Additive genetic variance was the predominant contributor in the expression of chlorogenic acid and its isomers, scopoletin, scopolin, and rutin; dominance where present was in the partial dominance range. The role of nonallelic interaction was negligible for all variables except scopoletin and rutin. Tannins consisting of chlorogenic acid and its isomers were under dominant gene control, whereas the coumarins, scopoletin, and scopolin, and the flavonoid rutin were under recessive gene control. A considerable degree of positive pleiotropic effect was exhibited by all phenolic constituents except scopoletin, where negative correlations were prevalent.

CHEMISTRY

On a survey of 34 farms, levels of total alkaloids in cured tobacco leaves from the 1985 crop were higher than the 14-year average of leaves from the same stalk position. Levels of reducing sugars were higher in the two lower stalk positions but were similar for upper stalk positions when compared with the long-term average. Values for total nitrogen found in the cured leaves were lower than the 14-year average for all stalk positions except for under-tip leaves, which were slightly higher. Levels of chlorine were lower for the lower stalk positions and were higher for the upper stalk positions when compared with the long-term average. Values of lamina weight were higher than the 14-year average for all stalk positions.

Characteristics of cigarettes and cigarette smoke measured for flue-cured tobacco grown on 27 farms in 1983 in Ontario included total particulate matter (TPM), nicotine, water, tar, tar (wet), TPM-to-nicotine ratio, tar-to-nicotine ratio, puff number, neophytadiene, total gas phase aldehydes, cigarette weight, and cigarette pressure-drop. Delgold represented 85% of the varieties grown on the farms tested. Most of the measured characteristics were lower than the 1982 average, except for smoke water, puff number, cigarette weight, and pressure drop, the last two factors suggesting a slight decrease in filling value for the 1983 crop. The content of smoke nicotine was reduced from 1982, but was higher than long-term averages. Total aldehyde levels were slightly higher than the 1982 and long-term average. Neophytadiene was much lower than in 1982, but was close to the long-term average. TPM-to-nicotine and tar-to-nicotine ratios have increased compared with 1982 and are similar to the long-term averages.

Leaf shatterability

Shatterability of tobacco leaf is negatively associated with quality and usability. Certain chemical constituents such as the cations, chloride, malic acid, lignin, crude fiber, and acid detergent fiber were negatively associated with the resistance of the leaf to shatter. Moisture, sugars, and total phenols were positively associated with resistance to shatter. Moisture was the most readily controlled constituent but was significantly modified by the cations and chloride.

TOBACCO PROTECTION

Entomology

Crop losses by aphids. Aphid infestations over 3 years resulted in an average yield reduction of 5.2% in untreated flue-cured tobacco plots. Heavy infestations had a great effect on the yield of the second and third primings, little effect on the fourth priming, and no effect on the first and fifth primings. Physically, aphid injury adversely affected color, odor, and texture of the cured leaves and consequently reduced the grade, lamina weight, and price of first, second, third, fourth, and fifth primings by 24, 22, 19, 8, and 8%, respectively. Aphids reduced tobacco quality by decreasing total alkaloids, by reducing sugars and the sugar-to-alkaloid ratio, and by increasing total nitrogen in all primings.

Chemical control. A herbicide, diphenamid, and each of six insecticides, cyfluthrin, cypermethrin, deltamethrin, flucythrinate, permethrin, and acephate, applied sequentially or in tank-mixed combinations on tobacco seedlings after transplanting, effectively controlled the dark-sided cutworm in all treatments over 4 years. There was no significant difference in residual toxicity between the insecticide–diphenamid tank mixture and diphenamid and the insecticide applied sequentially. Acephate on tobacco leaves was as toxic to the cutworm larvae as were the pyrethroids, but was much more persistent.

Plant pathology

Blue mold. There was no record of blue mold in Canada in 1985. Metalaxyl or oxadixyl applied in the planting water, at considerably lower rates,

was more efficient than preplant soil application in providing tobacco with a longer period of protection against blue mold. Trials in growth chambers proved that the longer the wet period, the more susceptible tobacco becomes to the causal fungus *Peronospora tabacina*.

Pole rot. In laboratory studies formaldehyde inhibited the germination of *Rhizopus arrhizus* spores. In curing chambers, rates of formaldehyde that effectively controlled pole rot interfered with yellowing and caused green fixation.

Ethrel sprayed on mature plants in the field 2 days before harvesting the second, fourth, or fifth priming reduced the length of the yellowing period in the curing chamber by 23% and significantly reduced pole rot.

Weed control

The herbicides pebulate and diphenamid, registered for use on tobacco, and the experimental herbicides napropamide, MBR 20457, fluazifop-butyl, sethoxydim, RE 36290, SC 1084, HOE 00736, and diclofop-methyl were evaluated at various rates for their effect on flue-cured tobacco grade index, yield, return index, lamina total alkaloids, and reducing-sugar content. A significant difference from the untreated check was produced only in grade index at the 5% level, primarily by RE 36290 with active ingredient at 0.15 kg/ha. These differences were not reflected in the more important economic indicator, return index.

NEW CROPS

One hundred hectares of peanuts were produced in Ontario in 1985. Yields produced were average. However, the percentage of sound, mature kernels was lower in some cases because of mid-season drought. Advanced breeding lines from the University of Guelph continued to perform well. These lines should provide growers with an increase in yield and kernel size over existing cultivars.

Field investigations over the last 6 years have shown that the potato leafhopper is the most abundant, consistent, and economically important insect pest in peanuts. During this study, the potato leafhopper was present continuously from late June to early September each year. Data from the monitoring program showed that infestations reached economic threshold levels in early July and again in early August. Therefore, two applications of insecticides were needed for effective control.

Research and commercial modifications to the once-over peanut harvesters worked extremely well this year, resulting in reduced field losses (3–5%) and decreased free soil in the harvested product.

Average yield (2000 kg/ha) of the winter canola cultivar trial was down this year mainly because of the dry weather in the early spring. Canola yields were increased with increases in fall nitrogen (up to 75 kg/ha) and spring nitrogen (up to 200 kg/ha). Winter survival at Delhi was good this year.

Experiments initiated with evening primrose indicated no difference in yield between the four row-widths (60, 70, 80, and 90 cm) and the two dates of planting (18 and 27 September). Average yields produced were 800 kg/ha, with an average oil content of 25% and gamma linolenic acid content of 7.6%.

Apera spica-venti (silky bentgrass), a major weed of winter cereals in Europe for many years, has recently become established as a weed of winter cereals in three counties in southern Ontario. The experimental herbicides isoproturon and chlortoluron provide effective control. Various cultural practices, including crop rotation, delayed seeding, and increased cultivation of row crops, combined with the use of appropriate herbicides, appear to be the ideal combination for control of silky bentgrass.

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INTRODUCTION

The research station at Harrow serves southwestern Ontario, where favorable soils and climatic conditions permit an intensive and diversified agriculture. The station has 34 researchers involved in interdisciplinary research in seven commodity-oriented programs designed to improve yield, quality, and efficiency of crop production. Crops under study include field and greenhouse vegetables, stone fruits, pome fruits, corn, soybeans, field beans, and winter wheat. Crop improvements are achieved by the breeding of new varieties with superior characteristics and the development of improved crop, pest, and soil management practices.

The report provides brief summaries of results obtained in 1985. Further information can be obtained by writing to the Research Station, Agriculture Canada, Harrow, Ont. N0R 1G0.

C.F. Marks
Director

FIELD CROPS

Corn

Corn rootworm. Field plot studies showed that mass-trapping of males was not a feasible method of reducing infestations of the western corn rootworm, *Diabrotica virgifera virgifera*, below economic thresholds in grain corn. Mating behavior of the pest suggested that mass-trapping of female adults of the rootworm could be effective in management of moderate infestations of the pest.

Comparison of noble blade, ridge, and moldboard plow tillage. The potential of two conservation tillage systems versus the conventional moldboard plow system for improving the productivity of a poorly drained soil was compared over 3 years in a corn–soybean rotation on Brookston clay loam soil. Changes in soil physical properties were monitored by measuring soil organic matter, aggregate stability, and bulk density. Plant development was monitored by measuring rates of emergence, plant height and growth stage, days to silking, and yield parameters. Preliminary analyses showed negligible differences in soil structure and plant development. However, yield averaged 5% greater for the fall moldboard plow compared with the noble blade and ridge tillage systems, which had similar yields. Although conservation tillage did not increase productivity, there is potential for matching the productivity of conventional fall moldboard plow systems.

Ridge-planting systems for clay soils. The potential of a ridge tillage (also known as till-plant) system for improving the productivity of poorly drained soils (Brookston clay) were compared in corn (c), corn-soybean (sb), and sb–sb–c rotations with: zero tillage; conventional tillage (fall plow); zero tillage on ridge top; top of ridge scraped prior to planting (corn stalks chopped); top of ridge rototilled prior to planting (corn stalks chopped); and zero tillage (corn stalks chopped). The data showed that the seed zone in a ridge tillage system dried out significantly faster than in a zero tillage system and did not appear to be wetter or colder than fall plowed soil. Preliminary analyses have shown negligible changes in soil structure. Average yields can be ranked as conventional > ridge > zero tillage. However, individual ridge plots often resulted in plant development and yield equivalent or superior to conventional tillage. Preliminary data analyses stress the importance of adequate surface drainage in a ridge system and indicate that the productivity of a ridge (minimum till) system may approach that of a conventional tillage system.

Stewart's bacterial wilt. Stewart's bacterial wilt (*Zea mays* L.) caused by *Erwinia stewartii* was observed on dent corn in seven counties in southwestern Ontario in 1985. Disease severity ranged from severe to minor in the Ontario corn performance tests in Essex and Wellington counties, respectively. This is the first report of the disease on dent corn since 1932. Inoculations of seedlings in the greenhouse showed differences in virulence between isolates of the pathogen. Studies on the disease are continuing.

Soybeans

Economics of weed control. Chemical weed control using metribuzin or alachlor plus linuron as preemergence applications was assessed with and without the addition of cultivation. Based on a 4-year average yield and a value of $221/t, the gross margin (total dollar income minus operating costs) was calculated for each treatment. Reducing the herbicide rates below the recommended rates when no cultivation was used resulted in a reduction in gross margin and acceptable weed control. The use of cultivation im-

proved the weed control level for metribuzin from a low of 82% to a low of 98% but resulted in an average gross margin reduction of 7.3%. However, for alachlor plus linuron the weed control improved from a low of 75% to a low of 94%, and the gross margin increased 30.6%. Cultivation also permitted the opportunity to band the herbicide over the soybean row, and in this case reduce the herbicide input by one-third. Weed control with metribuzin was maintained at 98–100%, with only a gross margin reduction of 2.1%; alachlor plus linuron weed control remained at 94%, and gross margin improved 46.4%. These results indicate that the economics of cultivation (actual dollar return) may depend somewhat on the chemical treatments that are being used, but in all cases weed control will be improved. Additional but perhaps not so obvious benefits include improved soil aeration, breaking of the soil crust, reduced moisture evaporation, activation of preemergence-applied chemicals, improved moisture absorption by soil, and most importantly, the opportunity to observe the general condition of the entire crop as well as any potential serious weed problems.

Phytophthora root rot. A survey of races of *Phytophthora megasperma* f. sp. *glycinea* in Essex and Kent counties was completed. In addition, specific genes for resistance to phytophthora root rot were identified in recommended cultivars. The most popular cultivar (Corsoy 79) is resistant to most races of the pathogen but is susceptible to two races known to occur in Ontario. Losses from phytophthora root rot will continue until cultivars with resistance to all races of the pathogen are available to growers.

A 2-year study of ridge tillage on Brookston clay loam indicated that yield of four cultivars differing in tolerance to phytophthora root rot was less on ridges than in flat cultivation. Conservation tillage using permanent ridges does not appear suitable for disease-prone soils. The resistant cultivar was affected less than the moderately tolerant and susceptible cultivars, indicating that the deleterious effect of ridges might be negated by resistance to root rot.

Field beans

Breeding. F_4 selections obtained from four crosses of white bean × runner bean, *Phaseolus coccineus* L., had fair agronomic type in the field and a high level of resistance to common bacterial blight, *Xanthomonas phaseoli*, in field and greenhouse tests.

Isogenic lines for the *Are* gene for anthracnose resistance derived from the sixth backcross to the cultivars Seafarer, Fleetwood, and Ex Rico 23 showed no significant adverse effects of the *Are* gene on yield and maturity.

Three populations were selected for maturity in F_3 and for both maturity and bean yield in F_4 generations at three sites representing southern, middle, and northern (main) bean production areas in Ontario. Results indicated that selection for maturity at a southern site would effectively apply to northern areas, but selection for yield could differ depending on the cross.

In a backcross breeding program to transfer resistance to anthracnose (Are gene) and bean common mosaic virus (BCMV, I gene) to the yellow-eyed cultivar Steuben from a black-seeded introduction, PI 326.418, virus resistance failed to result in yellow-eyed progeny in the BC_6. In progeny tests, plants grown from yellow-eyed seed were all susceptible to the virus, but plants grown from brown-eyed seed segregated for eye color and reaction to BCMV, indicating a strong association between genes controlling eye color and the I gene.

Nitrogen fixation. The response of Kentwood and Fleetwood to four nitrate fertilizer levels (N at 0, 112, 224, and 336 kg/ha) was studied in the presence of indigenous and applied *Rhizobia* over 2 years. There were significant quadratic effects of nitrate levels on bean yield, plant height, total dry weight, and top and root weight, with effect at a peak when N was between 112 and 224 kg/ha. Maturity was delayed linearly as nitrate levels increased. Both cultivars responded similarly to the added nitrate, showing no effect of genotype × nitrate interaction. *Rhizobium* inoculation did not increase bean yield but it delayed maturity by about an average of one day. There was a high nodule mass and high acetylene reduction activities to noninoculated and inoculated plots. These findings indicate that the N-fixation system in these cultivars is not adequate for maximum yields.

Phosphate deficiency. White beans sown in field plots sterilized by methyl isothyocyanate fumigation had severe symptoms of phosphate deficiency, which, however, could not be explained by a lack of phosphate-solubilizing microorganisms. Microorganisms reinvaded fumigated, tilled soil very quickly, and a high proportion of them were capable of solubilizing insoluble phosphate.

Root rot resistance. When plant roots rot, reduced transpiration and heat dissipation lead to higher leaf temperatures, which can be monitored by infrared thermometry. This method was applied to screening segregating progeny from crosses of white beans susceptible and resistant to root rot.

White mold. Spread of white mold (*Sclerotinia sclerotiorum*) in Ex Rico 23, a tolerant cultivar, was much slower than in susceptible ones (Kentwood and Seafarer). The difference was related to the movement of oxalic acid, a phytotoxin secreted by the fungus, in the plant tissue. This affords a rapid method of screening leaf tissue for intrinsic resistance.

Wheat

Breeding. A line, HG5, released as genetic stock, is apparently immune to wheat spindle streak mosaic and has a fair level of general agronomic merit. This line will be of considerable value to wheat breeders as it permits them to transfer the immunity to other lines and cultivars without any major accompanying deleterious genes.

Harus (H1-11-3), a soft white winter wheat, was licensed and seed was distributed to commercial seed growers through SeCan. It has high yield and some resistance to powdery mildew, wheat spindle streak mosaic, preharvest sprouting and lodging, and is adapted to southwestern Ontario, where 85% of the Ontario wheat crop is produced.

Fusarium head blight. In a 3-year study, winter wheat fertilized with urea had only 66% as many blighted heads as wheat fertilized with ammonium nitrate.

Nitrogen fertilization. A cooperative study conducted at six locations across Ontario for 2 years showed that winter wheat cultivars (Augusta, Frankenmuth, Fredrick, and Houser) did not differ in yield response to levels of N fertilizer applied as spring top dressing. Using the existing financial and yield parameters, optimum level of N for yield was found to be 70 kg/ha. Compared with the current recommendation of 110 kg/ha, setting recommendations of N at 70 kg/ha could result in a net annual benefit to Ontario producers of $4.2 million and would improve wheat quality, as the percentage protein was directly related to level of N fertilizer.

HORTICULTURAL CROPS

FIELD VEGETABLES

Green peas

Cultural practices. Peas grown on beds in a field severely infested with root rot fungi had 10% less root rot than those grown conventionally.

Effect of herbicide on root rot. Of 20 herbicide combinations tested, some increased root rot severity, some had no effect on root rot, and some reduced root rot. Those that reduced root rot were Prowl; Treflan + Bladex; Surflan + Treflan; and Treflan, Basagram + Citowett.

Seed treatment. Of 12 different chemical combinations tested, Captan + Galben and Ridomil best protected seeds from the root rot complex of *Fusarium*, *Pythium*, and *Aphanomyces*.

Peppers

Insect control. Applications of several insecticides applied at 5-day intervals protected peppers from a light infestation of the corn borer reducing damage to zero compared with 15% in the nontreated plots. However, acephate was the only insecticide that was effective against the pepper maggot and green peach aphid as well as the corn borer in these tests.

Potatoes

Insect control. Early potatoes were well protected from all insect pests by aldicarb (Temik) applied at half the recommended rate either as a planting treatment or an application in the furrow followed by a sidedress application 3 weeks later. Foliar sprays of alphamethrin (Fastac) or cloethocarb (Lance) provided good control of Colorado potato beetle and potato leafhopper but not of aphids, whereas clocythrin (Karate) and a chlorpyrifos–cypermethrin mixture controlled the three pests. An improved formulation of the exotoxin of the bacterium *Bacillus thuringiensis* was as effective as carbofuran (Furadan) against the potato beetle, indicating potential for this microbial insecticide in the management of pests of potatoes.

Laboratory determinations of activity against the potato beetle indicated LD_{95} values in ppm of clocythrin 5.6, alpamethrin 9.2, carbofuran 43, chlorpyrifos 66, mexacarbate 88, fluvalinate 105, and phosmet 415.

Rhizoctonia stolon rot. An investigation of the empirical finding that *Rhizoctonia* stolon rot was more severe following a corn crop showed that Harrow Fox sandy loam was *Rhizoctonia*-suppressive, and that suppressiveness could be increased by the addition of *Gliocladium* spp. *R. solani* was seen only once on corn, and only in trace amounts on about 25% of wheat and oat plants. It occurred frequently and sparsely on soybeans, but could not be isolated easily. Isolates from oats and potatoes were pathogenic to potatoes.

Tomatoes

Bacterial canker. Viable canker bacteria (*Corynebacterium michiganense*) were detected in infected tomato debris buried 15 and 30 cm deep in

a Fox sandy loam field in September 1984 and removed in May 1985. Greenhouse-raised tomato (cultivar H-722) transplants, grown in a field of Fox sandy loam with a history of tomato canker, or in a clay loam field where infected tomato debris had been buried, did not contract the disease.

Breeding. The processing and fresh-market tomato-breeding programs became well established in 1985. Emphasis is being placed on germ-plasm development for processing tomato, utilizing related species and unadapted breeding lines to improve disease resistance, adaptability, and quality.

A study of cultivar trials of processing tomatoes grown in Ontario for 2 years at five locations revealed significant genotype–environment interactions for yield of marketable fruit each year and in a combined analysis across years. Regression analysis indicated that low-yielding genotypes had above-average yield stability across environments, whereas several high-yielding genotypes were unstable. Regression analysis alone could result in misleading conclusions about the performance of high-yielding tomato genotypes. Large variances in genotype–environment interaction were detected relative to genotype variances. The interaction variance components involving year were large relative to the genotype–location interaction variance, indicating the need for multiyear evaluation and selection for stability, even when breeding for a limited geographic region. Stability of performance was not associated with geographic origin of the genotypes assessed in this study.

In a series of three experiments in the field and in controlled environments the response of reportedly flooding-tolerant and flooding-sensitive tomato lines to various flooding stresses was evaluated. Although there were differences among the genotypes in shoot and adventitious root weight, shoot-to-root ratio, stomatal conductance, and transpiration rate, these differences were not associated with the presumed flooding tolerance of the genotypes. There were no significant differences among the genotypes in their response to the flooding treatments. It was not possible to identify any morphological or physiological trait that might be used when selecting for flooding-tolerant tomato genotypes.

Projects designed to generate haploid tomato plants in vitro and to evaluate and utilize somaclonal variation in tomatoes are in progress.

Domestic, high-density tomato transplants. The field performance of domestic transplants produced in multicelled Plastomer 200 trays (density of 850 plants per square metre) was compared to field-grown, southern Georgia transplants. Survival of the domestic plants in the field in two separate trials was either slightly better or far superior to transplants from Georgia (probably dependent on quality of particular shipments of southern transplants). Growth of the domestic transplants was more rapid and much more uniform among plants than that of the southern plants. Harvest took place 3–4 days earlier with the domestic plants because of the greater uniformity in growth and fruit ripening among plants. The yields in three replicates of plants originally domestic (high density) and southern plants were the same. Weed management was easier with the domestic plants because the field was uniformly covered, whereas the dead plants associated with southern plants created open spaces, allowing weed growth. The improved uniformity and performance in the field of the plants from multicelled trays were probably a result of the uniform amount of medium for root growth as well as uniform light and watering for each plant. In contrast, roots of southern plants grown outdoors in the field are not confined, and variability in growth among plants was very high.

Effect of flooding and height of clay bed on growth. Soil beds of two heights, 45 cm and 15 cm, were prepared during the autumn of 1984 to determine whether high versus low beds were more effective in overcoming flooding damage to tomato plants on clay soils, which are prone to flooding after heavy rains because of their poor water-percolating qualities. Tomatoes (H-2653) were transplanted into the beds on 7 June 1985. The plants were severely flooded on 7 to 9 August 1985, at a time when they were flowering and had a number of fruits at various stages of development. After flooding, all blossoms aborted on the plants on both types of beds. Plant growth after flooding was superior on the high beds in comparison with the low beds; the dry weight of plants 3 weeks later was 50 versus 32 g, respectively, for the two beds (least-significant difference significant at 1% level). The high beds retained more daytime heat during the night than the low beds at both 5-cm and 20-cm depths. For example, on 22 August 1985 soil temperatures at 7:00 a.m. in the low beds were 9.8 and 10.0°C at the 5-cm and 20-cm depths; corresponding soil temperatures in the high beds were 17.9 and 16.4°C. Soil temperatures at 3:00 p.m. were similar for all treatments.

Effect of long-term fermentation on tomato seed quality during extraction. Good seed quality is essential to establishment of a seeded crop in the field. It had been suggested that long-term fermentation of tomato seeds during their extrac-

tion might reduce the inoculum of bacterial diseases on the seed. It was therefore of interest to determine the effect of long-term fermentation at various temperatures, both on the germination and the vigor (ability of the hypocotyl to elongate rapidly) of the seed. Seeds were fermented for up to 30 days at 15, 20, and 25°C. Seeds retained greater than 90% germination for 17 days at a fermentation temperature of 15°C, 11 days at 20°C, and only 6 days at 25°C. In contrast, high seed vigor deteriorated more rapidly and was retained for 5 days at 15 and 20°C and only 2 days at 25°C. If medium seed quality is acceptable, the limit to fermentation should be 15 days at 15°C, 10 days at 20°C, and 4 days at 25°C.

Stem rot. The disease, caused by artificial inoculation with *Erwinia carotovora* subsp. *carotovora*, was retarded by a high potassium-to-nitrogen ratio (K-to-N, 4:1) in the cultivar CR6 grown under nutrient film technique, but not by a normal (2:1) or low (1:1) ratio. However, the high K-to-N ratio resulted in light-colored foliage and lower yield.

Water stress on leaf and root growth. Two tomato cultivars (H-2653 and C-28) were grown on loamy sand soil in glass-faced boxes under constant environmental conditions. Four water-stress treatments consisted of dry, medium dry, wet, and waterlogged. The total number of roots of both tomato cultivars was the highest in the wet treatment. There were relatively dense root systems at all depths in the medium-dry treatment. The number of roots in the waterlogged treatment was high in the top 10 cm of soil, but the rooting depth was markedly reduced as a result of stress induced by continuous flooding. In the dry treatment, the number of roots was reduced at all depths and the rooting depth of cultivar H-2653 was greater than that of C-28. The stomatal conductance of both cultivars was reduced by water stress. Water stress also caused reduction in leaf surface area, plant height, number of branches, and over-dry weights of shoots and roots. The results have implications for water management of tomatoes. The cultivar H-2653 is relatively insensitive to short dry spells because of its deep root systems. On the other hand, irrigation should be beneficial for the C-28 cultivar, even in short dry spells. However, as tomatoes have a fairly high water requirement, they should not be allowed to suffer water stress for a long period of time.

Weed competition. Nightshade is a weed in the tomato family that cannot be readily controlled by currently registered selective herbicides. Yield losses caused by nightshade interference were measured in both transplanted and direct-seeded tomatoes. In general, yield losses were much greater in direct-seeded tomatoes than in transplanted tomatoes at comparable nightshade densities. Threshold densities of nightshade at which significant yield losses could be detected were two plants per square metre in transplanted tomatoes and only one plant for every 4 m^2 in direct-seeded tomatoes. Nightshade interference reduced both the size and the number of fruits. Production of nightshade seed was substantial, with over 4000 seeds produced per square metre, even at densities of only one plant for every 4 m^2.

Windbreaks. Vegetable crops in the first half of this century in southwestern Ontario were commonly grown interspersed with wide (5–10 m) strips of rye, which acted as windbreaks and provided protection from the damaging effects of strong winds on the crops. As land prices rose, the practice was less favored. Thus, the current studies on improvement of tomato yield with plastic windbreaks were undertaken to establish an agronomic basis for an eventual economic evaluation of the benefits of windbreaks. TH-318 tomatoes were transplanted in a 1.2-ha site free from neighboring wind impediments and in Grandby sandy loam. Tomato yields were increased for about 30 m leeward of a 1-m-high Tensar plastic fence placed in an east–west direction to impede predominantly southwest winds. Early yields were unaffected, but mid-season yields were increased from 5 to 14 t/ha. Correlation of yields with plant fresh weight ($r = 0.739$) was better than with dry weight ($r = 0.407$).

GREENHOUSE VEGETABLES

Computerized greenhouse environment control. A computerized greenhouse environment control system was designed and evaluated. Novel features of the system included: a distributed, microprocessor architecture; an operator interface through a standard microcomputer; and data logging on magnetic disk and graphic display software. The system proved to be reliable and user-friendly during a 4-month trial in a commercial greenhouse.

Polytube heat exchangers for greenhouse ventilation. A seven-tube-in-shell air-to-air heat exchanger fabricated out of flexible polyethylene tubing was designed and evaluated for heat recovery from ventilation air in greenhouses. Mathematical modeling and laboratory testing of a 30-m long prototype revealed that such a system can be used to recover 70% of the heat exhausted in greenhouse ventilation air.

Twin-wall polyvinyl chloride glazing. Twin-wall polyvinyl chloride (PVC) (Hostalit Z®) glazing was evaluated as an alternative to glass for

covering greenhouses. Two similar greenhouse compartments, one covered with the PVC material and the other with a single layer of glass, were monitored during a full year of tomato cropping. During the mild winter of 1982–1983 the PVC cover reduced heat loss to 22% of that of the glass house. Light admitted in the PVC house was 18% less than in the glass house. Seasonal yields were comparable under both covering materials, but early yields were delayed under PVC.

Cucumbers

Biological control of pests. The midge *Aphidoletes aphidimyza* has been found to be a very effective biological agent for control of aphids on cucumbers under greenhouse conditions. The usefulness of this predator is greater than previously believed because it was found to attack whitefly adults as well as aphids. For example, numbers of the whitefly were reduced by as much as 50% when aphids were not available as food.

Powdery mildew and gummy stem blight. Excellent control of cucumber powdery mildew was achieved with low (0.5–1.5 g/L) rates of microfine formulations of sulfur without phytotoxicity. Iprodione gave excellent control of gummy stem blight, and the two diseases are controlled very effectively with a combination of the fungicides.

Gummy stem blight is best controlled by manipulating the environment to avoid temperatures falling below the dew point. The causal fungus, *Didymella bryoniae*, is responsible for severe postharvest losses in fruit on which water has been allowed to condense.

Tomatoes

Spacing of greenhouse tomatoes. A study on the effect of six equidistant spacings (23, 30, 38, 45, 53, 60 cm) on photosynthetically active radiation (PAR) interception by four-row plantings (separated by 90-cm alleys) of greenhouse tomato (*Lycopersicon esculentum* Mill. 'Jumbo' and 'CR-6') was carried out over two spring and two fall seasons. Interception of PAR was related to leaf area index, and therefore close spacing resulted in a small number of days from planting to full PAR interception. Leaf net photosynthesis (Pn) was greatest in the periphery of a canopy where most of the available light was received. The exposed parts of plants seemed to adjust their Pn upwards and thus compensate for the reduced Pn of their increasingly shaded parts when spacing was decreased. Closer plantings resulted in longer internodes, thinner stems, smaller leaf areas, and lower fruit set rates. The proportion of total plant dry matter allocated to fruit decreased, and the shoot-to-root dry-matter ratio increased with decreased spacing. Total and marketable yield per plant declined linearly, faster in spring than in fall, with successive decreases in plant spacing. Marketable yield per square metre in the fall increased (mostly) linearly with decreasing plant spacing, but in the spring it attained a maximum at intermediate spacings and declined with wider and closer spacings. Fruit size decreased consistently with decreasing plant spacing. On the basis of these findings, plant densities that are higher than usual are now recommended for fall greenhouse tomato crops; the practical significance of all findings of this study has not been fully assessed yet.

TREE FRUITS

Apple

Fire blight. Streptomycin-resistant strains of *Pseudomonas syringae* pv. *papulans* were found among strains isolated from blister spot lesions on Mutsu apple fruit in an orchard sprayed with streptomycin to control blister spot. Higher numbers of resistant bacteria were found in the streptomycin treatments than in the nonstreptomycin treatments. Resistant strains were found the year following streptomycin treatment, suggesting nonreversion to the wild type. Streptomycin treatments, nevertheless, provided significant control of the disease.

In 3 years of evaluation at Smithfield Experimental Farm seven cultivars of apple exhibited a range of susceptibility to the fire blight pathogen *Erwinia amylovora*. The cultivars Macfree, Britegold, Ottawa 637, and Murray were more resistant than the cultivars Trent, McIntosh, and Moira. Slight differences were noted in disease expression between the Smithfield and Harrow stations in keeping with differences in the microclimate.

Apricot

Breeding. Twelve new hybrid selections were made and propagated on Haggith apricot seedlings for advanced trials in 1987. Each selection had a good level of performance based on 12 rated characters. They had good field ratings for cold-hardiness, disease resistance, fruit size, attractiveness, uniformity of ripening, and flesh firmness; and average to good ratings for productivity and fruit quality. The new selections provided a 22-day ripening sequence from 7 July to 29 July. Nine of the 12 selections had Harcot as a common parent, demonstrating the prepotency of this cultivar in transmitting desirable traits to its offspring compared with the other cultivars used as parents.

Peach

Drip irrigation and ground cover on soil water status. Five-year-old peach trees were grown under two ground covers (clean cultivation versus permanent sod) and two irrigation treatments (drip versus no irrigation) on Fox sand. The available soil water (ASW) was taken weekly during the growing season at 20-cm intervals down to a depth of 120 cm. Water uptake in April and May was usually small, since leaves were not fully expanded. Therefore, the ASW was relatively high, regardless of treatments. As the season progressed, the ASW under nonirrigated treatments gradually decreased. By the end of July, the ASW had dropped below 40% in the upper 120 cm of the soil horizon. The ASW continued to drop and reached less than 30% towards the end of the growing season. On the other hand, the ASW under irrigated treatments remained above 70% during the entire growing season. Average ASW under permanent sod was slightly lower (<10%) than under clean cultivation. Average ASW under drip irrigation was about 80%, whereas that under nonirrigated conditions was 40% during the whole growing season.

Integrated orchard management. Three cultivars (Garnet Beauty, Harbrite, Canadian Harmony); two ground covers (cultivated, permanent sod); and trickle irrigation versus no irrigation were studied in an experimental peach orchard planted in 1980 on Fox sand. Growth rate in the first 6 years was not affected by cultivars but was moderately affected by ground covers and substantially affected by irrigation. Cultivated plots promoted slightly more tree growth than those with permanent sod strips between the tree rows. Trickle-irrigated trees were substantially larger than nonirrigated ones. Cultivars differed significantly in their effect on total marketable yield in the first, second, and fourth year of fruit production but not in the third year. Trickle irrigation significantly increased marketable yield each year compared with no irrigation, and in 1985 was responsible for a 20% increase in yield. Average yield in 1985 without irrigation was 16.4 t/ha, whereas with irrigation it was 19.6 t/ha. The best combination of treatments to 1985 consisted of trickle irrigation in the row of trees and a permanent sod strip of creeping red fescue (*Festuca rubra* L.) between the row of trees. The poorest system was the same as that above but excluded irrigation. The cultivated systems with or without irrigation were intermediate.

Rootstocks. A rootstock trial was initiated in 1982 on Fox sand with Redhaven as the scion tester and 10 different peach seedling rootstocks: Bailey, Chui Lum Tao, H7338013, H7338016, H7338019, Halford, Harrow Blood, Lovell, Siberian C, and Tzim Pee Tao. In 1985, rootstocks differed significantly for their effect on scion growth, defoliation, total yield, marketable yield, and yield of large-sized (>6.3 cm) and medium-sized fruit. The yield of small-sized fruit (<5.4 cm) and split pits was not significantly affected by rootstocks. Halford promoted the highest total yield and Siberian C the lowest, whereas Chui Lum Tao promoted the highest marketable yield and Siberian C the lowest. Bailey promoted the highest yield of large-sized fruits and Harrow Blood the lowest, whereas Halford promoted the highest yield of medium-sized fruit and Siberian C the lowest. Yield efficiency was highest on Tzim Pee Tao and lowest on H7338016. Tree size was greatest on Halford and smallest on Harrow Blood. Defoliation was earliest on Siberian C and latest on Harrow Blood.

Pear

Fire blight. The experimental bactericides MBR10995 and MBR25930 (Riker, France) have provided significant control of both blossom and shoot blight of pear caused by *Erwinia amylovora*. These compounds were as effective as streptomycin in several years of testing at Harrow. As nonantibiotic compounds they would provide effective alternative bactericides for control of fire blight.

Rootstock. Fruit production of Bartlett and Harvest Queen pears was compared on four clonal *Pyrus communis* rootstocks, Old Home × Farmingdale (OH × F); one quince (Quince A); and standard Bartlett seedlings. Two-thirds of the Bartlett trees have died because of fire blight or winter injury, whereas 87% of the Harvest Queen trees are still alive. Bartlett produced the highest accumulated yield (1980–1985) on OH × F 87 (48.6 kg per tree), followed by Quince A (46.3 kg per tree), and only yielded 33.6 kg per tree on Bartlett seedlings. Assessment of the Bartlett data is difficult because of the large number of tree deaths. Harvest Queen had the highest yields on OH × F 69 (76.1 kg per tree), followed by OH × F 87 (74.4 kg per tree), and only produced 40.4 kg per tree on Bartlett seedlings. For Bartlett trees, the largest were on Bartlett seedling (89.9 cm^2, trunk cross-sectional area) whereas Quince A produced the smallest (29.9 cm^2). For Harvest Queen trees, the largest were on OH × F 69 (116.3 cm^2), whereas Quince A produced the smallest (53.7 cm^2).

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[3]On a Canadian International Development Agency (CIDA) assignment to Tanzania from May 1984 to May 1986.
[4]On a transfer of work to Plant Breeding Institute, Cambridge, England, from December 1984 to February 1986.

INTRODUCTION

The Ottawa Research Station (ORS) is the major center for plant breeding in eastern and central Ontario. It also has substantial programs in biotechnology for crop improvement and integrated pest management of alfalfa pests. The central office for the Plant Gene Resources of Canada is part of the station. The management of the Central Experimental Farm, including numerous services, is also the station's responsibility.

The breeding programs at Ottawa are supported by multidisciplinary research efforts in plant molecular and cell genetics, cytogenetics, plant physiology and pathology, entomology, cytochemistry, and grain quality. The experimental farm at Kapuskasing continues to conduct experiments on crop production and beef cattle management for the Northern Claybelt in collaboration with the Animal Research Centre. The experimental farm at Thunder Bay is concerned with crop production practices for northwestern Ontario.

A new high-yielding naked-seeded oat named Tibor was licensed, and pedigreed seed was released to the SeCan Association. Léger barley has set new standards for yield and adaptability in eastern Canada. Four new corn hybrids were supported for license, one for Manitoba and three for Ontario. Two cultivars of hardy woody ornamentals, A. Mackenzie rose and Samba weigela, were registered.

The following individuals retired from the Ottawa Research Station in 1985: Dr. Tom Gochnauer, bee pathologist; Dr. Roland Loiselle, head of Plant Gene Resources of Canada; and Dr. Felicitas Svejda, ornamental plant breeder.

This report summarizes only some of the more important research results from the station in 1985. Further information can be obtained from the publications listed at the end of the report. Reprints of the research publications and copies of this report are available on request from the Ottawa Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

A.I. de la Roche
Acting Director

CEREAL CROPS

Wheat

Breeding. Greater winterhardiness for Ontario soft white winter wheat is one of our major goals. The hard red winter cultivar Lennox was chosen as the hardy parent and crossed to Fredrick, which is the leading soft white cultivar of Ontario. One hundred and seventy plants were picked at random in the F_2 and carried to F_6 by the ear-to-row pedigree method without selection. Seed of the F_6 rows was classified for kernel color, hardness, and protein content, and cold-hardened seedlings were subjected to artificial freezing tests. The LD_{50}'s of the parents were –12.3°C for Fredrick and –14.9°C for Lennox. The LD_{50} values of the progeny ranged from –9.8 to –17.3°C, with a mean of –13.6°C, which was also the mid-parent value. The progeny segregated into 147 lines with red kernels, 19 with white, and 4 mixed, suggesting a three-gene difference for kernel color. The mean LD_{50} of the 23 white lines (the mixed lines were sorted by hand before testing) was –12.45°C compared with –13.7°C for the 151 red lines. These results suggest some linkage between red kernel color and freezing tolerance, but four lines with white kernels had LD_{50}'s ranging from –14.2 to –14.8°C. Two of these had soft kernels and so are promising parents for the next breeding cycle.

Pathology. Winter survival of winter wheat was unusually high throughout the main production area in 1985. Snow mold damage was generally light but was moderate to severe in some fields having extended snow cover. Powdery mildew (*Erysiphe graminis* DC. ex Mérat) was much more widespread and severe than usual. Take-all [*Gaumannomyces graminis* (Sacc.) Arx and Oliv.] and eyespot [*Pseudocercosporella herpotrichioides* (Fron) Dei] were widespread and severe in the southwest, where drought stress hastened senescence. Leaf rust (*Puccinia recondita* Rob. ex Desm. f. sp. *tritici*) and *Septoria tritici* blotch (*Septoria tritici* Rob in Desm.) were widespread and moderately severe. Loose smut [*Ustilago tritici* (Pers.) Rostr.] was prevalent, and light infections of stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Eriks. and Henn.) occurred in the barberry area of eastern Ontario. Fusarium head blight (*Fusarium graminearum* Schw.) was not a problem.

Physiology. Resistance to preharvest sprouting of entries in the Ontario winter wheat cooperative

test and breeding programs was evaluated using a rain-simulator for intact spikes and a germination protocol on threshed grains. Augusta showed the greatest sprouting resistance and Houser the least among the commercial cultivars. Two breeding lines, one from Guelph (OAC81-37) and one from Ottawa (D5-47), were more dormant than the commercial cultivars, and a New York line (NY6708-10) was similar to Augusta and Fredrick.

Grain quality. Studies were begun using quantitative imaging techniques to examine grain structures and their influence on milling quality. Results indicated that approximately 80% of the variation in milling yields among 35 different cultivars was due to a combination of kernel length, fluorescence reflectance intensity, and kernel size. Milling experiments are continuing to improve the predictability of milling characteristics using rapid image analysis techniques.

Barley

Breeding. The ORS cultivar Léger, released in 1982, set a new standard for yield and adaptability of barley in eastern Canada. A new disease-resistant strain, OB631-3, outperformed Léger in 1985 in the eastern cooperative barley test. Four more strains, OB711-1, OB712-2, OB712-9, and OB715-2, were promoted to the 1986 cooperative six-row test and four lines, OB751-12, OB751-27, OB752-21, and OB752-22 were promoted to the two-row cooperative test for 1986. Calli were induced from immature embryos of Léger and 240 plants were regenerated. They will be studied for somaclonal variation.

Pathology. Leaf stripe (*Pyrenophora graminis* Sto and Kurit.) was found in low amounts in farm fields in the New Liskeard area and in some preliminary yield trials at other research stations in Ontario. Treatment of infected seed with Maneb wettable powder and nine new experimental chemicals gave effective control of leaf stripe. An intensive cereal management test using Massey barley showed in the 2 years of testing that the use of Ethepon growth retardent and the addition of nitrogen fertilizer increased yields on land previously sown to barley but not on soybean land. On the other hand, the use of Propiconazole (Tilt) fungicide increased yields of Massey on soybean land but not on barley land.

Oats

Breeding. A new naked-seeded oat cultivar, Tibor, was licensed, and pedigreed seed was released to the SeCan Association in 1985. Tibor is a high-yielding, large-seeded, high-protein, strong-strawed, tall, early maturing, smut-resistant cultivar that shows great promise as a high-energy and nutritious feed for poultry and pigs. When supplemented with minerals and vitamins, the naked oats served as a complete grower ration for pigs. Crown rust resistance has been incorporated into the recommended cultivars Donald, Ogle, and Tibor and to many promising experimental entries through backcrossing programs, and resistant selections are being evaluated in advanced tests. Immature embryos from Donald, Tibor, and a naked oat with a chevron-type spikelet were successfully induced to callus, and progeny from regenerated plants will be studied for somaclonal variation.

Pathology. Crown rust (*Puccinia coronata* Cda.) was prevalent, particularly in eastern Ontario in areas where the alternative host buckthorn (*Rhamnus cathartica* L.) occurred near oat fields. Treatment of Tibor seed with chemicals (powder form) such as Carbathiin, Thiram, or Maneb was necessary to obtain good seedling emergence. Seed stored in a deep freezer for 6 months maintained a higher germination rate than seed stored at room temperature, but both lots showed improvement after treatment with chemicals. Concentrations as high as three times that recommended for wheat were not phytotoxic to Tibor oats and in some cases gave the highest emergence values.

Physiology. Preliminary studies showed that manipulation of dormoat lines to improve spring emergence depends upon maximizing the number of conditionally dormant seeds. Sixteen dormoat lines were processed with four different protocols aimed at increasing spring emergence. Two provided levels of emergence better than the control: freshly harvested seeds stored at –20°C until planting; and seeds incubated at 40°C in a moist environment for 1 week prior to planting in late fall. More lines responded to the first treatment as compared with the second, but for the lines that were responsive to both, the heat treatment gave higher levels of emergence.

Grain quality. The fluorescent probe 4-methylumbelliferyl heptanoate (MUH) was evaluated as a potential indicator of lipase activity in oat breeding lines. The probe showed high correlations (0.85–0.95) with true lipase activity as measured by free fatty acid release. The fluorescent assay is extremely rapid and sensitive and is readily applied to mature, germinating, and processed grains.

CYTOGENETICS

Cereal cytogenetics

Intergeneric hybrids were obtained by pollinating a strain of *Hordeum californicum* Covas and Stebbins ($2n = 2x = 14$), collected in the Carmel Valley of California, with *Triticum aestivum* (L.) 'Chinese Spring' ($2n = 6x = 42$). Hybrid seedlings were recovered through embryo rescue at a frequency of 0.79% of pollinated florets. The hybrid plants resembled the *Triticum* parent in morphology as is usual in hybrids between the two genera, although these were somewhat shorter, with a pronounced prostrate early growth habit. The somatic chromosome numbers of the three hybrid plants examined were stable at $2n = 28$. The average chiasmata frequency per cell in meiocytes of the hybrids ranged from 0.06 to 0.38. The mean chromosome associations at meiosis based on all three plants was $0.7^{II} + 27.86^{I}$. The maximum observed number of paired configurations per meiocyte was five rod bivalents. These results indicate that there is no homology between genomes of the two parental species. Since the chiasmata frequency in the hybrid was even lower than reported for some polyhaploids of wheat, the genome of *H. californicum* may even have a slight suppressing effect on pairing of homologous chromosomes of wheat. The original hybrids were completely sterile; however, colchicine treatments were effective in inducing a partly fertile amphiploid. The meiotic behavior in the latter was characterized by a high degree of chromosomal desynapsis. In spite of this, all progeny examined to date have had the expected chromosome number of $2n = 56$.

Chromosome banding

The chromosomes of *Thinopyrum distichum* (Thunb.) Love (*Elytrigia disticha; Agropyron distichum* $2n = 28$) can be arranged into a giemsa-banded karyotype with 14 pairs. These include two different satellites: a small satellite borne on a subterminal chromosome and a larger satellite borne on a more median chromosome. The giemsa-banded karyotype indicates that *Thinopyrum distichum* is an allotetraploid. The NOR (nucleolus organizer region) of *Thinopyrum distichum* is suppressed in the hybrid *Triticum durum* × *Thinopyrum distichum*. The active NOR visible in this hybrid belongs to chromosomes 1B and 6B of the *T. durum* cultivar Nordum.

Bromus cytogenetics

Chromosome numbers were determined in F_2 and BC_1 (backcross) progeny from the $2n = 63$ chromosome hybrid of (*Bromus riparius* Rehm. × *B. inermis* Leyss). In the F_2 progeny, 55% of plants had more than 63 chromosomes and 28% had fewer. The remainder possessed the parental chromosome number. Therefore, fewer of the progeny are segregating toward the parent with the lower ploidy level (*B. inermis*, $2n = 56$). Only three plants out of 123 had chromosome numbers of $2n = 56$ and only nine had $2n = 56$–59. The chromosome number of the BC_1 progeny ranged from $2n = 56$ to $2n = 63$. The modal class when *B. inermis* was the female was $2n = 56$, but for the reciprocal it was $2n = 58$. Introgression of germ plasm from *B. riparius* to *B. inermis* may be facilitated by one backcross, but the transfer of germ plasm from *B. inermis* to *B. riparius* could be easily accomplished without backcrossing.

ENTOMOLOGY

Population dynamics and integrated pest management (IPM)

Alfalfa weevil. As forecast, populations of the alfalfa weevil increased to outbreak levels in many parts of southern Ontario. Heavy populations occurred in all the Lake Ontario counties east of Toronto, and scattered hot spots were detected as far west as Georgian Bay. The epicenter of the outbreak was the dairy-intensive Bay of Quinte area, where populations were the fifth largest in history, ranging as high as 4000 larvae per square metre. The potential for damage was aggravated by warm, dry weather in late April and early May, which induced the adults to lay most of their eggs ahead of schedule in the ground litter. As a result, peak attack occurred at an earlier than normal stage of crop development, and the potential for damage was greater than in any year since 1977.

IPM activities were maintained in 10 of the major alfalfa-producing counties. This involved on-line information delivery to western Ontario and comprehensive scouting by Ontario Ministry of Agriculture and Food and Agriculture Canada personnel in the major areas of outbreak—east and west. In the Quinte area, yield reductions ranging as high as 80% occurred on farms not scouted or where media alerts were not heeded; however, losses on those farms under IPM surveillance were held below 10%. The benefit–cost ratio for IPM was 6.8:1.

Life table data from three locations at the population epicenter showed that the major mortality agents, the parasitoids *Microctonus aethiopoides* Loan and *M. colesi* Drea and a disease caused by *Erynia spp.* responded in a delayed manner to

constrain generation survival to near normal levels (2.4%). This reverses a 3-year trend and foreshadows that populations will begin to subside in 1986.

There was little evidence of a bivoltine strain of the weevil in 1985. In the Quinte area, fewer than 1% of the new adults became reproductive in early summer, and continuing studies on this phenomenon confirmed that the females are sexually mature before the males. As a result, eggs that are laid early are usually infertile. Those laid later rarely accumulate a sufficient number of heat units to hatch and develop through to the adult stage.

Alfalfa blotch leafminer (ABL). Following its invasion of eastern Ontario during the mid 1970s, populations of the ABL increased rapidly for 3 or 4 years and then declined gradually to near tolerable levels. This pattern was subsequently repeated in the Bay of Quinte area and beyond, as populations spread westerly across the province in a succession of wave-like oscillations. A detailed analysis of 33 life tables compiled during this period showed that maggot mortality within the leaf mines was the key factor that determined population trends. Maggot mortality was the result of two contemporaneous processes fluctuating through a similar order of magnitude: exploitation and interference competition among the instars, and predation by a complex of nabids and mirids. Although the former process was density-dependent, its regulatory potential was dampened by the inverse response of the predators whose activity diminished the competitive interaction. Prepupal mortality was high, but relatively invariant; there was some suggestion that successful pupation was related to increased fitness conferred by intense predation and interference competition during the larval stage. Mortality from other causes was low and contributed little to population trends.

The principal predator of the ABL is an indigenous nabid, *Nabis americoferus* Carayon, that has readily adopted the leafminer as a new source of food. In the laboratory, *N. americoferus* nymphs developed at a faster rate on a diet of ABL larvae than on one composed of pea aphids. Developmental zero was about 11°C, and 494 degree-days were required for development of a complete generation. In eastern Ontario, there are sufficient heat units for only two generations annually; however, one or more of the nymphal stages or adults (or both) forage for prey throughout the season.

During the past few years, the ABL has been increasingly attacked by the wasp *Dacnusa dryas* (Nixon), a parasitoid native to Europe. Since 1979 *D. dryas* has been propagated in nursery plots at the Central Experimental Farm and redistributed in 12 counties across Ontario. A detailed survey in 1985 showed that it is now established throughout the eastern half of the province, and in the western half it is spreading rapidly north and west from the Niagara region. Rates of parasitism in several counties where it was first released varied from 65% to 95%, averaging 84.

FORAGE CROPS

Corn

Four new corn hybrids were supported for licensing: OX726 in Manitoba and OX736, OX742, and OX784 in Ontario. OX726 is a single cross with supérior stalk and root-lodging resistance, combined with good test weight, yield, and moisture (2200 corn heat units—CHU). The hybrids for Ontario (2575–2850 CHU) are three-way or modified three-way crosses, ensuring economical seed production. They are also adapted to western Quebec.

Several three-way hybrids developed from three early inbred lines show a further advance in earliness. They will be tested in the coolest Canadian environments in 1986.

Shuttle selection, in the tropical winter nursery at the International Maize and Wheat Improvement Centre (CIMMYT, in Spanish) and in Ottawa in the summer, has identified strains with excellent agronomic qualities and resistance to egg masses of *Ostrinia nubialis* (Hubn.) and to inoculation with *Giberella zeae* (Schivabe) Petch. Source populations have shown excellent combining ability with a number of elite testers.

Significant differences between CIMMYT Highland populations have been identified for germination and early growth at 10°C. Further investigations with the most promising populations are in progress.

Pathology

Rust caused by *Puccinia sorghi* Schiv. appeared late in the season on both breeding lines and hybrids. Preliminary indications are that the outbreak in 1984 was due to the lack of a resistance gene rather than the appearance of a new race. Stalk rot caused by *Fusarium graminearum* Schiv. appeared in a few uninoculated lines, but was not severe. *Fusarium moniliforme* Sheldon was isolated from a few ears, but infection was not severe. Two species of *Alternaria* caused severe damage to several breeding lines and had spread to adjacent hybrids by late season. Although natural infection occurred in the field in a com-

paratively dry season, artificial infection in the greenhouse required exposure to high humidity for 48 h and a temperature of 24°C to 28°C. Neither *Colletotrichum graminicolum* Ces. (anthracnose) nor *Kabatiella zeae* Davis (eyespot) was found on corn in the Ottawa area.

Alfalfa

Of the six creeping-rooted alfalfa cultivars studied, Kane and Rangelander produced higher levels of dry matter (DM) per plant in the last 3 years, as compared with Saranac. Only a small percentage of the plants displayed their creeping-rooted habit at Ottawa. Their winterhardiness was excellent.

At ORS, a new technique to inoculate seeded alfalfa plots in the field with *Verticillium albo-atrum* Reinke and Berth. (*Vaa*) was successfully established. A chemostat was developed to produce 80 L of *Vaa* (conidial) inoculum in 3 weeks. Disease symptoms in the field appeared in less than 2 months.

A new technique is being used to select plants simultaneously resistant to bacterial wilt (BW), *Corynebacterium insidiosum* (McCull) H.L. Jens, and verticillium wilt (VW) *Vaa* in the greenhouse. The root-ball method has been modified, whereby in the last month the alfalfa plants are harvested using scissors dipped in *Vaa* inoculum and the stubble sprayed with the inoculum. One month later, the alfalfa roots are rated for BW and the vegetative growth for VW. Only plants resistant to both diseases are retained.

During the last 3 years, experiments were conducted to study the benefits of nitrogen (N)-fixing forage legumes (alfalfa, red clover, and birdsfoot trefoil) to grasses (timothy, bromegrass, orchardgrass, tall fescue, and red fescue) in a mixed or rotated cropping system in the field and greenhouse. Using the ^{15}N tracer technique, the N fixed and transferred from legumes to associated grasses and the N released from labeled ^{15}N alfalfa residues after plow-down to a subsequent nonfixing crop (barley) was estimated.

Evidence was obtained of the benefit through direct N transfer from living legume root-nodule systems and N released from plowed-down alfalfa residues to associated or subsequent crops. This benefit increased with the ratio of legumes to associated grasses, clipping times, and seasons. Among the legumes, alfalfa was the highest N_2 fixer and benefited grasses most as compared with red clover and birdsfoot trefoil. Earlier maturing orchardgrass and tall fescue showed greatest response to the N released from the legumes, as compared with late maturing timothy, bromegrass, and red fescue. The N transfer from alfalfa to associated grasses contributed 26, 46, and 38% of the total annual N yield of the grass and represented an absolute amount of N at 5, 20, and 19 kg/ha during the first, second, and third year, respectively. Physiological studies of hydroponically grown alfalfa under controlled environments, using $^{15}N_2$, indicated that the direct excretion of nitrogenous compounds (ammonia, alanine, serine, glutamate, and aspartate) by alfalfa root-nodule systems was maximized by high light intensity and long days.

Pathology

An improved technique was developed to evaluate resistance of alfalfa (*Medicago sativa* L.) cultivars to phytophthora root rot caused by *Phytophthora megasperma* Dresch. f. sp. *medicaginis* Kaun & Erwin in the greenhouse. To complete one test run, this method required only 6–8 weeks, which is half the time required for a field test. The longevity of an isolate of *Verticillium albo-atrum* Reinke & Berthold in alfalfa stems buried in soil plates at 5°C or below was at least 3 years, the longest period known so far.

Soybean

During the 3-year period 1983–1985 the line OT83-4 was the highest yielding entry in the Ontario 2600 heat unit licensing trial. It is the same in maturity as the variety Evans (maturity group 0) and was 9% higher in yield. In other agronomic characteristics it is very similar to Evans. Breeder seed will be released in 1986.

Backcrossing has been completed to produce isolines of Maple Presto and Evans. The Maple Presto isoline has the recessive gene *ln* for narrow leaves. Results from 12 stations per year of testing indicate that it is essentially similar to Maple Presto in all agronomic characteristics, except for a slightly smaller seed size (13 g/100 seeds versus 15 g/100). The Evans isoline is insensitive to long photoperiods, probably because of the presence of the recessive gene *e4*. In Ottawa it matures up to 3 weeks before Evans. The line K618-1-2-1 has a bottom-pod height about 5 cm greater than Maple Arrow. Over 2 years (12 stations per year) its yield was equal to Maple Arrow, and its maturity is only 2 days later.

Pathology

The severity of soybean bacterial blight caused by *Pseudomonas syringae* pv. *glycinea* Young, Dye, & Wilkie was measured in terms of percentage of leaf area infected, percentage of leaves infected, percentage defoliation, number of leaf spots per plant, and visual severity rating over a number of years. The relationship of these disease ratings to each other was significantly correlated, with the exception of percentage of defoliation. A

strong correlation ($r = 0.77$) existed between the log of number of leaf spots per plant and percentage of leaves infected, indicating that counting of leaf spots can be replaced by counting of infected leaves and can thus reduce the time for disease assessment.

Grasses

The forage grass program is focused on cultivar development and investigation of the genetics and breeding behavior of autopolyploid forages. Two timothy (*Phleum pratense* L.) populations are now in the second cycle of both mass and within half sib recurrent selection for dry-matter (DM) yield and acid-pepsin dry-matter disappearance (APD). The range of APD in both populations is approximately 10 percentage units, and there appears to be no association between DM yield and APD. It should therefore be possible to increase APD without sacrificing yield in commercial cultivars.

Switchgrass (*Panicum virgatum* L.) is being evaluated as an alternative midsummer pasture species. A C-4 type plant, it accumulates DM most rapidly during the hot summer months, when temperate species are least productive. Little is known about the fall hardening period. A preliminary study with four winter-hardy populations showed that the crown moisture content is above 70% until approximately mid August, but then falls to 50% or less by mid September. Over 50% of plants (two populations) harvested in late October survived temperatures of –20°C in freezing tests.

GENETIC ENGINEERING

Developmental plant physiology

Diploid *Medicago sativa* L. germ plasm from the subspecies *sativa, caerula, falcata*, and × *varia* was screened for the ability to produce somatic embryos on seedling explants in vitro. In general, the accessions showed poor regenerability, and although regenerable genotypes were identified in all four subspecies, it was not possible to correlate high regeneration frequencies with a particular germ-plasm source. In contrast, 76 tetraploid accessions of alfalfa screened in a similar manner showed a strong correlation between in vitro regeneration and two landrace germ-plasm sources, the cultivar Ladak and the species *M. falcata* L. Both diploid and tetraploid accessions and cultivars showed a high degree of variation in callus-producing ability and in vitro somatic embryo formation. This variation was evident both between cultivars and among the plants of many of the approximately 100 lines tested. The in vitro regeneration response appears to be largely independent of medium type, regeneration protocol, explant source, and callus-producing ability. Several *M. falcata* diploid and tetraploid genotypes that rapidly (15–35 days) produce large numbers of somatic embryos (400 + per explant) on a single medium have been identified and are under study.

Experimental haploidy

An efficient procedure for achieving high frequencies of microspore embryogenesis and plant regeneration in isolated pollen cultures was established for *Brassica napus* L. cultivar Topas. The influence of donor growth temperature, pollen density, culture medium composition, and culture temperature on frequency of embryo formation was evaluated and optimal conditions were identified. Embryogenesis could be consistently obtained in more than 1% of the cultured pollen. The cytological behavior of pollen during the early stages of embryogenesis was characterized through the use of nuclear-specific fluorescent stains. Experiments were undertaken with intranuclear microinjection of foreign DNA and intracytoplasmic microinjection of mitochondria into isolated pollen. As part of another study, more than 5000 pollen-derived embryos were sent for evaluation in the canola breeding program at the research station in Saskatoon.

Anther culture studies in *B. juncea* (L.) Czern were initiated, and haploid embryo production and plant regeneration were achieved in three of six cultivars assessed.

Somatic cell genetics

The selection for *B. nigra* variants insensitive to growth-inhibiting concentrations of the amino acid analogue 5-methyltryptophan (5MT) was demonstrated to be reproducible. The inhibitor was found to act as a rapid and specific tryptophan antagonist under selection conditions. Kinetic analysis of the selection experiments and the use of an isolated variant to model the selection experiments indicated that variants may occur at frequencies of 10^{-2} –10^{-3}. The first variant selected had 20–100 times the resistance to 5MT, but little if any cross-resistance to two other amino acid analogues.

A project involving the selection of herbicide-resistant mutants in *B. napus* cultivar Jet Neuf cell and protoplast cultures was initiated. Toxic levels of the Dupont herbicide Glean were determined, and effective dosages of chemical mutagens were identified. Several protoplast-derived cell colonies with potential herbicide resistance have been selected, and experiments to regenerate plants from these colonies were undertaken.

Methodology was established for isolating protoplasts from cortical stem tissue of the *B. napus* cultivars Westar and Topas. Pretreatment of tissues on a nutrient salt solution resulted in consistent isolation of viable protoplasts. The highest frequencies of cell division and colony formation were obtained when protoplasts were floated on the surface of medium containing 0.4 *M* sucrose and 2% Ficoll. Shoots were regenerated in 10–20% of the protoplast-derived colonies on medium containing 3 mg/L zeatin. These shoots were rooted in the absence of growth regulators, and the regenerated plants could be transferred to soil and grown to maturity in the greenhouse.

Studies were initiated that were aimed at producing somatic hybrids between *B. napus* and *B. hirta* Moench. and between *B. napus* and *Diplotaxis* spp. Protoplast fusion was achieved through treatment with polyethylene glycol, and strategies for identifying hybrid cell colonies were tested. Potential hybrid colonies were selected from the *B. napus* + *B. hirta* hybridization study, and experiments to achieve plant regeneration were undertaken.

A procedure was developed for the efficient isolation of cytoplasmic vesicles (cytoplasts) from *B. nigra* cell suspension cultures. A study on the fusion of *B. nigra* cytoplasts with *B. napus* protoplasts was undertaken in order to establish a novel and rapid method for interspecific transfer of cytoplasmic traits. A number of approaches for selecting cells with novel cytoplasmic traits ("cybrids") were evaluated, and several potential cybrid colonies were identified in postfusion cultures. Previously established methods for achieving plant regeneration from these colonies were used.

Plant molecular genetics

High frequencies of transformation have been achieved by intranuclear microinjection of alfalfa protoplasts with both Ti plasmids and vectors carrying small T-DNA fragments. Analyses of plant DNA confirmed the presence of the complete nopaline synthase gene sequence and demonstrated integration independent of the right T-DNA border. Confirmation that the *Vir* region of the Ti plasmids did not contribute to integration of artificially introduced plasmid was obtained. An efficient system for the transformation of stem epidermal explants of the *B. napus* cultivar Westar by cocultivation with *Agrobacterium tumefaciens* was developed. The expression of an animal gene in *B. campestris* L. and *B. napus* has been achieved. The coding region from a cDNA clone of the gene for Chinese hamster metallothionein II was inserted into a cauliflower mosaic virus vector. The insert was shown to be stable *in planta*, and large quantities of animal protein have been immuno-detected in *B. campestris* leaves.

ORNAMENTALS

Pathology

An Ottawa soil containing about 104 propagules per gram of the fungus *Trichoderma viride* Pers. ex Fr. was suppressive to *Rhizoctonia solani* Kühn and *Pythium aphanidermatum* (Edson) Fitzpo. Aerated steam treatment of the soil did not completely eradicate *T. viride*, but reduced the population to ca. 120 propagules per gram. The fungus multiplied rapidly in the treated soil to reach the original concentration within 3 weeks.

The fungus *Phomopsis juniperovora* Hahn appears to be the primary cause of dieback of red cedar (*Juniperus virginiana* L.) and white cedar (*Thuja occidentalis* L.) in eastern Ontario. Artificial inoculation showed that when the fungus was applied to foliage at 20°C–25°C after the plants had been exposed for 21 days to a temperature of –30°C, infection was severe and dieback of the tips to 10–12 cm occurred. When *Cytospora* sp. spores were inoculated onto the infected foliage, dieback was more severe and extended to 20–30 cm from the tip. Inoculation with *Cytospora* sp. alone failed to produce symptoms.

Floriculture

Flowering in *Streptocarpus* was inhibited by high levels of indole acetic acid (IAA). In vitro studies indicated that neither photoinduction nor evocation were prevented, but that IAA-inhibition of flowering was due to inhibition of stimulus transport to developing meristems. IAA was also shown to influence the transport of factors necessary for adventitious bud formation. Bud production on leaf explants is strictly polar, occurring at the proximal region, but in the presence of IAA proximal bud production was inhibited and distal production was enhanced.

Micropropagation

The efficiency of micropropagation of *Begonia* × *hiemalis* (Fotsch) is limited by the rate of growth of the adventitious buds. Bud growth was improved by a period of liquid-shake culture. The optimum time for the liquid culture was after 6 weeks on agar. This sequence resulted in a significantly larger production of shoots that could be rooted and developed into commercially acceptable multistemmed plants.

An oilseed haploidy program was initiated between Agriculture Canada and the International Development Research Centre (IDRC). The collection of *Guizsotia abyssinica* Cass. (niger seed) showed considerable diversity in plant form and in vitro response. Procedures were established for maintaining apical shoots in culture and for the long-term low-temperature (5°C) storage of germ plasm. This germ plasm storage technique will be used to recover responsive plant material in the haploidy program and also will enable plant breeders to maintain genetic lines.

Plant breeding

Two cultivars were registered, A. Mackenzie rose and Samba weigela. A. Mackenzie combines winterhardiness with free and recurrent flowering and high levels of resistance to mildew [*Sphaerotheca pannosa* (Wallr. ex. Fr.) Lev.] and blackspot (*Diplocarpon rosae* Wolf). It survived the winters without protection in locations with more severe climates than Ottawa. A. Mackenzie produces double-red, fragrant flowers, and an upright, vigorous shrub (1.5–2 m high, 1.6 m spread). Samba is a very hardy, free-flowering weigela, with abundant gray-purple foliage and red flowers, developing a medium-high, well-balanced shrub (0.8–1 m height and spread). Hardy flowering shrubs with foliage colors other than green are rare. Like other weigelas, Samba does not suffer from diseases. Samba has been tested in Ottawa since 1978 and is currently grown at other test locations across Canada.

Ornamental gardens

In 1985, six species of annuals were evaluated in the test garden. The top-rated cultivars were as follows: China aster (Golden Arrow, Flame, Firebird); ageratum (Blue Champion, Blue Danube, Blue Heaven); alyssum (Wonderland Deep Rose, Snow Cloth Improved, Royal Carpet); calendula (Anagor, Early Nakayasu, Pacific Golden Beauty); flowering cabbage and kale (Nagoya Red, Osaka Pink, Osaka White); and phlox (Large-flowered Mix, Beauty Mix, Rosa Albo-Oculata).

Nursery research

Root development and infection of *Cornus sericea* L. 'Flaveriramea' and *Cotoneaster dammeri* C.K. Schneid. 'Skogsholmen' with a potentially commercial endomycorrhiza inoculum from chopped leek-roots, was studied during vegetative propagation of softwood cuttings. Although the inoculum potential of *Glomus clarum* Nicol. Schenck, *G. intaradices* Schenck & Smith, and *G. vesiculiferum* (Thaxter) Gerd. & Trappe was similar at the start of the experiment, initial infection by *G. clarum* was delayed for 10 days in both plant species and occurred at least 20 days after initial root formation. The exponential phase of infection by *G. intaradices* and *G. vesiculiferum* occurred 10 days after the exponential phase of root growth and was delayed for 20 days in *G. clarum*. No delay in root development because of these mycorrhizae was noted, and final root dry weights were significantly greater in *G. intaradices* and *G. vesiculiferum* treatments for both plant species. These results emphasize the need to evaluate mycorrhizal inocula in terms of host specificity and suitability for use in a particular production schedule.

It was shown that the mycorrhizal fungi *Glomus epigeaus* Daniels & Trappe had a significant effect on *Cornus sericea* 'Flaviramea' water relations under applied drought stress. The results indicate that mycorrhized plants avoid more severe leaf desiccation under drought stress by controlling water loss from leaf tissue.

PLANT GENE RESOURCES OF CANADA

Very few of the important agricultural crops grown in Canada are native to this country. Plant Gene Resources of Canada (PGRC) is the essential element of a national program in crop genetic resources that includes obtaining, maintaining, and conserving seed and clone collections; participating in national and international exchanges of germ plasm; and providing information and documentation on all of the above.

Over 80 000 seed samples of a great variety of crops are conserved under controlled conditions at PGRC. We maintain the national base collection (CN, 17 000 samples); the active collection (PGR, 16 000 samples); and the Canadian *Avena* (CAV) and Canadian *Hordeum* (CHC) collections. The last two consist of a major world collection of oats and barley. We conserve duplicate samples of international pearl millet, rapeseed, and mustard collections. The national apple repository network, involving six Agriculture Canada research stations across Canada, preserves almost 200 apple stocks.

Last year, 8144 accessions were involved in 336 germ-plasm exchanges with individuals in 40 countries.

Information on the CN collections (oats, barley, wheat, tomato, and alfalfa) is stored in computerized crop data banks. Genetic resources inventories were published in 1985 for wheat (4822 accessions) and barley (6999 accessions). They list cultivars and genetic stocks under a number

of traits or descriptors. The PGRC newsletter, published semiannually, reports on activities concerning plant gene resources. It has a mailing list of 648 419 in Canada and 229 in 43 other countries.

PGRC provides a focus for Canadian activities in plant genetic resources, initiating and encouraging projects all across the country.

EXPERIMENTAL FARM KAPUSKASING, ONTARIO

Cereal management

Three cultivars of barley—Birka, Bruce, and Léger—were evaluated over 3 years (1983, 1984, 1985) under five seeding rates, 110, 220, 330, 440, and 550 seeds per square metre of soil. Birka and Bruce reached their maximum yield when sown at 330 seeds per square metre, whereas Léger required a higher rate of 440 seeds per square metre. Léger was the highest yielding cultivar, followed by Bruce and Birka. The percentage of yield increase of Bruce, the smallest seeded cultivar, was smaller at the lower seeding rates than Léger and Birka. The weight per 1000 kernels was highest at a seeding rate of 220 seeds per square metre and declined as the rate was increased. Plant height of the three cultivars was reduced with the higher seeding rate. The cultivars reached maturity 3–4 days earlier under a higher seeding rate. Total number of seeds per head decreased from 41.8 to 31.8 as the rate of seeding increased from 110 to 550 seeds per square metre, and similarly the weight per head was also reduced from 1.82 g to 1.28 g with the higher rate. Tillering was also reduced significantly from a high of 3.53 tillers per plant to 1.68 when the rate was increased from 110 to 550 seeds per square metre, with Birka tillering the most at 3.03 and Léger the least at 1.62. These results supported the new seeding rates recommended in *Field Crop Recommendation*, Publication 296, Ontario Ministry of Agriculture and Food.

Forage management

Baylor brome (*Bromus inermis* L.), Champ timothy (*Phleum pratense* L.), Hallmark orchardgrass (*Dactylis glomerata* L.), and a mixed-grass stand consisting of fescues (*Festuca* sp.), bluegrass (*Poa* sp.), quackgrass (*Elytrigia repens* L.), and reed canarygrass (*Phalaris arundinaceae* L.) with N at 180 kg/ha were cut at three stages of growth on the first cycle (10%, 50%, 100% heading); the second cut was taken 5, 7, and 9 weeks later. A total of 10 minerals (P, Ca, Mg, K, Cu, Fe, Mn, Zn, S, and Na) were analyzed, along with crude protein (CP) and acid detergent fiber (ADF). The percentage of CP in all four species was reduced significantly, with a delay in the cutting on the first cycle. ADF values increased significantly on the stand of brome, timothy, and orchardgrass when harvesting was delayed from 10% to 100% heading. This difference in ADF was not observed in the mixed-grass stand. Of the 10 minerals examined, Fe, Zn, and Na did not show any differences in levels from the first-cycle cutting schedule, whereas the seven other minerals showed a decrease as harvesting was delayed. Levels of P, Ca, and Fe were similar among the species evaluated. Magnesium levels were highest in the grass mixture followed by orchardgrass, timothy, and brome, with a range from 0.29% to 0.18%. Levels of K were highest in orchardgrass, timothy, brome, and the grass mix, respectively, with a range of 3.9–2.3%. A level of 14.1 ppm of Cu was found in the grass mix followed by 10.3 ppm in timothy, with brome and orchardgrass at only 8.5 ppm. The highest level of Mn occurred in the orchardgrass at 57 ppm, followed by brome at 41 ppm, with timothy and the grass mixture at 36 and 35 ppm, respectively. The grass mixture had the highest level of Zn at 29 ppm, followed by timothy at 26 ppm, orchardgrass at 22 ppm, and brome at only 19 ppm. Sulfur levels varied from 0.17% in brome to 0.12% for timothy and orchardgrass, and the grass mixture was at only 0.09%. Sodium levels between species had the widest range of all the minerals tested. Orchardgrass and timothy had levels of 962 ppm and 788 ppm of Na. These preliminary results of only 1 year of data indicate the need for further studies in mineral levels on grasses under cool, moist growing conditions.

EXPERIMENTAL FARM THUNDER BAY, ONTARIO

Cereals

The top-yielding oat strain in the western coop test was O.T.238 at 3953 kg/ha compared with the top-ranking Eastern Oat Q.O.199.60, which yielded 4221 kg/ha. The western two-row barley trial produced a top yield of 4093 kg/ha for T.R.482. The highest yielding strain in the eastern six-row barley trial was T.B.82127 at 5922 kg/ha, compared with a western strain, B.T.916, which yielded 5307 kg/ha. The Ontario early, medium, and late barley production trials consisted of 10 cultivars sown at 108 kg/ha and 162 kg/ha at 10-day intervals on three separate dates. The early trial, sown on 14 May, produced the highest yield, 4828 kg/ha by Léger at 162 kg/ha,

compared with 3097 kg/ha in the medium trial and 2242 kg/ha for the late trial. The Ontario early, medium, and late oat trials were designed in the same manner as the barley trials using eight cultivars. Ogle was the top-yielding variety in all three trials. In the early trial, the seeding rate of 76 kg/ha produced a yield of 3651 kg/ha, whereas the rate of 114 kg/ha yielded 2284 in the medium trial and 2204 kg/ha in the late trial.

Forages

Several cultivars of three species of grasses—meadow foxtail (*Alopecurus pratensis* L.), tall fescue (*Festuca arundinacea*), and reed canarygrass (*Phalaris arundinaceae* L.)—were introduced and evaluated for 2 years. Twelve varieties of meadow foxtail produced minor differences in forage yields. The top-yielding variety was G4551 at 8687 kg/ha. The tall fescue variety Kenny had a top yield of 5698 kg/ha, compared with the top reed canarygrass variety Vantage of 9409 kg/ha.

Potatoes

Thirty-one varieties of Elite 1 potatoes were grown to produce 2 t of seed potatoes at the Elite 2 level for Ontario regional potato trials. Fourteen varieties of Pre-Elite material produced 175 kg of tubers at Elite 1 level. Selections were made from 6300 tubers from 12 breeders' lines; of these, 1200 tubers were selected for further advancement. In the greenhouse 7000 tubers were produced from true potato seed grown from 13 breeders' lines.

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INTRODUCTION

The Vineland Research Station serves the horticultural industry with comprehensive crop protection research that is organized under four multidisciplinary programs: tree fruits, grapes and berries, vegetables, and ornamentals. Some work is also done on forage and tobacco. Scientific disciplines represented at the station include entomology, acarology, ecology, mycology, virology, bacteriology, nematology, pesticide residue chemistry, toxicology, and computer science. The Smithfield Experimental Farm, located near Trenton, is administratively linked to the station and carries on horticultural production and processing research, as well as pest control programs, in collaboration with Vineland.

This report summarizes some of the research results from the station in 1985; more detailed information can be obtained from the publications listed at the end of the report. For more information on these or other research projects, or for copies of this report, please write to the Director, Research Station, Research Branch, Agriculture Canada, Vineland Station, Ont. L0R 2E0.

D.R. Menzies
Director

TREE FRUITS

Insects and mites

Biological control. Two parasites of the cherry maggot, *Rhagoletis cerasi* L., have been imported from Europe (in cooperation with the International Federation of Meat Traders' Association (CIBC), Delemont, Switzerland) as potential control agents for the apple maggot, *Rhagolitis pomonella* (Walsh), which is indigenous to North America. In the laboratory, *Opuis rhagoleticolus* Sach. has successfully attacked larvae of *R. pomonella*, and *Phygadenon weismanni* Sach. has attacked pupae of *R. pomonella*. A method of rearing *P. weismanni* in the laboratory has been developed and a small laboratory colony established.

Chemical control. Applications of superior oil to small (1.5–2.0 m) plum trees in spray volumes ranging from 787 to 2360 L/ha indicated that all volumes were equally effective in controlling San José scale, *Quadraspidiotus perniciosus* (Comstock). On larger (4.0–4.5 m) apple trees, tests over 4 years failed to show any advantage for the application of spray volumes greater than 2400 L/ha. None of the treatments, including combinations of oil sprays during the dormant stage and summer sprays of diazinon, were effective in preventing the resurgence of scale populations.

Populations of the spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabricius), developed four- to sixfold resistance to permethrin and fenvalerate after about 4–5 years of use. These populations showed up to 17-fold cross resistance to all other pyrethroids and 39-fold resistance to DDT. Resistance is probably due to a nonmetabolic kdr-type mechanism and has become widespread across southern Ontario from the Simcoe area east to Smithfield, but not in the Essex–Kent or Meaford areas.

Ecology. Fecundity, oviposition, and egg development were determined in an Ontario population of the spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabricius). Female fecundity was highly variable (1–152 eggs per female) and was not affected by temperature. The oviposition threshold was estimated to be 9°C, and the rate of oviposition increased linearily with increased temperature between 10 and 26°C. The threshold temperature and thermal constant for egg development were estimated as 2.3°C and 174 degree-days, respectively. This information will be used to predict the time of first egg hatch, an important factor in timing insecticide applications.

Predator–prey relationships. Antiserum prepared in rabbits to apple maggot pupae was used successfully to detect maggot meals consumed naturally by five species of carabid and staphylinid beetles collected from orchards. The detection of maggot meals ranged from a low of about 6% in certain staphylinid species to a high of about 30% in certain carabid species. The results indicate that predaceous beetles may contribute significantly to the control of apple maggot.

Nematodes

Biology. The life cycle of *Meloidogyne microtyla*, a root-knot nematode, was completed on tomato in 30 days, although young adult females were first observed at 15 days after inoculation. By the eighth day, sexes were distinctive in the germinal primordium, body shape, and breadth of the esophageal area at the median bulb. Development of both sexes in the third and fourth larval

stages proceeded similarly to other root-knot species, although rectal glands were observed in the third males, a feature not previously reported for other species. Sex-related differences in body shape and width at the median bulb persisted through all stages; cuticular structures (spicules and stylets) formed at the time of the fourth molt.

Severe damage to creeping red fescue (*Festuca rubra* L.) used as an orchard cover crop in the Georgian Bay area was attributed to high populations of *M. microtyla*. Nematode population densities that ranged from 1000 to 7000 juveniles per kilogram of soil were associated with a 10-year decline in the cover crop stand. In the most severely affected areas, dandelions (*Taraxacum officinale* Weber) completely replaced the creeping red fescue, with damage most severe between the tree rows. Controlled studies have shown up to a 42% loss in accumulated top clippings of creeping red fescue over 18 weeks. As a result, this grass is not recommended as a cover crop where *M. microtyla* is present.

Diseases

Apple scab, Venturia inaequalis. The fungicides captan, Baycor, Baycor plus captan, and DPX H 6573 were evaluated for control of apple scab. All fungicide treatments reduced apple scab infection of foliage and fruit relative to the nonsprayed control but were not different from one another. On 28 June a reduction was observed in shoot length of trees receiving DPX H 6573 containing active ingredient (a.i.) at 0.08 g/L (213.6 mm versus 238.1 mm for nonsprayed trees). No other fungicide treatments were associated with decreased shoot length.

European canker, Nectria galligena. European canker of apple (*Malus domestica* Borkh. 'McIntosh') caused by *Nectria galligena* Bres. was first observed in Wentworth County, Ont., in March 1985. The fungus has been present for at least 5 years and was limited to one orchard, with approximately 20% of the trees infected. The geographical range of this fungus in Canada now includes the apple-growing region of central Ontario.

Peach canker, Leucostoma cincta, L. persoonii. Seven peach clones varying in susceptibility to infection by *L. cincta* and *L. persoonii* were assessed for wound response. Suberin deposition first observed in cells of the impervious tissue, which formed before phellogen generation at the wound and as early as 7 days postwounding, was negatively correlated with the field-performance ranking of the seven clones.

Potted peach trees (*Prunus persica* (L.) Batsch 'Loring') were mechanically defoliated, and the influence of temperature on the formation of the primary protective layer and on phellogen generation in the leaf abscission region was examined histologically. Plants maintained at 7.5, 12.5, and 17.5°C showed first indications of the formation of a primary protective layer at 18, 9, and 6 days, respectively. Subsequent generation of phellogen and the appearance of the first phellem cell were observed at 30, 18, and 12 days, respectively. The primary protective layer formed approximately 700 μm proximal to the separation zone and was composed of cells with lignified walls and thin suberin linings.

Brown rot, Monilinia fructicola. Sources of *M. fructicola* inoculum in peach orchards were studied at five sites in 1984. Apothecia were found in 1983 in a noncultivated peach orchard. In 1984, no apothecia were found, although conidia were produced on mummies that had overwintered on the ground or in the tree and on cankers, fruit peduncles, and blighted twigs. Sporulation occurred on blighted blossoms and associated twig cankers in late May, although blossom blight incidence was low in 1984 (less than 1.0%). At the time of approaching fruit maturity, the principal sources of inoculum were thinned fruits on the ground (up to 14% infected) and nonabscised, aborted fruits in the tree (up to 32.5% infected). Thinning at or after pit hardening in a nonsprayed orchard resulted in 6.0 and 14.0% infection of thinned fruits on the ground, respectively. In the laboratory, inoculation of early maturing peach cultivars resulted in greater numbers of conidia than on late maturing cultivars, although late maturing cultivars were colonized more rapidly. Early maturing cultivars provided added inoculum for infection of late-season cultivars.

Harvested cherry fruits were used to determine relationships between inoculum density, infectivity, and rate of disease development of brown rot on sweet cherries. The degree of fruit infection was directly related to inoculum density, and both lesion appearance and sporulation occurred earlier as inoculum densities increased. At an inoculum density of 1 × 104 spores per millilitre, 50% fruit infection occurred in 6 days, whereas at an inoculum density of 2 × 105 spores per millilitre, 50% of the fruit was infected in 2 days. Similarly, 50% sporulation occurred in 8 days at 1 × 104 spores per millilitre and in 4 days and 2 × 105 spores per millilitre. Total spore production was highest at the highest inoculum density. In the orchard, inoculum densities of 1 × 105 spores per millilitre are realistic during rain runoff.

Research Station, Vineland Station, Ont.

GRAPES AND SMALL FRUITS

Nematodes

Vectors. Ontario populations of *Longidorus elongatus* de Man were shown to ingest and transmit imported and indigenous nepoviruses. In tests with *Chenopodium quinoa*, the transmission of raspberry ringspot virus (strain S) and tomato blackring virus (TBRV) (strain S) varied directly with nematode number, with up to 45 and 52% infection, respectively. No transmission of TBRV strain G or peach rosette mosaic virus occurred. All viruses, except TBRV-G, were detected in nematode extracts by bioassays. These data indicate the potential economic importance of this nematode, should it be present in association with raspberry ringspot virus (strain S) or tomato blackring virus (strain S).

Diseases

Resistance of grapevine understock to tomato ringspot virus. DeChaunac scions grafted onto Sonona, SO4, 5BB, 3309, 4453, and Concord, and DeChaunac self-grafted and own-rooted vines were planted in a commercial vineyard with a high incidence of tomato ringspot virus infection. Grafted vines remained healthy over seven growing seasons, whereas own-rooted DeChaunac became infected during and following the second growing season. Virus was undetectable in all grafted understocks, including susceptible DeChaunac. It is apparent that the graft union influences translocatory movement and multiplication of virus, thus preventing infection of susceptible scions. Yield reductions were apparent in DeChaunac grafted onto SO4, 5BB, 4453, and Concord understocks; total sugar, acid, and pH levels of the juice were unaffected.

Virus diagnostic procedures. A significant expense associated with enzyme-linked immunosorbent assay (ELISA) is the disposable polystyrene microtiter plates. Cleaning these plates in detergent at 60°C resulted in a decline in plate efficacy. Treatment of wells with 1% nitrocellulose after cleaning resulted in a significant improvement in plate performance, allowing them to be used up to six times with only a marginal reduction in sensitivity over new plates.

An inexpensive ELISA plate reader was constructed by interfacing a solid state photometer with a light microscope. By utilizing the light path system of the microscope, only a light-sensing circuit and narrow bandpass filter were necessary to obtain reliable ELISA substrate readings. Laboratory tests have shown that this unit provides accuracy, reproducibility, and linearity comparable with an up-to-date commercial unit.

VEGETABLES

Insects

Carrot weevil, Listronotus oregonensis (LeConte). Laboratory-reared carrot weevil adults were exposed to various temperature–photoperiod regimes to determine factors controlling oviposition. Photoperiod was shown to be the principal controlling factor, providing the temperature was greater than 12.5°C. These results suggest that the carrot weevil normally is limited to a single generation in Ontario because most summer adults mature when daylength is no longer favorable for egg development. Occasionally, warmer temperatures in early summer can result in earlier maturation of summer adults and a partial second generation.

Control of the carrot weevil. Three synthetic pyrethroid insecticides, permethrin, cypermethrin, and deltamethrin were equally effective when three sprays at 10-day intervals were applied to carrots for control of the carrot weevil, reducing injury by about 82%. They were not as effective as phosmet, the material currently recommended for control of carrot weevil. The latter reduced injury by about 98%, whether applied twice (beginning at the third-leaf stage) or three times (beginning with the first true leaf). The results indicate that the application of the first spray of phosmet can be left until two or three leaves have developed, without risking serious crop injury, and that if pyrethroid insecticides are registered for carrot rust fly, *Psila rosae* (Fabricius) in the future, they will provide adequate control of the carrot weevil as well.

Aster leafhopper, Macrosteles fascifrons (Stal.). Twelve insecticides currently registered with potential for use in Ontario on carrots and lettuce were tested, using a Potter tower, for toxicity to the aster leafhopper (ALH), the vector of aster yellows (AY). The synthetic pyrethroids deltamethrin, permethrin, cypermethrin, and fenvalerate were about 3.3 to 67 times more toxic than carbaryl, currently the standard insecticide for ALH control in Ontario. Carbaryl was less toxic than carbofuran but more toxic than other insecticides used on carrots, i.e., phosmet, parathion, mevinphos, malathion, and diaxinon. Acephate was the least toxic insecticide tested. In field trials, permethrin reduced the incidence of AY in lettuce and was as effective as about 10–20 times the concentration of carbaryl.

Nematodes

Biology. Six potato (*Solanum tuberosum*) cultivars, Superior, Yukon Gold, Monona, Norchip, Kennebec, and Russet Burbank, were

grown in Tioga loamy sand in tile microplots noninfested or infested with *Pratylenchus penetrans*. All nematode populations increased through the season with no differences in the rate of nematode buildup in soil on the six potato cultivars. The nematode suppressed yield of marketable tubers of Superior by 73% and of Yukon Gold by 25%. Losses for Russet Burbank (61%), Kennebec (55%), Monona (46%), and Norchip (43%) were intermediate.

Diseases

Phoma canker of parsnip, Pastinaca sativa. Resistance and susceptibility to *Phoma* canker of parsnips was observed in 10 cultivars grown in mineral soil at Vineland and muck soil at Bradford as well as in growth-room studies. Differences between cultivars were found with respect to percentage of roots with canker, plant stand remaining, and weight of harvestable parsnips 34 and 65 days after inoculation with the fungus at Vineland and Bradford, respectively. At both sites, Harris Model was the most susceptible cultivar, whereas Hollow Crown and All American were the most resistant. Disease progress on foliage of resistant cultivars was less than on susceptible cultivars, and final foliage ratings correlated strongly with percentage of incidence of *Phoma* canker on roots. This is the first report of *Phoma*-resistant parsnip cultivars. Both Harris Model and Hollow Crown cultivars showed significant reductions in seed germination when inoculated with fungus spores. The fungus was shown to overwinter on parsnip petioles in muck and mineral soils at various soil depths. Control measures should be directed at minimizing the amount of overwintering host tissue and reducing seed germination by the fungus.

ORNAMENTALS

Insects

Western flower thrips, Frankliniella occidentalis (Pergande). Ninety percent of Ontario growers with thrips control problems on greenhouse ornamental plants were found to have *F. occidentalis* present. This was the first report of the species in eastern Canada. Tests confirmed the virus–vector relationship between tomato spotted wilt virus and *F. occidentalis*, with up to 30% of *Lycopersicon esculentum* and up to 80% of *Gomphrena globosa* infected by thrips. Epidemics of this virus were found in tomato, chrysanthemum, dahlia, marigold, and gloxinia in commercial greenhouses.

Serpentine leafminer, Liriomyza trifolii (Burgess). The failure of synthetic pyrethroids to control the leafminer is primarily due to metabolic resistance. The systemic insecticide aldicarb has become ineffective against leafminer larvae in spray chrysanthemums, even though residues greater than 100 ppm were present in the foliage. Three new products, Avermectin B1, Evisect, and ABG-6162, with a.i. at 0.005, 0.5, and 1.0 g/L, respectively, were very effective in laboratory tests against leafminer larvae. The first two products killed early-instar larvae in leaves, whereas the third product was slower acting and prevented adult emergence from pupae. These materials are not registered.

Nematodes

Biology and control of foliar nematode, Aphelenchoides fragariae, on Rieger begonia. The foliar nematode that causes leaf burn and necrosis on Rieger begonia multiplies rapidly in leaf tissue; generation time appears to be about 7 days, with multiplication rates of 5–10× per generation. Plant leaves frequently become detached at nematode population densities of 5000/cm^2 of leaf area. Oxamyl, applied either as a foliar spray or as a soil drench, reduced the number of nematodes in infested plants. Drenches were more effective than sprays, and repeated applications at 3-week intervals were more effective than single treatments.

Diseases

Botrytis cinerea tolerant of fungicides. B. cinerea causes considerable damage to many floricultural crops. Strains of the fungus have developed that are tolerant of two fungicides, iprodione and benomyl, probably because of prolonged or excessive use of these fungicides. In some greenhouses, up to 96 or 100% of the strains were tolerant of iprodione or benomyl, respectively. Some *Botrytis* strains were 10× more tolerant of iprodione than were the wild sensitive isolates, whereas benomyl-tolerant strains of the fungus were greater than 1000× more tolerant than sensitive ones. Isolates tolerant of both fungicides made up over 16% of all the *Botrytis* isolated.

Pseudomonas cichorii, leaf spot of chrysanthemums. Pseudomonas leaf spot remains a significant problem for cut and pot chrysanthemum production, particularly when mist or overhead watering is used. Tests for susceptibility to *P. cichorii* of over 35 varieties of pot mums, representing 17 breeding lines showed that none were completely resistant. However, the cultivars Sequest, Sequoia, Jade, Jasmine, Surf, and Fiesta were less susceptible than the other cultivars tested. Water was necessary for con-

tinuing leaf infection, but not once flower or stem infections were initiated.

Elm yellows and ash yellows. Elm yellows (elm phloem necrosis) has been discovered in the Niagara Peninsula in both American elm (*Ulmus americana*) and red elm or slippery elm (*U. rubra*). No specimens of rock elm (*U. thomasii*), the only other native elm species, were found to be infected. Reported vectors for this lethal tree disease have not been found in Canada.

FIELD CROPS

Nematodes

Oxamyl treatment of alfalfa seeds. Saranac alfalfa seeds were treated with methanol containing oxamyl at 50 mg/mL . Seed germination, growth, and nematode control were examined using soils infested with *Pratylenchus penetrans* and *Meloidogyne hapla*. Germination was not affected by the seed treatment. Twenty-one days after sowing, the top and root growth of seedlings from the treated seed had increased 39–62% and 73–113%, respectively, over untreated seed; nodulation had increased by as much as 488%; and the number of *P. penetrans* was reduced by as much as 77%. In soils infested with *M. hapla*, growth increases and *M. hapla* gall reductions were noted but they were not as great as those on soils infested with *P. penetrans*. Oxamyl content of alfalfa seed did not decline after many months of storage.

SMITHFIELD EXPERIMENTAL FARM

Tomatoes

Tomatoes for concentrated product. Factors that determine yield and flow characteristics of tomato puree were found to be associated mainly with the content of water-insoluble solids and the serum viscosity of the fruit. Levels of both total solids and soluble solids were not important in this regard. Water-insoluble solids are related to the pulp component (which comes mainly from the cell wall), cellulose, and other insoluble substances. Serum viscosity, a property of the liquid component of the puree, is due largely to pectic substances. These also derive from the cell walls, making cell walls the principal determinant of the all-important yield and flow properties of concentrated tomato products.

Total levels of solids and soluble levels of solids varied greatly from one year to another, depending on moisture and other climatic conditions during the period of fruit development and maturation on the plant. However, the content of water-insoluble solids was mainly cultivar-dependent and was only minimally affected by growing conditions. Levels of all three solids fractions, as well as serum viscosity, differed characteristically from one cultivar to another. Advantage can be taken of this to improve processing yields in commercial plants producing tomato products such as puree, paste, and ketchup.

Competition and herbicide screening for nightshade control in tomatoes. In 1983, nightshade populations of up to 160 plants per square metre caused severe yield reductions in tomatoes. In 1984 and 1985, nightshade populations of 0, 1, 2, 5, 10, and 50 plants per square metre were established in tomatoes. Tomato yields were reduced 22 and 36% in 1984 and 1985, respectively, because of a population of one plant per square metre.

Fresh weights in the field of hairy nightshade (*Solanum sarachoides* Sendt.) and eastern black nightshade (*Solanum ptychanthum* Dun.) indicate that hairy nightshade is a much larger plant when both have adequate growing space. Hairy nightshade germinated sooner and grew more quickly once it emerged when both species were germinated in a greenhouse as approximately 20°C. In the field at Smithfield, where both species are present, hairy nightshade predominates, possibly because it germinates more quickly under cooler spring conditions.

Lentagran, chloramben, bentazon plus chloramben, diethatyl, and oxyflurorfen plus chloramben gave good nightshade control. There was some injury to the tomato plants with all these treatments, and yields were significantly lower than the check.

Tomato breeding. Varieties named and released include Earlirouge, Earlibright, Bellestar, and Quinte. Greenhouse screening indicates that both Bellestar and Quinte contain resistance to verticillium wilt.

All four cultivars have the high crimson color and can be used as hand-picked selections for either the fresh market or processing. Quinte is the late-season standard for processing. Earlirouge and Earlibright are early-season selections, with larger fruit size found in Earlirouge.

Bellestar is an early Roma type having the jointless character.

Apples

Apple scab, Venturia inaequalis. Sterol-inhibiting fungicides have provided good control of apple scab. When used in an eradicant program

within 72–96 h after the beginning of scab infection periods, control of scab has been as good as that obtained with a conventional protection program, but with one to three fewer sprays per season. Mixtures of sterol-inhibiting fungicides with broad-spectrum protectants provided better scab control than either product alone when used on a 10-day spray program. Reducing the rate of the sterol inhibitor in the mix did not appear to reduce the effectiveness of the mixture in controlling scab. These results show potential savings are possible with sterol-inhibiting fungicides by reducing the number of sprays in an eradication program, by extending the interval between sprays when using fungicides mixtures, and by reducing the rate of the sterol-inhibiting component in fungicide mixtures.

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Prairie Region
Région des Prairies

W.L. Pelton

J.E. Knipfel

A.W. Strachan

Director General *Directeur général*	W.L. Pelton, B.S.A., M.S.A., Ph.D.
Program Specialist *Spécialiste en programmes*	J.E. Knipfel, B.S.A., M.Sc., Ph.D.
Contracts Specialist *Spécialiste en contrats*	Vacant
Chief, Administration *Chef de l'administration*	A.W. Strachan

PREFACE

The Prairie Region, with headquarters in Regina, Sask., consists of ten research stations, three experimental farms, and five substations that serve agriculture throughout the Prairie Provinces. In 1985 the region managed a budget of $62.3 million and employed 257 professionals and 806 support staff.

Conservation of soil and water resources is emphasized in the Prairie Region. Under semiarid conditions and moderate grazing by livestock in southern Alberta, more than 55 years were required for the soil to return to conditions similar to those found under native range. In the Brown–Dark Brown soil zone, zero-tillage seeding practices for winter wheat gave about 10% more yield than did conventional seeding; continuous cropping of winter wheat was less economical than were rotations that included fallow; and chemical fallowing procedures were economically comparable to conventional fallowing procedures.

Improved efficiency of livestock production is the objective of animal productivity research. Sire rankings for progeny performance were shown to be unaltered by substituting medium-energy (forage-based) rations for high-energy (grain-based) rations. Medium-energy rations are advantageous in increasing reproductive capacity and reducing digestive disturbances. Evaluation of exotic and British cattle breeds and their crosses is continuing, with emphasis on interactions of genetics and environment as related to cow productivity. Sow reproductive efficiency was increased by restricting the suckling by piglets, whereas feed restriction during pregnancy had no effect on litter size, birth weights, or weaning weights of piglets. Digestibility of roughages was dramatically increased by supplementing feed with branched-chain amino acids or their fatty acid analogues. In comparison with established breeds, use of sires of Romanov or Finn breeds did not reduce profits and produced crossbred females with high reproductive capability. Adding bacteriophages to beef was shown to reduce meat-spoilage bacteria, thereby extending the retail case life of the meat. New standards were developed to improve the precision and versatility of pork-quality scoring.

Protection research involves insect pests, pathogenic agents, and weed control. Research on insects includes studies of the insect itself, evaluation of biological and chemical control measures, assessment of economic damage, and development of integrated management systems. From survey results in southern Alberta, infestations of cutworms and grasshoppers were predicted to be severe in 1985 and control measures were implemented in response to the surveys. The 30% reduction in yield caused by the wheat midge in northeastern Saskatchewan resulted in an estimated economic loss of $30 million. Verticillum wilt of alfalfa may be spread through the pollinator activities of leafcutter bees and through the use of fresh manure from animals fed diseased alfalfa. Grazing animals also spread the pathogen. Wild oat control in the Peace River area was best achieved with trifluralin but the weed could also be well controlled through delayed seeding and cultivation of crops. Insect predators have been found for leafy and cypress spurge, absinth, perennial sow-thistle, and diffuse knapweed.

Crop cultivars licensed during 1985 included Riel and Jasper oats, Saffire safflower, N0488 and N0004 corn, Jackson barley, HY320 and Lancer wheat, Tipu and Titan field peas, Marshall's Delight monarda, Cutlass mustard, Tribute canola, and S1283 Oilseed sunflower.

Prairie Region managed contracting-out programs for agricultural engineering research and development (AERD) (mechanization and farm buildings) and wild oat control for the Research Branch, as well as the station initiatives program regionally. Twenty-nine scientists monitored 43 contracts valued at $3.32 million.

Scientists in the Prairie Region cooperated in several nonfederal programs in Alberta and Saskatchewan. As well, Prairie Region scientists contributed to projects developed through Economic and Regional Development Agreements (ERDA) between the federal government and those of Saskatchewan and Manitoba.

During 1985 Prairie Regional Headquarters in Regina relocated to share premises with other branches of Agriculture Canada. Mr. H. Korven, regional contracts specialist, retired. Dr. T.F. Townley-Smith was appointed acting director of the Regina Research Station, replacing Dr. J. Dueck who was seconded to the Canada–Pakistan cooperative project. Mr. G. Boughton was appointed superintendent of the Indian Head Experimental Farm. Dr. T. Lawrence was appointed acting director of the Swift Current Research Station, replacing Dr. D.M. Bowden who was appointed director of the Summerland Research Station, Pacific Region.

W.L. Pelton
Director General

PRÉFACE

La Région des Prairies, dont l'Administration centrale est à Regina (Saskatchewan), compte dix stations de recherches, trois fermes expérimentales et cinq stations satellites qui servent le secteur agricole des Prairies. En 1985, elle a administré un budget de 62,3 millions de dollars et disposé d'effectifs de 257 professionnels et de 806 employés de soutien.

La recherche sur les ressources naturelles met l'accent sur la conservation des sols et de l'eau. Dans des conditions de culture semi-aride et de paissance modérée par le bétail dans le sud de l'Alberta, il a fallu plus de 55 ans pour que le sol retrouve des conditions analogues à celles qui existaient dans les parcours naturels. Dans la zone de sols bruns et brun foncé, les pratiques de semis direct du blé d'hiver ont produit près de 10 % plus de rendement que le semis classique, la culture continue du blé d'hiver s'est avérée moins rentable que les assolements incluant la jachère, et les méthodes de jachère chimique se sont avérées économiquement comparables à la jachère classique.

Les recherches sur la productivité animale ont pour objet d'accroître l'efficacité de l'élevage. On a constaté que le remplacement de rations énergétiques (à base de céréales) par des rations modérément énergétiques (à base de fourrages) ne nuisait pas à la notation des géniteurs en ce qui a trait à la performance de leur descendance. En effet, les rations modérément énergétiques sont avantageuses pour accroître la capacité de reproduction et réduire les troubles digestifs. Les travaux d'évaluation de races de bovins exotiques et britanniques et de leur croisement se poursuivent et mettent l'accent sur les interactions de l'hérédité et du milieu dans la productivité des vaches. Le rationnement de l'allaitement des porcelets a permis d'accroître la performance de reproduction des truies, alors que le rationnement des aliments pendant la gestation n'a eu aucun effet sur la taille de la portée, le poids à la naissance ni le poids au sevrage des porcelets. Le fait de compléter des aliments par des acides aminés à chaîne ramifiée ou leurs homologues d'acides gras a permis d'accroître de façon spectaculaire la digestibilité des fourrages grossiers. Par comparaison avec les races établies, l'utilisation de géniteurs des races Romanov et finnoise ne réduit pas les profits et permet de produire des femelles croisées de grande capacité de reproduction. Il a été démontré que l'addition de bactériophages au boeuf réduit la contamination bactérienne de la viande, prolongeant ainsi sa conservabilité à l'étalage. De nouvelles normes ont été élaborées pour améliorer la précision et la polyvalence de la notation de la qualité du porc.

Les recherches en matière de protection portent sur la lutte contre les insectes parasites, les agents pathogènes et les mauvaises herbes. Les travaux sur les insectes parasites comprennent des études sur les insectes eux-mêmes, l'évaluation de moyens de lutte biologique et chimique, l'évaluation des dommages économiques et la mise au point de systèmes de gestion intégrée. Les résultats d'études effectuées dans le sud de l'Alberta ont permis de prédire des infestations graves de ver-gris et de sauterelles en 1985 et d'appliquer des moyens de lutte adaptés aux prédictions. La réduction de 30 % des rendements causés par la cécidomyie du blé dans le nord-est de la Saskatchewan a entraîné des pertes économiques estimatives de 30 millions de dollars.

Il se peut que la flétrissure verticillienne de la luzerne se répande grâce à l'activité pollinisatrice des mégachiles et à l'utilisation de fumier frais d'animaux nourris de luzerne contaminée. Les animaux au pâturage contribuent également à disséminer l'agent pathogène. C'est la trifluraline qui a donné les meilleurs résultats dans la lutte contre la folle avoine dans la région de Rivière-de-la-Paix, mais le recul du semis et le travail du sol pourraient également aboutir aux mêmes résultats. Des insectes prédateurs ont été découverts pour les euphorbes ésule et cyprès, l'armoise absinthe, le laiteron des champs et la centaurée diffuse.

Les cultivars homologués en 1985 sont les avoines Riel et Jasper, le carthame Saffire, le maïs N0488 et N0004, l'orge Jackson, le blé HY320 et Lancer, les pois secs Tipu et Titan, la monarde Marshall's Delight, la moutarde Cutlass, le colza Canola Tribute et le tournesol S1283.

La Région des Prairies a administré des programmes d'impartition de contrats de la Direction générale dans le domaine de la recherche et du développement en génie rural (mécanisation et bâtiments de ferme) et dans celui de la lutte contre la folle avoine, ainsi que les programmes lancés par les stations à l'échelle régionale. Vingt-neuf chercheurs ont surveillé la réalisation de 43 contrats d'une valeur de 3,32 millions de dollars.

Les chercheurs de la Région des Prairies ont collaboré à l'exécution de plusieurs programmes non fédéraux en Alberta et en Saskatchewan. Ils ont également contribué à la réalisation de projets mis en oeuvre dans le cadre d'ententes de développement économique et régional entre le Fédéral et les provinces de la Saskatchewan et du Manitoba.

En 1985, l'Administration centrale de la Région des Prairies a déménagé de Regina à Saska-

toon où elle partage des locaux avec d'autres directions générales du Ministère. M. H. Korven, spécialiste chargé des contrats régionaux, a pris sa retraite. M. T.F. Townley-Smith a été nommé directeur suppléant de la Station de recherches de Regina en remplacement de M. J. Dueck qui a été détaché dans le cadre du projet coopératif entre le Canada et le Pakistan. M. G. Boughton a été nommé régisseur de la Ferme expérimentale de Indian Head. M. T. Lawrence a été nommé directeur suppléant de la Station de recherches de Swift Current en remplacement de M. D.M. Bowden qui a été nommé directeur de la Station de recherches de Summerland dans la Région du Pacifique.

W.L. Pelton
Directeur général

Research Station, Brandon, Manitoba

PROFESSIONAL STAFF

Administration

B.H. Sonntag, B.S.A, M.Sc., Ph.D.	Director
G.I. Johannson	Administrative Officer
S. Ramsay, B.Sc.(Agr.)	Information Officer
R.J. Bomford,[1] B.Sc., M.Sc.	Systems and programming
E.D. Simundsson,[2] B.A., M.L.S.	Librarian

Animal Science

G.W. Rahnefeld, B.Sc., M.Sc., Ph.D.	Head of Section; Beef cattle breeding
A.G. Castell,[3] B.Sc., M.Sc., Ph.D.	Swine nutrition
R.L. Cliplef, B.Sc., M.Sc., Ph.D.	Meats physiology
G.W. Dyck, B.S.A., M.Sc., Ph.D.	Swine reproductive physiology
R.R. Grandhi,[4] B.V.Sc., M.Sc., Ph.D.	Swine nutrition
D.L. Grinwich, B.Sc., M.Sc., Ph.D.	Swine reproductive physiology
R.M. McKay, B.Sc., B.S.A., M.Sc., Ph.D.	Swine genetics

Plant and Soil Science

L.D. Bailey, B.S.A., M.Sc., Ph.D.	Head of Section; Soil–plant relationships
P.N.P. Chow, B.Sc., M.Sc., Ph.D.	Herbicides and weed control
D.T. Gehl,[5] B.S.A., M.Sc.	Agronomy (ERDA)
C.A. Grant,[6] B.S.A., M.Sc.	Oilseed agronomy
R.B. Irvine, B.S.A., Ph.D.	Barley physiology and agronomy
W.N. Migus, B.Sc., M.Sc., Ph.D.	Corn breeding and physiology
J.M. Sadler, B.Sc., M.Sc., Ph.D.	Soil fertility and plant nutrition
R.G. Simons, B.Sc., M.Sc., Ph.D.	Forage agronomy
M.C. Therrien, B.Sc., Ph.D.	Barley breeding and genetics

Departure

R.D. Dryden, B.S.A., M.Sc. Retired October 1985	Agronomy and weed control

[1]Seconded from Systems and Consulting Directorate, Finance and Administration Branch.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]On transfer of work at East of Scotland College of Agriculture, Penicuik, Scotland, September 1985 to September 1986.
[4]On transfer of work at Virginia Polytechnic Institute, Blacksburg, Va., August 1984 to August 1985.
[5]Appointed October 1985 as a biologist under the Canada–Manitoba agri-food agreement.
[6]Graduate student in Branch Ph.D. training program.

INTRODUCTION

The research program at Brandon encompasses beef cattle breeding; swine nutrition, physiology, genetics, and management; breeding, physiology, and management of barley, corn, soybeans, and sorghum; and soil fertility, agronomy, plant nutrition, and weed control in cereal, oilseed, and forage crops. Research programs are designed to solve production problems and to evaluate new opportunities that will enable Canadian farmers, especially those located in the eastern prairie area, to maintain or improve their competitive position in domestic and foreign markets.

Mr. David Gehl was appointed as a biologist in October. Mr. Gehl has a M.Sc. degree from the University of Saskatchewan. He is responsible for soils and agronomy research conducted at this station under the Canada–Manitoba agri-food agreement (Economic Regional Development Agreement, ERDA).

Mr. R.D. Dryden, biologist, retired in October after more than 28 years of service with Agriculture Canada. His career included work on land reclamation at the Melita Substation, agronomy and weed control at Brandon, and foreign assignments in India and Sri Lanka.

Highlights of research activities in 1985 include the release of two corn hybrids with low corn heat unit requirements, new recommendations for weed control in several crops, release of preliminary information on response of several wheat varieties to nitrogen fertilizer, and publication of results of research in beef cattle breeding; swine breeding, nutrition, and physiology; soil fertility; plant nutrition; and agronomy.

This brief report contains highlights of recent findings of our research program. More detailed results can be obtained from our annual *Review of Results*, from published papers, or by direct contact with research personnel at the Research Station, Research Branch, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

B.H. Sonntag
Director

ANIMAL SCIENCE

Beef cattle

Carcass quality characteristics of three-way cross beef cattle reared at two locations. In research conducted at Brandon, Man., and Lacombe, Alta., from 1973 to 1979 the carcass quality characteristics of 3673 progeny produced out of 10 specific F_1 crosses of dams mated to bulls of the Charolais (C), Simmental (S), Limousin (L), and Chianina (Chi) breeds were compared. Dam crosses included the traditional Hereford × Angus (HA) and crosses sired by C, S, and L bulls out of H, A, and Shorthorn (N) dams. At both locations, terminal sire breed differences indicated that Chi progeny generally exhibited darker and C progeny lighter colored rib eye muscle; Chi progeny had the lowest percentage chemical fat and C the highest; and Chi progeny showed the highest percentage moisture and C the lowest. Although there were significant differences in Warner–Bratzler shear force values at both locations, these differences were not large. The significant breed rankings ($P \leq 0.05$) were S > Chi and Chi > L at Brandon and Chi > L at Lacombe. At Brandon, the significant breed rankings for pH were Chi > S and Chi > L and for texture score were Chi > C, Chi > S, and Chi > L. Chi progeny had the lowest conformation scores and L progeny the highest. At Lacombe, significant progeny differences were recorded for water retention capacity with S > Chi. At Brandon, breed of sire of dam effects indicated the progeny from S-cross dams had the highest texture scores while progeny from L-cross dams had the lowest percentage chemical fat, the lowest skeletal maturity scores, and the highest percentage moisture. Progeny from C-cross dams had the highest conformation scores. At both locations, significant differences in Warner–Bratzler shear force were observed with S > L and S > C. Direct comparison of progeny from exotic-cross dams versus progeny from HA dams at both locations indicated that the progeny from HA dams had lighter colored rib eye muscle, a lower percentage moisture, higher marbling scores, and a higher percentage chemical fat. At Lacombe, the HA dams had progeny with lower Warner–Bratzler shear force. At Brandon, the progeny from HA dams had lower texture scores, higher firmness scores, lower percentage protein, and generally lower conformation scores. Although significant differences were found between breeds of terminal sire and breed cross of dam for some of the traits evaluated, they were too small to be of any commercial consequence.

Calving and preweaning performance of crossbred progeny of some foreign and domestic beef cattle breeds. Calving and preweaning performance for 3939 Charolais-, Simmental-, and Limousin-sired calves born in 48 western Canadian beef cow herds of Hereford, Angus, and Shorthorn breeding during the period 1970–1972 were evaluated. Hereford cows produced calves with longer gestation lengths, higher birth weights, slower preweaning growth, and lower weaning weights than Angus cows. Shorthorn cows produced progeny with the shortest gestation lengths and intermediate performance in other traits. Limousin sires produced calves with the longest gestation lengths, the least calving difficulty, the lightest birth weights, the lowest birth-to-weaning mortality, and the slowest preweaning growth. Charolais- and Simmental-sired calves did not differ significantly in gestation length, postnatal mortality, or preweaning growth rate, but Simmental-sired calves were lighter at birth and calved more easily.

Swine

Genetic correlation between boars, barrows, and gilts for various carcass traits. Genotype × sex interactions ($-1.0 < r_G < 1.0$) were found for total carcass fat, area of lean in the ham face, and percentage lean in the ham face. Carcass length, longissimus muscle area per kilogram of cold carcass weight, and percentage ham of side and lean in the ham face did not exhibit genotype × sex interactions. There was no benefit from separate genetic parameter estimates for sex in selection response equations, regardless of the presence or absence of genotype × sex interactions.

Effect of diet and sex on growth and carcass characteristics of Lacombe and Yorkshire pigs. A total of 144 pigs consisting of three pairs of littermate boars, castrates, and gilts from each of 12 litters of Lacombe (L) or Yorkshire (Y) breeds were assigned to 24 pens, six pigs of the same breed and sex in each pen. Half the pigs in each group were fed from 9 weeks of age to 89 kg average liveweight on two different diets: either a higher nutrient density (HND) diet (16.3% protein and 12.48 MJ metabolizable energy ((ME) per kilogram) or a medium nutrient density (MND) diet (16.1% protein and ME at 11.71 MJ/kg). The MND diet increased ($P < 0.01$) the feed consumption (2.45 versus 2.22 kg/day), resulting in a higher ($P = 0.08$) growth rate (806 versus 780 g/day) for L but not for Y pigs. In both breeds, growth rate was higher ($P < 0.05$) in castrates and boars than in gilts. Boars were consistently leaner than castrates, but the superiority of gilts over castrates with respect to carcass leanness was limited to Y pigs. These differences in response influence the choice of diet and sex used in pig testing systems for identifying replacement breeding stock.

Effect of green foxtail seeds in diets on growth performance of pigs. Barley–wheat–soybean meal growing–finishing diets containing 0, 5, 10, 15, 20, and 25% of wheat screenings (95% green foxtail seeds) were fed ad libitum to a total of 48 Yorkshire barrows and gilts from 34 to 89 kg liveweight. Higher dietary levels of green foxtail resulted in a gradual increase ($P < 0.05$) in feed intake and reduced ($P < 0.05$) feed efficiency with no consistent effects on growth rate or carcass composition. Increased dietary levels of green foxtail also reduced the apparent digestibility of energy and nitrogen in barrows.

Effect of chlortetracycline supplementation on reproductive performance of gilts. A total of 89 crossbred gilts were limit-fed (2.5 kg/day) a 14% protein corn–soybean meal gestation diet containing 0 or 220 g of chlortetracycline (CTC) per tonne from 157 days of age until 15 days after breeding at second estrus. The reproductive tract and fetal data were recorded after sacrificing the gilts at 30 or 70 days of gestation. The pubertal age (191 versus 195 days) and body weight (106 versus 107 kg) were similar between the control and CTC-fed gilts. At 30 days of gestation, gilts fed CTC had a higher number of corpus lutea (14.2 versus 12.9), live embryos (12.1 versus 9.7, $P = 0.04$), and embryo survival (85.5 versus 75.4%) than the control group. At 70 days of gestation, increases ($P > 0.05$) were observed only in the number of corpus lutea (13.9 versus 12.4) and live embryos (10.0 versus 9.6).

Reproductive performance of multiparous sows following nutrient intake restriction after mating. On the first day of mating at postweaning estrus, 96 sows were allocated to three dietary treatments of 1.84 kg control diet (C), 0.92 kg control diet plus 0.92 kg pelleted hay (R), or 1.84 kg pelleted hay per day (M) for the following 10-day period. Subsequent to the 10-day period of nutrient intake restriction, all sows were fed 1.84 kg of the control diet once daily. The treatments had no effect on pregnancy rate (24, 23, and 22 sows, respectively), number of piglets born, number born alive, number weaned, and piglet weight at birth or at weaning. During the 10-day period of nutrient intake restriction, sows on the M treatment lost more weight (8.6 kg) than sows on the R (3.4 kg) or the C (0.7 kg) treatments. However, weight gain from estrus to day 110 of gestation was similar for all three treatments (16.5, 17.8, and 17.1 kg, respectively). Thus,

restriction of nutrient intake early in pregnancy is not a critical factor affecting litter size and weight at birth or weaning in the multiparous sow.

Fetal weight at mid pregnancy. A stepwise regression analysis was utilized to determine the influence of 11 variables on fetal weight (FW). Nine of the variables had an effect and accounted for 66.53% of the variation in FW. The first six variables selected were parameters associated with the individual fetus and accounted for 65.35% of the variation in FW. These parameters and their respective increases in the R^2% were uterine weight for the area of implantation (47.51%), fetal age (8.76%), amniotic fluid volume (3.23%), fetal sex (3.37%), fetal membrane weight (1.68%), and allantoic fluid volume (0.80%). Location of the fetus in the uterine horn, diet intake, and the number of fetuses in the uterine horn had minor effects; year group of gilts and left versus right uterine horn had no significant effect on the R^2%.

Effects of reduced suckling on days to estrus, conception during lactation, and embryo survival in sows. Trials to investigate the effects of limited suckling on sow reproduction and piglet growth were conducted using 41 first parity and 32 second parity Yorkshire sows. Separation of sows from their litters (22 h/day, days 21–35 postpartum) induced estrus in 60% of primiparous and 72% of second parity sows during lactation. Compared to control group animals, primiparous sows had higher weaning weights and second parity sows had higher rates of embryo survival on day 30 of gestation. Piglets subjected to suckling restriction had weights at 2 weeks after weaning equal to those weaned after 5 weeks of unrestricted suckling. Suckling restriction can provide the dual benefits of an extended piglet nursing period and a decreased breeding-to-breeding interval in sows.

Depletion of 5α-androstenone (boar taint, sex odor) following castration. Castration of mature boars resulted in serum and loin fat levels of 5α-androstenone gradually declining. The levels decreased to approximately 10% of those from intact boars by 12 weeks after castration. Sensory odor scores of loin fat from boars 12 weeks after castration were significantly lower than those from intact boars and were consistent with increased acceptability of the product. Results of this study suggest that meat from castrated mature boars 12 weeks after castration is as acceptable as that from mature sows and worth an equivalent price. Therefore, producers may realize a profit by castrating and feeding mature boars provided they have the time and facilities to hold them for 10–12 weeks and receive a price equivalent to that paid for sows.

PLANT AND SOIL SCIENCE

Cereal crops

Barley breeding, physiology, and management. Barley cultivars developed at Brandon continue to be among the top performers in the western cooperative licensing and eastern prairie barley tests. Currently, there are three entries in the former tests: one malting and two feed types. BT 363, a feed type, has been the top yielding line for the past two seasons. In the latter tests, there are seven Brandon entries: a two-row malting type, four six-row malting types, and two six-row feed types. All barleys advanced to these tests are selected because they are superior to current standards in yield, disease resistance, and other agronomic characteristics.

In studies to identify barley cultivars with improved growth at cool temperature, winter barleys were crossed with spring barleys. Lines selected from such crosses showed no potential for improved yield. However, Johnston, a Brandon cultivar, showed excellent potential as a genetic source for cool temperature tolerance.

In a series of hydroponic and field experiments to determine the effects of various cations and cationic interactions on the yield and nutrient uptake of barley, it was found that high concentrations of calcium or magnesium reduced dry matter yield. Also, the tissue concentration of both calcium and magnesium became greater as the concentration of both nutrients increased in the soil or solution culture. Neither the calcium nor magnesium concentration in the solution had an effect on potassium uptake. However, at very high concentrations of calcium and magnesium, the uptake of manganese and zinc increased.

Management of semidwarf wheat. Field studies confirmed that semidwarf wheat cultivars adapted to the eastern Canadian prairies have the ability to outyield red spring wheat cultivars. The semidwarf wheats yielded more and showed greater efficiency in nitrogen fertilizer use under optimum growing conditions. HY 320 consistently outyielded American semidwarf cultivars like Len and Solar, Katepwa hard red spring wheat, and Glenlea utility wheat. When conditions were such that yield response to nitrogen fertilizers was low, HY 320 yielded better than or equivalent to Marshall, another American semidwarf wheat.

Weed control in cereals. Sequential application of two types of herbicides, preplant incor-

poration of triallate or trifluralin and post-emergence application of barban, difenzoquat, or flamprop-methyl, for grass control in wheat showed no detrimental effects to the crop and good control of weeds. The results are of practical importance to producers, in that in years when soil-incorporated herbicides fail to control weeds due to adverse weather conditions, post-emergence herbicides could be used without harming the crop.

In other field, greenhouse, and laboratory studies, chlorsulfuron mixtures with barban or difenzoquat at rates ranging from 0.02 kg/ha to 0.08 kg/ha had no detrimental effect on wheat. However, mixing the chemical with diclofop-methyl or flamprop-methyl reduced wheat yield. Laboratory investigation revealed that chlorsulfuron reduced the rate of penetration and translocation of ^{14}C-diclofop-methyl in the plants, thus explaining the antagonistic effect noted for mixtures of these two chemicals.

Corn breeding, physiology, and management. Despite adverse climatic conditions during the past two growing seasons, progress has been made in developing and evaluating corn cultivars adapted to the short cool growing season of the Canadian prairies. In 1985, two Brandon hybrids, N0488 and N0004, were supported for licensing and released to industry. N0488, distributed by Pickseed as 2488, is a 2150 corn heat unit (CHU) hybrid that combines high yield and drier grain at maturity. N0004, available from Ciba Geigy as N004, is a high-yielding 2200 CHU hybrid with excellent stalk strength.

Weed control in sorghum. Research at Brandon supported the registration of three herbicide treatments for weed control in sorghum: preplant incorporation of atrazine for the control of wild oats, green foxtail, and broad-leaved weeds; preplant incorporation of metolachlor plus seed treatment with a crop protectant for the control of green foxtail; and postemergence application of bromoxynil plus MCPA ester or 2,4-D amine for the control of broad-leaved weeds.

Oilseed crops

Soil management for improved crop productivity. Field, growth chamber, and laboratory studies were conducted to assess sulfur (S) status of eastern Canadian prairie soils, to develop an effective index for assessing the availability of soil S to plants, and to develop new technology for the efficient management of plant-available S in the soil. Total soil S at various depths was significantly correlated with both total nitrogen (N) and organic carbon (C). The soils were divided into three groups on the basis of N:S ratios. Group 1 consisted of soils with low N:S ratios, high levels of sulfate–sulfur, and a high potential to supply plant-available S to all crops. Group 2 included soils with medium N:S ratios. They may be deficient in plant-available S for some crops but have a high potential to convert total S to sulfate–sulfur. Group 3 soils exhibited high N:S ratios and a low potential to convert total S to sulfate–sulfur. Thus, they may be deficient in S for most crops. When all three soil groups were cropped to alfalfa, barley, and rapeseed, it was found that the soil N:S ratio was the best predictor of yield. Barley was the most responsive of the three crops to S fertilizer, although it had the lowest concentration of S (0.15 mg/g of soil) and highest plant N:S ratio (16) at optimum yield. Rapeseed was more responsive to applied S than alfalfa, but both crops had similar levels of S at optimum yield (0.26 and 0.27 mg/g of soil, respectively). Rapeseed, however, had the lowest plant N:S ratio (12 for rapeseed versus 14 for alfalfa). This reflects the greater uptake of S by rapeseed and the high N content of alfalfa.

Crop rotation studies. A summary of 3 years of data on two crop rotations (flax/soybeans–wheat–corn–barley) under minimum and zero tillage systems with recommended fertilizer and weed control practices showed that yields of flax, soybeans, and corn were higher on minimum- than on zero-tilled plots. Wheat yields were similar on both tillage treatments. High yields of barley after corn in the flax rotation on zero-tilled plots compared with minimum-tilled plots were attributed to the residual effects of very poor corn production in the year preceeding barley.

Weed control in oilseeds. Research supported the licensing of Sabre (bromoxynil/MCPA), Hoe-Grass II (diclofop-methyl/bromoxynil), and Sabre/Poast tank mix for broad spectrum weed control in flax and Lontrel (clopyralid) for the control of Canada thistle and wild buckwheat in canola.

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INTRODUCTION

The programs at the Morden Research Station are directed toward the development of new cultivars and the improvement of management practices for buckwheat, field corn, field peas, new crops, flax, sunflowers, potatoes, vegetables, and herbaceous and woody ornamentals. This report summarizes some of the results obtained from research conducted during 1985.

Three new cultivars were licensed or released, Tipu and Titan field peas and Marshalls Delight *Monarda*. A semidwarf buckwheat line was released as germ plasm, and a new line of lathyrus, with a low content of neurotoxin, was developed. New information on the genetics of plant diseases was obtained. Several successful herbicide treatments were identified for control of weeds in a wide range of crops.

Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 3001, Morden, Man. R0G 1J0.

D.K. McBeath
Director

FIELD CROPS

Buckwheat

Breeding. A semi-dwarf line of buckwheat, CM 221, was released as germplasm. It has a height of approximately 80 cm, compared with 110 cm for presently grown cultivars. This is conditioned by a single recessive gene. The height reduction is due mainly to shortening of the first six internotes of the plant with remaining growth being normal. The resultant plant has reduced height and early initiation of branching, especially from cotyledonary axils. This results in a much branched upright growth habit resistant to lodging.

Management. In a seeding rate study that included new large-seeded and semi-dwarf genotypes, there was no consistent effect of seeding rate on plant height, seed weight (grams per 1000 seeds) or seed density. In six of the eight location-years, there was no interaction of genotype × seeding rate for seed yield, indicating that, generally, the cultivars and lines reacted similarly to differences in seeding rate. It was concluded that a seeding rate of 30 to 45 kg/ha would ensure optimum yield in most years.

Weed control. Desmedipham, for broad-leaved weed control, was most effective when applied at the four-leaf stage of buckwheat. Tank mixtures of desmedipham with grass herbicides provided excellent control of most annual weeds. Fluorochloridone applied preemergence combined high crop tolerance with complete control of wild mustard.

Field corn

Breeding. Two major differences between dent (Canadian) and flint (European) corn hybrids were found to be that the grain filling period for the dent hybrids was 7.3 days shorter than for flints, and that dent hybrids, on average, had 5.5% less moisture at the time of physiological maturity. The rate of drying after physiological maturity was the same for both hybrid groups. Rate of drying was not affected by pericarp thickness, but was affected by number and tightness of husks.

Weed control. Flamprop-methyl, applied at the four- to five-leaf stage of field corn, continued to be a very promising herbicide for the control of wild oats. Several new vegetable oils were equal to Bio-Veg as adjuvants for cyanazine.

Field peas

Breeding. Two new cultivars of field peas were licensed. Tipu is a semi-leafless, yellow seeded cultivar, in which leaflets are modified into tendrils. This characteristic results in superior standing ability, more uniform drying at harvest, better penetration of insecticide and herbicide sprays, and reduced incidence of leaf diseases. Titan is a conventional, yellow-seeded cultivar adapted to western Canada. It outyields Century by 9% and its seed size is slightly larger. Both cultivars will be distributed by SeCan.

Weed control. Trifluralin, tank-mixed with EL 107 or fluorochloridone, and applied preplant, soil incorporated, resulted in excellent weed control with acceptable crop tolerance. Postemer-

gence treatments of bentazon, cyanazine, or metribuzin, tank-mixed with grass herbicides, were equally effective.

New crops

Breeding. A line (LS 8246) of grass pea, *Lathyrus sativus*, low in the neurotoxin β-*N*-oxalyl-L-α-β-diamino propionic acid (ODAP), has been developed. ODAP, a free amino acid, has been identified as the causal agent for lathyrism, a neurodegenerative disorder precipitated by excessive consumption of *Lathyrus sativus*. LS 8246 contained ODAP at concentrations of 329, 259, and 401 μg/g of seed in 1982, 1983, and 1985, respectively, compared with 2615 μg/g in Pusa 24, a cultivar developed in India.

Weed control. Preemergence surface applications of fluorochloridone were effective for the control of wild mustard in lentils. Tank mixtures of metribuzin with grass herbicides combined excellent broad spectrum weed control with acceptable crop tolerance.

Flax

Pathology. Regression analysis of the postseedling rust reaction (PSRR) of 10 flax cultivars to exotic virulent races 22 and 79 indicated that the reaction to one race is a quadratic function of the reaction to the other race. The correlation coefficient was 79%. Generally, high levels of PSRR to both races were associated with the K^1 and L^6 seedling resistance genes.

Weed control. Clopyralid continued to be an excellent herbicide for control of Canada thistle in flax. New mixtures of bromoxynil and MCPA were compatible with most grass herbicides and provided excellent broad-spectrum weed control.

Sunflowers

Genetics. The correlation coefficients for oil content among four sets of hybrids and their parental lines ranged from –0.36 to +0.44. This would indicate that selection of high oil lines from within a population may not lead to the development of high oil hybrids. The effect of heterosis on oil content was very high, resulting in an increase of 6 percentage points above the mean oil content of the parents. This increase was higher than has generally been reported.

Pathology. Since its discovery in 1981, downy mildew race 3, virulent to all current hybrids, has been found to be of increasingly wider distribution. This race is now firmly established in southern Manitoba.

Studies on the twisted leaf syndrome of downy mildew (Research Branch Report, 1982) indicate that its inheritance is complex and is due to a heterozygous condition among two or three genes for resistance to downy mildew, including Pl_1, Pl_2, and Pl_3.

Management. In a plant density study that included hybrid and open-pollinated oil-type cultivars grown at two soil fertility levels, there were few significant interactions, indicating that the genotypes responded similarly to the fertility and plant density levels. With increase in plant density from 30 000 to 75 000 plants per hectare, there was a slight delay in flowering time, an increase in plant height, test weight, and oil content, and a decrease in achene weight, but achene yield was not markedly affected. In a similar study with the non-oil cultivar Sundak, the fertilizer application increased achene yield in two of the three years and increased achene size in one of the three years. Achene size decreased with increase in plant density and achene yield reached a maximum at approximately 30 000 plants per hectare. As a result of these studies, the recommendations for plant density in Manitoba were revised.

Weed control. Fluorochloridone, preemergence and surface applied, was the most effective treatment for wild mustard control. Soil-incorporated treatments of fluorochloridone required higher dosages, and postemergence applications resulted in significant crop injury. AC 222239 controlled both wild mustard and wild oats, but crop yields from this treatment did not equal the hand weeded treatment because of surviving green foxtail.

Soybeans

Weed control. Volunteer wheat, a major weed problem in this crop, was not controlled by FOE 3440A and fenoxaprop and only partially controlled by cloproxydim. EL 107, when added to trifluralin or ethalfluralin, greatly increased the control of wild mustard.

HORTICULTURAL CROPS

Ornamentals

Breeding. A new cultivar of *Monarda*, Marshalls Delight, was described and introduced. This cultivar is a complex hybrid originating from *M. fistulosa menthifolia* and *M. didyma* 'Cambridge Scarlet'. Flowers are pink (RHS 63-B) and are produced in early to mid summer. This cultivar demonstrates good resistance to powdery mildew and moderate resistance to rust, the two most serious diseases of *Monarda*. *Monarda* is grown as an ornamental herbaceous perennial.

Evaluation. Plant evaluations were continued for woody and herbaceous species and cultivars. Two-hundred and ninety-seven herbaceous and 27 woody plants and seeds were accessioned for further evaluations. A new planting of ground covers was established.

Potatoes

Management. Total and marketable yields of Carlton potatoes increased with decreasing in-row spacings from 46 to 22 cm. Yields also increased when harvesting was delayed from 75 to 85 and 95 days after planting. The increased yield produced by a delay in harvest from 75 to 85 days resulted from both a greater number of tubers harvested and a larger average size of tubers, whereas the increased yield between 85 and 95 days resulted from only a larger average size of tuber. Net crop value (value of harvested crop minus the cost of seed) reached a maximum for the 75 day harvest with an in-row spacing of 22 cm regardless of seed cost, whereas for the two later harvests, net crop values were highest at the 22 cm spacing using a low cost of seed ($234.00/t), and at the 30 cm spacing using a high cost of seed ($498.67/t).

Small tubers derived from single-node stem cuttings of four cultivars of potato, Carlton, Conestoga, Tolaas, and Yukon Gold, were tested with various treatments to break dormancy. Dipping tubers, from which a small portion of the stem end had been removed, into a 10^{-5} *M* solution of gibberellic acid for 1 h proved to be as good as, or superior to, exposing whole tubers to gas from a rhindite solution for 48 h prior to planting.

Vegetables and fruits

Carrots. Carrot cultivars grown for processing were evaluated for marketable yield and color of cooked roots over a period of 4 years, 1982–1985. The highest yields were obtained in 1982, and the lowest, in 1984. The color was excellent in 1982 and 1983, acceptable in 1984, and unacceptable in most cultivars in 1985. In 1985, only Dess Dan and Casey had an *a:b* ratio slightly above the minimum acceptable value of 0.95. Dess Dan, Midas Touch, Texsun, Red Cored Chantenay, Camillo, and Casey were rated to be the best performers among the cultivars tested during a 4-year period.

Cauliflower. Yield, head diameter, and objective color measurements of fresh and processed curds were influenced by cultivar and growing season over a 3-year period. Sensory evaluation indicated that all cultivars tested yielded a frozen product similar to, or better than, those currently available in the marketplace. To allow for an extended processing season, the earliest cultivar, Snow Crown, and the midseason cultivar, Andes, appear to be most suitable for processing production in the prairie region.

Utilization and quality

Anthocyanins, total phenolics, and sugars increased with ripening of saskatoon berries. Titratable acidity and pH differed among cultivars but showed little change with berry development. Significant correlation with anthocyanins was obtained for total phenolic content, titratable acidity, pH, and sugar-to-acid ratio. However, the relationships between surface color and compositional factors of the berries were low and seldom significant. These results suggest that high levels of anthocyanins in saskatoon berries are associated with high total phenolics, high acid content, low pH, and low ratios of sugar to acid.

Weed control. Onions exhibited acceptable tolerance to postemergence applications of oxyfluorfen applied at the two- to four-leaf stage at rates with active ingredient (a.i.) not exceeding 0.24 kg/ha. Cyanazine with a.i. at 1.3 kg/ha applied preemergence resulted in complete killing of the crop. Oxyfluorfen selectively controlled purslane, whereas bromoxynil controlled wild mustard, redroot pigweed, and lamb's-quarters.

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S.M. Woods, B.Sc., M.Sc., Ph.D.	Programmer–Analyst

Cereal Breeding

D. Leisle, B.S.A., M.Sc., Ph.D.	Head of Section; Durum wheat breeding
D. Brown, B.S.A., M.Sc., Ph.D.	Oat breeding
A.B. Campbell, B.S.A., M.Sc., Ph.D.	Common wheat breeding
E.M. Czarnecki, B.S.A., M.Sc.	Common wheat breeding
P.L. Dyck, B.S.A., M.Sc., Ph.D.	Wheat genetics
E.R. Kerber, B.S.A., M.Sc., Ph.D.	Wheat cytogenetics
M.I.P. Kovacs, B.Sc., M.Sc., Ph.D.	Cereal chemistry
O.M. Lukow, B.Sc., M.Sc., Ph.D.	Cereal chemistry
D.R. Metcalfe, B.S.A., M.Sc., Ph.D.	Barley breeding and genetics
R.I.H. McKenzie, B.S.A., M.Sc., Ph.D.	Triple-medium wheat breeding
J.S. Noll, B.Sc., Ph.D.	Cereal chemistry and physiology

Cereal Diseases

R. Rohringer, Dr.Sc.Agr.	Head of Section; Molecular biology of cereal rusts
J. Chong, B.Sc., M.Sc., Ph.D.	Oat crown rust
C.C. Gill,[2] B.Sc., Ph.D.	Viruses
S.M. Haber, B.Sc., M.Sc., Ph.D.	Viruses and biotechnology
D.E. Harder, B.Sc., M.Sc., Ph.D.	Oat stem rust
N.K. Howes, B.Sc., Ph.D.	Molecular biology and biotechnology
W.K. Kim,[3] B.Sc., M.Sc., Ph.D.	Molecular biology of cereal rusts
J.W. Martens, B.Sc., Ph.D.	Wheat stem rust
J.J. Nielsen, Dr.Sc.Agr.	Smuts
D.J. Samborski, B.S.A., M.Sc., Ph.D.	Wheat leaf rust
A. Tekauz, B.Sc., M.Sc., Ph.D.	Leaf diseases
P.L. Thomas, B.S.A., M.Sc., Ph.D.	Microbial genetics, smuts

Stored Products

J.T. Mills, B.Sc., Ph.D., D.I.C.	Head of Section; Development and control of storage molds
D. Abramson, B.Sc., M.Sc., Ph.D.	Mycotoxicology
P.S. Barker, I.A., M.Sc., Ph.D.	Biology and control of stored grain pests
S.R. Loschiavo, B.Sc., M.Sc., Ph.D.	Stored grain insect biology

Integrated Pest Control

W.J. Turnock, B.S.A., M.Sc., Ph.D.	Head of Section; Ecology and population dynamics
G.L. Ayre, B.S.A., M.S.A.	Insect ecology
R.P. Bodnaryk, B.A., M.Sc., Ph.D.	Biochemistry and toxicology
G.K. Bracken, B.Sc., M.Sc., Ph.D.	Physiology and behavior
G.H. Gerber, B.S.A., Ph.D.	Histology, physiology, and behavior
R.J. Lamb,[4] B.Sc., M.Sc., Ph.D.	Systems biology
O.N. Morris, B.Sc., M.Sc., Ph.D.	Insect pathology
W. Romanow, B.S.A., M.Sc.	Insect surveys and control
G.H. Wylie, B.A., Ph.D.	Host–parasite relations

Departure

V.M. Bendelow, B.Sc., M.Sc., Ph.D. Retired 14 March 1985	Cereal chemistry

VISITING SCIENTISTS

R. Heitefuss, Dr. Sc. Agr.	Resistance genetics and physiology
Yoo Chong Myung, Ph.D.	Electrophoresis of insect proteins

Graduate students

A. Baillie, B.S.A.	Oat breeding
R. Butts, B.Sc., M.Sc.	Entomology
P.P. Claude, B.Sc.	Genetics in wheat
M. Howlader, B.Sc., M.Sc.	Entomology
L. Kawchuk, B.Sc.	Bunt of wheat
W. Legge, B.S.A., M.Sc.	Durum wheat research
Luo Ma, B.Sc., M.Sc.	Physiology and biochemistry of insects
G. Maiteki, B.Sc.	Entomology
G. Penner, B.S.A.	Cytogenetics in wheat
A. Plourde, B.Sc.	Plant breeding
M. Trottier, B.Sc.	Entomology
T. Warkentin, B.S.A.	Oat breeding

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On medical disability leave from 4 December 1985.
[3]On a transfer of work to University of Aachen, Aachen, West Germany, 16 April 1985–22 December 1985.
[4]On a transfer of work to Commonwealth Scientific and Industrial Research Organization (CSIRO), Canberra, Australia, 15 August 1985–1 May 1986.

INTRODUCTION

Research programs at the Winnipeg Research Station focus on three main areas of responsibility: the development of improved cultivars of cereals specifically adapted to the "rust area" of the eastern prairies; research on the protection of stored cereals, oilseeds, and their products; and research on the integrated control of insect pests of field crops. In each of these areas, interdisciplinary teams of scientists are pursuing both mission-oriented and basic research.

Improvement of cereal cultivars requires the close collaboration of plant breeders, geneticists, cytogeneticists, plant pathologists, and cereal chemists. As a result of such collaboration, a new oat cultivar, Riel, was licensed in 1985. It combines exceptional kernel quality, excellent rust resistance, and good yield under Manitoba conditions. A breeding program to develop high-yielding, triple-medium wheats for the eastern prairies was also initiated following the recent decision by the Canadian Grain Commission and the Canadian Wheat Board to establish a new class of wheat having medium protein, medium hardness, and medium gluten strength.

Our research on the storage and protection of cereals, oilseeds, and their products is national in scope and involves close cooperation with the Canadian Grain Commission, the Plant Health and Plant Products Directorate, and the grain industry. Particular emphasis is being placed on understanding the ecology of organisms infesting stored grain, the development of safe storage guidelines, chemical and physical measures to control infestations, and the microbiological and environmental factors influencing the occurrence of mycotoxins. We are also focusing attention on improved means of detecting infestations and controlling storage insects with minimal use of chemicals. In ongoing research to this end, it was shown that measurement of carbon dioxide concentration in stored grain is a practical method for detecting spoilage. A simple early-warning test kit utilizing this principle was developed for use by producers.

Research on the integrated control of field crop insects, particularly those that attack canola and the various "special crops" grown in southern Manitoba, includes the biology and ecology of pest species, the evaluation of biological and chemical control measures, the assessment of economic damage, and the development of integrated management systems. In 1985 it was verified that a parasite (*Aphidius smithi*) of the pea aphid, originally released in 1983, had overwintered and is becoming established.

During 1985, Dr. P.L. Dyck was named an honorary member and Dr. J. Chong was awarded the Gordon J. Green Award by the Canadian Phytopathological Society, in recognition of their outstanding research contributions in identifying rust resistance genes, and in describing the fine structure of cereal rusts, respectively. Dr. R.N. Sinha was awarded the Entomological Society of Canada Gold Medal for his outstanding achievements in stored product entomology.

The Winnipeg station celebrated its 60th anniversary in 1985. Since 1925, we have released 33 cereal cultivars including hard red spring and durum wheats, oats, and malting barley. In 1985, over 80% of the area sown to hard red spring wheat was sown to cultivars from our station and these and other rust-resistant releases continue to make cereal production possible in the rust area. We look forward to serving the agricultural industry as successfully in the future as in the past with continuing research in the development of improved cereal cultivars, control of insect pests of field crops, and protection of stored grain from pests.

The following is a brief summary of research carried out in 1985. Further information or reprints of this report or of the listed publications can be obtained by writing to individual scientists or to the Research Station, Research Branch, Agriculture Canada, 195 Dafoe Road, Winnipeg, Man. R3T 2M9.

T.G. Atkinson
Director

BREEDING, GENETICS, AND CYTOGENETICS

Barley

On-going plant-scale malting and brewing trials to evaluate the market potential of the two-rowed line TR212 gave satisfactory results on the 1984 crop. Further production was contracted by the Canadian Wheat Board in 1985 for the second and final year of evaluation. Adequate pedigreed seed has been produced for the release of this line to producers if the 1986 evaluations are favorable. Five additional Winnipeg selections were evaluated in the two-rowed western cooperative test, and seven in the eastern prairie test. These lines

have good agronomic features, refined malting quality, and resistance to stem rust.

Research continued to identify and incorporate resistance to various diseases. The seedling-type resistance to stem rust shown by the Australian selection B12 did not stand up in field tests; thus the Peatland gene continues to be the sole source of resistance. A good source of resistance to the new virulent net blotch culture 858 has been identified in the line TR473. This resistance source was utilized in crosses and rapidly advanced to F6 generation by single seed descent. Progress continued in the incorporation of resistance to loose smut, barley yellow dwarf virus (BYDV), and rootrot into both two- and six-rowed lines.

The screening for low polyphenol mutants, using sodium azide as the mutagen, yielded 15 potential selections. Two were shown to be homozygous, free from anthocyanin–catechin phenolic compounds. These are being studied further to determine whether better beer stability can be obtained without the associated problems noted in earlier low polyphenol selections.

Common wheat

In 1985 the new cultivars Benito, Columbus, and Katepwa occupied a total of 41% of the prairie bread wheat hectarage. Katepwa made a dramatic increase to 18% from less than 2% in 1984. Two lines were retained in the 1985 cooperative test for a third year of testing. The line BW92, which yields equal to Neepawa but which has significantly higher protein content, will be considered for licensing in 1986. The line BW90, which combines a protein content equal to Neepawa with significantly higher yield, has a problem in that it lacks class distinguishable kernel characteristics. It is being retained for possible test marketing by the Canadian Wheat Board.

Backcrossing to transfer *Aegilops* leaf rust resistance into Katepwa and post-harvest dormancy into Benito was completed and homozygous lines are being established for further testing.

A new breeding program to develop triple-medium wheats for the eastern prairies was initiated with the establishment of the new Prairie Spring class of wheat and with support from the agri-food subagreement of the Canada–Manitoba Economic Regional Development Agreement. Several hundred introductions and segregating populations were evaluated and initial selections of promising parental material made.

A genetic study of leaf rust resistance in nine accessions, selected after extensive testing from over 7000 accessions from the United States Department of Agriculture World Wheat Collection, determined that they all carried previously identified genes. The genes involved were primarily *Lr*T2, *Lr*T3, and *Lr*16, and those present in RL6057 and RL6077. These results emphasize the difficulty of identifying sources of new rust resistance genes for breeding programs. Additionally, a group of 391 accessions from the Plant Breeding Institute, Cambridge, were evaluated for stem and leaf stem resistance. Thirty-four and 100 of these were resistant to stem and leaf rust, respectively. Known stem rust genotypes were assigned to 11 accessions, and known leaf rust genotypes to seven accessions.

Seedling stem rust resistance derived from *Aegilops squarrosa* RL5497-1 was shown to be due to a single new gene, which gives high resistance to all races tested. Certation was involved in the transmission of this gene, with the pollen carrying the resistance gene being more effective. A similar case of certation was identified for closely linked leaf rust and stem rust resistance genes derived from RL5347 (*A. speltoides* × *Triticum monococcum*).

A study of the hexaploid cultivar Prelude and the derived tetraploid "Tetraprelude" showed that elimination of the D-genome affected both stem rust resistance and gliadin protein composition. Tetraprelude was resistant to stem rust race C25 (38) while Prelude was susceptible. Also, in contrast to Prelude, Tetraprelude lacked gliadin band 38 but had band 45. Moreover, Tetraprelude showed greatly improved gluten quality characteristics. It has been shown in durum wheat that gliadin band 45 is associated with strong gluten characteristics. It is postulated that these changes are due to the presence of a suppressor on the D-genome.

Durum wheat

The cultivar Medora increased in importance in Manitoba occupying about 32% of the area sown to durum wheat. Together with the cultivar Coulter, these Winnipeg releases account for almost 60% of the province's durum production. Four new entries with slightly shorter straw and good lodging resistance are showing promise in advanced field tests.

Investigation of the genetic basis of stem rust resistance in the cultivars Medora, Coulter, and Wakooma indicates that in Medora and Coulter resistance is more complex than in Wakooma, and should thus afford more stable protection against race changes. In the backcross program to incorporate loose smut resistance from DT369 into commercial cultivars, the genetic data suggest that resistance is recessive. This complicates the backcrossing process, and other sources of resistance are being investigated.

Genetic analysis confirmed that glume color is closely linked to gliadin bands 42 and 45, with a crossover value of 7–10%. It was also shown that gluten strength, as measured by the sodium dodecyl sulfate (SDS) sedimentation test, related closely to the genetics of the gliadin bands, with the heterozygous band 42/45 genotypes falling midway between the weak gluten homozygous band 42 and the strong gluten homozygous band 45 types. Gluten strength data indicated that an additional gene, independent of those controlling these two gliadin bands, is also involved.

Improved methodology was developed for the SDS-sedimentation test and for analysis of phospholipids. The sedimentation test, used for early generation quality screening, was simplified by eliminating several steps involving agitation of the solution, thus improving productivity. The modified phospholipid analysis using an altered digestion procedure, simplifies the determination and improves reproducibility.

Oats

Riel, a new spring oat cultivar that combines exceptional kernel quality with excellent disease resistance and good yield, was licensed in 1985. It is the first tan-hulled oat cultivar licensed in Canada, a result of earlier research showing an association of tan hull with reduced hull content. Riel possesses genes *Pc*38 and *Pc*39 that confer very good resistance to all known isolates of oat crown rust. It possesses stem rust resistance genes *Pg*2 and *Pg*13, and possibly *Pg*1 and *Pg*9, but like Dumont and Fidler is susceptible to the rarely occurring race NA26. Like Dumont and Fidler it is resistant to all races and collections of loose and covered smut to which it has been tested. Riel appears to be very susceptible to barley yellow dwarf virus.

Based on 4 years of testing, Riel exceeds the yield of Dumont and Fidler in Manitoba by 4 and 10%, respectively, but yields poorly in Saskatchewan and Alberta. It is the same height as Dumont but has slightly better straw strength. Riel has exceptional kernel quality with about 2% higher protein than other Canadian oats, and compared with Dumont, has 2% lower hull and 1 kg/hL higher test weight. Oil content is similar to Harmon and Dumont. Riel appears to have better resistance to after harvest sprouting than other Canadian oats. A total of 1500 kg of pedigree was sown in 1985.

A very effective device for dehulling oats was developed under a station initiative contract. It was also found to be effective in dehulling barley and sunflowers and will be used by the Canadian Grain Commission in the grading of these crops. It will be particularly useful in the grading of oats where the newly licensed tan-hulled cultivar, Riel, could be mistaken for heated oats. This device easily removes the hulls to expose the unpigmented groats, allowing grain inspectors to properly grade these oats. Without it, the Grain Inspection Division would not have agreed to the licensing of Riel. Licensing to permit manufacture of the dehuller is being handled by Canadian Patent and Development Limited.

CEREAL DISEASES

Pathology research is multifaceted and plays an integral part in the breeding of all cereal cultivars. Annual disease surveys are conducted to determine the prevalence of races of rusts and smuts and to determine the occurrence of viruses and of leaf spot diseases caused by fungi; new genes for resistance to various diseases are identified and transferred to desirable germ plasm; breeders' lines are evaluated for resistance to fungal parasites and viruses; basic studies are conducted on the biology, genetics, histochemistry, and ultrastructure of the pathogens; and long-term research is under way to explain the mechanism of host–parasite interactions and the molecular basis of resistance to cereal rusts.

Cereal rusts

In 1985, rusts appeared earlier than usual in Manitoba creating a serious epidemic potential, especially with respect to winter wheat. However, cool dry weather delayed the development of epidemics. Winter wheat escaped damage. The oat rusts did not cause significant losses. Analysis of the virulence characteristics of the various cereal rusts collected in the 1984 season led to the following observations.

Stem rust of wheat. Sixteen differential lines were used to characterize 390 field survey samples. Twelve races, including four new ones, were identified but none of these were virulent on commercial spring wheats grown in the "rust area" of the prairies. Race C53, predominant since 1977, was the prevalent race in Saskatchewan, Manitoba, Ontario, and Quebec.

Leaf rust of wheat. The identification of races from leaf rust survey samples was carried out using 19 backcross lines of wheat, each with a single gene for resistance. Lines with resistance genes *Lr*19, *Lr*21, *Lr*29, and line T6 × PI58548 were resistant in all survey samples tested. Fifty-nine virulence combinations were identified, using 17 genes for resistance. Sixteen isolates from Manitoba were virulent on adult plants of Benito, which has genes *Lr*1, *Lr*2a, *Lr*12, and

*Lr*13. Virulence on the line with gene *Lr*16 occurred in 17% of the isolates from Manitoba and most of these isolates were virulent on adult plants with gene *Lr*13; both these genes are present in Columbus. However, these cultures produced only moderately susceptible reactions on seedlings and moderately resistant reactions on adult plants of Columbus. A number of F_2 cultures of leaf rust were found to detect *Lr*13 in the seedling stage. This simplifies testing for the presence of this important gene in unknown accessions or segregating populations of wheat.

Stem rust of oats. Race NA27 predominated in western Canada, and race NA25 in eastern Canada. A new race collected in the Ottawa area was found to be virulent on gene *Pg*16, the most recently isolated resistance gene for oat stem rust. Cultivars Fidler and Dumont remained resistant to the predominant races of the pathogen.

Crown rust of oats. No significant new physiologic races of crown rust were identified. In Manitoba, virulence continued to predominate on lines containing genes *Pc*35, *Pc*40, or *Pc*46, whereas many isolates collected in Quebec and Ontario were virulent on plants containing gene *Pc*35 or *Pc*56. On the prairies, none of the races threaten the combinations of crown rust resistance genes currently used in the breeding program. The cultivars Fidler and Dumont were highly resistant to all field isolates collected in 1984. In continuing studies on the effect of temperature on the expression of resistance, it was found that genes *Pc*65 and *Pc*66 were sensitive to temperature: both genes were ineffective at 26°C.

Incorporation of rust resistance into wheat cultivars. Stem rust resistance genes *Sr*2, *Sr*22, and *Sr*26, as well as other resistance genes, are in the process of being transferred into the spring wheat cultivars Columbus and Benito or into Norstar winter wheat. Backcrosses were completed to incorporate leaf rust resistance genes *Lr*3ka, *Lr*21, *Lr*22, among others, into cultivars Columbus, Benito, and Katepwa.

New sources of resistance. Lines of wheat with "unknown" resistance to stem rust were identified for further study as possible sources of new resistance genes. Highly resistant accessions of wheat were tested with bulked inoculum of leaf rust: a number of these accessions possessed genes *Lr*9, *Lr*16, and *Lr*24; others appeared to contain genes *Lr*T2, or *Lr*T2 plus *Lr*T3. F_1 progeny from crosses between the cultivar Makuru and two Iberian wild oats (IB2433 and IB3056) that showed good resistance to crown rust and stem rust of oats were successfully backcrossed to Makuru. A large number of F_2BC1 families are now available for genetic analysis to determine the inheritance of the resistance source.

Molecular biology of cereal rust diseases. Extracellular proteins from the intercellular space of stem rust-affected wheat leaves were analyzed for enzyme activity. Two infection-related peroxidase isozymes were detected in addition to more than 10 that were present in noninoculated leaves. At least 15 (out of 37) polymorphic glycosidases possessed concanavalin A-binding properties, but they were not identical with the glycoproteins of fungal origin since they also occurred in intercellular washing fluid from healthy leaves. Infection-related glycoproteins in these fluids showed extensive "race-specific" variability, but it is not known whether these differences are due to the expression of avirulence genes or whether they are products of other genes that may vary between the races tested.

Ultrastructure of cereal rusts. Various staining procedures and cytochemical tests on the wheat stem rust fungus were used to elucidate the chemical composition of the walls of the haustorium mother cell, of the host cell penetration site, the haustorial neck, and the haustorial body and to describe some of the chemical properties of the extrahaustorial matrix. The tests revealed two transition zones with respect to wall composition: at the host cell penetration site and at the neck ring. One or both of the two outermost layers of intercellular hyphal walls had affinity to arabinogalactan protein (β-lectin) and to lectins from *Bandeiraea simplicifolia*, soybean, *Ricinus communis*, *Lotus tetragonolobus*, and horseshoe crab. Hapten inhibition of these probes was successful when they were tested with model substances but was not observed when the same haptens were used in efforts to inhibit binding of these lectins to fungal wall structures in ultrathin sections. Thus, no definite conclusions can yet be drawn about the extent of the chemical complexity of the hyphal wall surface layers.

Chemotaxonomy

Proteins were extracted from urediospores of the bean rust fungus (*Uromyces phaseoli* var. *typica*; 2 isolates), of the cowpea rust fungus (*U. phaseoli* var. *vignae*; 2 isolates), and of the faba bean rust fungus (*U. viciae-fabae*; 1 isolate), and separated by two-dimensional isoelectric focusing-polyacrylamide gel electrophoresis under denaturing conditions. The two isolates of the cowpea rust fungus had identical polypeptide patterns whereas the two isolates of the bean rust fungus differed by 19 polypeptides. The polypeptide patterns of the bean rust, cowpea rust, and

faba bean rust fungi differed markedly from each other. Two hundred and seventy-seven polypeptides were detected in extracts of the faba bean rust fungus, whereas more than 335 polypeptides were detected in extracts of each isolate of the other two fungi. Although *U. phaseoli* var. *typica* and *U. phaseoli* var. *vignae* shared 183 polypeptides, *U. viciae-fabae* had only 149 and 146 polypeptides in common with these two rust fungi, respectively. This is consistent with the view that the two varieties of *U. phaseoli* are more closely related to each other than to *U. viciae-fabae*. However, when all detected polypeptides were compared, the differences between the two varieties were as extensive as those found between species. It is suggested, therefore, that the designation, by some mycologists, of the cowpea rust fungus as a separate species, *U. vignae*, is correct.

Smuts

Wheat. Ten field collections of loose smut of wheat taken in western Canada in 1984 represented known and established races. One collection from Turkey represents race T37, found previously in China. A collection of 148 resistant common wheats were tested for their reaction to the "new" races T37 and T41 of loose smut from China. None was susceptible, indicating that these races do not carry unknown genes for virulence.

Barley. Surveys in Manitoba and Saskatchewan detected smut in 93% of 163 fields of barley with an average of 0.9% loose, 0.1% false loose, and 0.2% covered smut. The inheritance of a prominent polypeptide present in one race of *Ustilago hordei* was examined by tetrad analysis, and found to be controlled by a single gene. It was inherited independently of the V6 gene for virulence.

Foliage mycoses caused by fungi other than rusts

Severe leaf spotting of oats in a field near Carman, Man., was diagnosed to be caused by the "anthracnose" fungus, *Colletotrichum graminicola*. This pathogen normally attacks crowns and roots of stressed plants of oats and other cereals. The leaf spot phase of the disease was reproduced in the laboratory on oats and wild oats, but wheat, barley, and rye were not affected. Apparently Anthracnose leaf blotch has the potential to damage lush, nonstressed oat crops, and will be monitored in eastern Manitoba in future.

An ongoing study of the barley scald pathogen, *Rhynchosporium secalis*, in Canada has confirmed the presence of numerous "races" as reported elsewhere. The Canadian cultivar Johnston, previously considered resistant to scald, was moderately susceptible to some races but Atlas 46 and line C.I. 3515 have been resistant to date. These cultivars may be good sources of resistance genes for future breeding programs.

Viruses

An extensive survey of natural barley yellow dwarf virus (BYDV) infections was carried out in 1985 covering areas not recently surveyed. Several new isolates of cherry oat aphid nonspecific strain (PAV-type) of BYDV were obtained and three were found to be particularly virulent. Barley stripe mosaic virus was isolated from wheat in the Red River Valley and from barley in central Alberta. In addition, a virus closely resembling cocksfoot mild mosaic virus was isolated for the first time in the Canadian prairies, as well as a highly virulent, but as yet geographically very limited, virus-like disease in barley. Monoclonal antibodies were prepared that were specific for one of the classes of virus-like particles recently isolated from ostensibly healthy cereals. The use of these antibodies permits isolation of these particles in pure form for investigation of their properties. Finding discrete species of single-stranded RNA confirmed that the unusual particles were indeed virus-like.

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 management of grain storage systems; factors that limit long-term storage; survey, prediction, prevention, and control of microflora and mycotoxins in stored cereals and oilseeds; identification and quantification of insects and mites in stored products; influence of attractants and feeding stimuli on insect behavior; and the control of insects and mites by environmental, physical, and chemical means.

Storage ecology

The results of the fifth year of a 10-year on-farm cereal storage study at Argyle, Man., to determine the efficacy of a 2.2 kW, two-duct ventilation system showed that wheat and barley harvested in August 1984 could be stored in ventilated bins with minimal quality loss. However, ochratoxin at about 700 ppb, was detected near the end of the storage year in one 544 t (20 000 bu) bin of wheat. The mycotoxin had developed on the floor near one wall in a small damp pocket of grain that had become heavily infected by fungi of the *Aspergillus glaucus*

group and *Penicillium* spp. The cooperating farmer was advised to carefully separate and destroy the affected wheat during his normal bin cleanup procedures to avoid possible animal sickness problems.

Quality loss of wheat at 19% moisture content, stored in six 1-m^3 bins with three levels of ventilation, was determined during 286 days of storage in the autumn, winter, and spring of 1983–1984 in Winnipeg, Man. The variables measured included: moisture content, temperature, CO_2–O_2 composition of intergranular air, seed germination, microflora, and fat acidity. In the two high-airflow bins, 12.2 L/s per cubic metre, no spoilage occurred because the grain was dried to 13% moisture content in 28 days. In the two low-airflow bins, 0.8 L/s per cubic metre, some spoilage occurred after 30 days. In the two control bins, 0 L/s per cubic metre, grain began to spoil within 10 days. Fungi of the *Aspergillus glaucus* group and *A. candidus* appeared to be the main agents responsible for spoilage.

Concentrations of CO_2 in interseed air were measured in 39 farm-stored bulks of wheat, canola, barley, and corn in Manitoba (Canada) and Minnesota (U.S.A.). Spoilage was confirmed by analyses of grain samples in 97% of the 34 bins having CO_2 concentrations greater than 0.03% of ambient air. Elevated CO_2 concentrations of 0.08–10.0% were detected in 87% of the 38 bins containing spoiling grain. This work demonstrates that measurement of CO_2 concentration in interseed air is a practical method for detecting spoilage in stored grain and has resulted in the development of an early warning grain spoilage test kit for producers. The device consists of a plastic syringe, a calibrated CO_2 analyzer tube containing material that changes color when exposed to CO_2, and a plastic tube for insertion into the grain. In grain showing from 0.08 to 0.1% CO_2, low level spoilage, either from mold or insects, is just beginning. Heating is not present at this stage. From 0.2 to 0.9% CO_2, serious spoilage is underway, and from 1 to 3%, and higher CO_2 concentrations, indicate increasing degrees of dangerous spoilage loss. Heating may start at about the 3% CO_2 level.

Microflora and mycotoxins

Thirty out of 32 isolates of *Aspergillus versicolor*, originally isolated from western Canadian canola and barley seeds, produced the carcinogenic mycotoxin sterigmatocystin on 39% moisture content ground corn. Levels of the toxin varied from 2.1 to 184.5 μg/g for barley isolates and from 0 to 123.9 μg/g for isolates from canola after 16–22 days at 28°C. The production of sterigmatocystin by a high percentage of *A. versicolor* strains, under ideal substrate and environmental conditions, appears to be characteristic of this ubiquitous storage mold.

The incidence of mycotoxins and interrelations among associated ecological variables in western Canadian common and durum wheat and barley were studied from 447 railway car samples collected during 1981–1983. The 41 prairie crop districts were ranked according to their vulnerability to fungal infection, mite infestation, and other cereal quality loss criteria. Principal component analyses were used for determining linear relationship patterns of ecological variables; ranking of crop districts was determined by Kendall's ranking approximation technique using the first (CI) and second (CII) principal components. The ranked crop districts were superimposed on maps with climatic subdivisions of the Canadian prairies. Only five of 447 samples contained ochratoxin A, with levels of 10–51 ppb. None of the samples contained aflatoxins, sterigmatocystin, citrinin, or penicillic acid. All ochratoxin-containing samples had established contamination of *Aspergillus glaucus* group (10–86% infection level), and *Penicillium* spp. (20–80% infection level). Most of these samples had low germinability, high fat acidity levels, and infestations by the stored product mite *Acarus siro* complex, *Lepidoglyphus destructor* (Schrank), and *Tarsonemus granarius* Lindquist. In wheat, the CI accounted for 24% of the variability, indicating that poorly germinable wheat was associated with the presence of *Penicillium*, *Aspergillus glaucus* group, and *Wallemia* and the fungiverous mites *T. granarius* and *A. siro*. The CII accounted for 10% of the variability, indicating that an increase in free fatty acids was correlated with a high incidence of *Aspergillus flavus* and *A. versicolor*. The CI interrelations were most common in crop districts lying in the subhumid prairie, northern part of the dry belt, and the southern part of the humid regions. Similar relationships were also defined and ranked on maps for durum wheat and barley crops.

Biology

Adults of the red flour beetle *Tribolium castaneum* (Herbst), and the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), were added to 218-kg bulks of wheat at densities of 1, 5, or 10 insects per kilogram. Multi-chamber traps consisting of six chambers and extending from the surface to the bottom in the center of the bulks captured about 57% of the red flour beetle in 6 weeks at 24°C at all densities. About 23% of the rusty grain beetle was caught at the highest density, and 14% at the one or five insects per kilogram densities. Insects were trapped at tem-

peratures as low as 3°C. Traps baited with wheat germ caught significantly larger numbers of flour beetles than did unbaited traps. Those baited with rusty grain beetles caught more beetles than did empty traps.

Single chamber insect-detection traps baited with synthetic aggregation pheromones of the rusty grain beetle were inserted into grain stored in primary elevator annex bins and in farm bins, or suspended in partly full or empty bins and outside under the eaves of bins. The mixture of the synthetic pheromones 4,8-dimethyl-*E*, *E*-4,8-decadienolide (ferrulactone I) or (*Z*)-3-dodecen-11-olide (ferrulactone II) was released from hollow polyester fibers positioned in the interior of the insect-detection trap. In annex bins, the number of beetles found in baited traps after 1 week ranged from 0 to 7300. In these bins, more beetles were found in traps at a depth of 30–60 cm than at 150–250 cm, and in traps with two fibers rather than with one fiber. In farm bins, baited and unbaited traps were relatively ineffective at grain temperatures below 14°C. Although more beetles were found in baited than in unbaited traps, the numbers were small and the differences not significant. Few beetles were found in traps suspended in partly full or empty farm bins and none in traps suspended outside under the eaves.

Survival of acclimatized adults of the lesser grain borer *Rhyzopertha dominica* (Fabricius), the sawtoothed grain beetle *Oryzaephilus surinamensis* (Linneaus), and the merchant grain beetle *O. mercator* (Fauvel) was determined in flour in the laboratory at –5, –2.5, and 2.5°C. Adults of *O. surinamensis* survived 1 week at –5°C but the other species did not. Adults of *O. mercator* died within the first week at –2.5°C whereas those of *R. dominica* died within 2 weeks and those of *O. surinamensis* within 4 weeks at the same temperature. At 2.5°C, *O. mercator* died in less than 2 weeks, *R. dominica* in less than 4 weeks, and about 50% of *O. surinamensis* remained alive after 4 weeks. These findings show that these species require heated buildings such as animal barns in which to survive the winter in the Canadian prairies. The temperatures in unheated granaries would be too low for survival of these species.

The durum wheats Medora, Coulter, and DT375 ranked highest, of 30 cultivars of ball-milled hard red spring and durum wheats, oats, barleys, and triticales, as media for oviposition and larval development of the red flour beetle and rusty grain beetle. The three lowest-ranking cultivars for the red flour beetle were Calibre oats, Bonanza barley, and Conquest barley, and for the rusty grain beetle, the oat cultivars Cascade, Dumont, and Terra. Significantly larger numbers of larvae of the red flour beetle were recovered from finely ground (cyclo-tech mill) than from ball-milled samples of almost all the cultivars. This result supports earlier observations that flour beetles can discriminate between particles of endosperm, bran, and germ in the ground samples and feed preferentially on particles which promote egg production and larval development. In ball-milled samples, the particles are too fine to permit insects to discriminate between particles.

Control

Localized high levels of malathion can occur when canola is in contact with treated storage surfaces and levels of 1 ppm can result from bin treatments. The maximum allowable limit in Canadian canola is 0.1 ppm. To assist in the marketing of seed containing marginal levels of malathion, a practical means of reducing malathion residues to acceptable levels was necessary. Accordingly, canola containing up to 1 ppm malathion and <10% moisture was stored for up to 32 weeks at 10, 20, and 30°C to determine the time required for residue levels to reach 0.1 ppm. Malathion levels of <0.1 ppm were found only in seed at 20°C, 7.7% moisture content by 32 weeks, and at 30°C, 7.1% moisture content by 16 weeks. The malathion degradation times were related to calculated safe storage times to determine acceptable storage conditions. Manipulation of temperature <60°C for short periods was ineffective in lowering malathion residues to 0.1 ppm. As a consequence of this work, an improved analytical method of malathion extraction from canola was developed.

Rye, wheat, or triticale of 6.1–9.6% moisture content was stored for up to 8 months at 22°C in cylinders on fir plywood or galvanized steel panels treated with malathion or pirimiphos-methyl containing active ingredients at 0.5 g/m^2, or on untreated panels. Top (2–4 cm from the panel surface) and bottom (0–2 cm from the panel surface) samples were taken at regular intervals. Bioassay of the cereals with adults of the rusty grain beetle resulted in negligible mortality in top samples but high mortality in bottom samples. Mortality, which decreased with the length of the storage period, was often higher in the cereals on surfaces treated with malathion than on those treated with pirimiphos-methyl. The study indicated that malathion and pirimiphos-methyl are translocated more rapidly by rye than by triticale, and that triticale takes up the insecticides more rapidly than wheat. Malathion uptake is often greater than that of pirimiphos-methyl. Cereals on treated steel surfaces become more contaminated than those on treated wood surfaces.

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The movement of the insecticides into the grain could provide insect control within grain residues or bulk grain up to 2 cm from treated surfaces, increasing the effectiveness of empty bin treatments. It is unlikely that appreciable contamination of these cereals by the insecticides applied to plywood or steel will occur, especially in bulks of grain where volumes are large relative to surface areas. The greater affinity of both insecticides for rye, however, should be considered when this cereal is being stored.

Diatomaceous earth was shown to be not effective against mites in grain. In grain at 16% moisture content and treated with diatomaceous earth at a rate of 1% by weight, some individuals of *Lepidoglyphus destructor* (Schrank) survived for 1 week. The mites survived well at dosage rates of 0.1% by weight in wheat but even this lower rate is unacceptable to the Canadian Grain Commission. Similar results were obtained with *Acarus siro* (L).

CROP PROTECTION

Research on insect pests of oilseed, field, cereal, and vegetable crops emphasizes aspects of their biology and control leading toward better prediction of infestations, crop protection, and the reduction of pest populations. The program includes the development of pest monitoring techniques, development and field testing of chemical and biological insecticides, and investigation of methods of reducing pest populations by biological and other nonchemical methods. These programs are supported by research on sampling techniques, survival, development, phenology, host selection, induction and termination of diapause, overwintering strategies, reproductive biology, and biochemical bases of neurotransmission.

Monitoring and prediction

The number of bertha armyworm moths captured in sex attractant traps in the Swan River valley indicated that larval populations might reach the economic threshold ($20/m^2$) in a few fields in 1985. However, the maximum larval population recorded was $13.6/m^2$ and no insecticidal treatments were reported. Larval populations of the cutworm species *Euxoa ochragaster* (Guenee) were not related to the number of moths of these species captured in sex attractant traps.

A comparison of three methods of sampling to determine the density of bertha armyworm larvae showed that a nondestructive method of searching sample units gave the same estimates as those that involved cutting the crop plants. The amount of experience in searching, among samplers, was shown to be the major factor affecting the estimate.

No adults of the corn earworm, *Heliothis zea* (Boddie), were captured in traps designed to capture moths entering Manitoba from the south. However, small catches of moths obtained from local crops in late September indicated that some moths must have entered in July or August.

Under the Canada–Manitoba Economic Regional Development Agreement, a project was initiated to determine the distribution, abundance, and damage caused by selected crop pests in Manitoba. Larval infestations of the European corn borer, *Ostrinia nubilalis* (Hbn.), in grain corn were much lower than in 1984. Cool, wet weather delayed the development of the corn crop and may have reduced the survival of corn borer larval. The cabbage root fly, *Delia radicum* (L.), was found to occur widely in Manitoba on the roots of canola. Infestations occurred in 20% of the fields sampled with 4% of the plants infested in all but one field, which had 18% infested. Sampling of sunflower fields confirmed that the distribution of the sunflower midge is confined to the Red River valley.

Damage assessment

Studies of the effect of different densities of cutworms on the survival and yield of peas, corn, and sunflowers indicated that these crops can tolerate higher densities of cutworm larvae than those currently accepted as the economic threshold level ($4/m^2$).

Insecticides

Evaluation of candidate insecticides for use against the flea beetle, *Phyllotreta* spp., on canola showed that the one candidate granular formulation and three of seven foliar sprays were as effective, and six of eleven seed dressings were more effective, than currently registered products. At 16 days after seeding the only seed dressing treatments that were still effective were UBI 2413, both formulations of Furadan Fl and Lance Fl. Lance Fl treatments continued to be highly effective 20 days after seeding and were equal to some of the in-furrow granular treatments in terms of control achieved.

The in-furrow granular treatments, in most cases, were slow in becoming effective at crop emergence. At 12 days after seeding, the highest mortality was caused by in-furrow granular treatments applied in combination with a seed treatment, except in the case of Counter 5G when combined with Vitavax RS Fl. However, Counter 5G applied in combination with a Furadan Fl or Promet seed treatment also produced high mor-

talities. At 16 days after seeding, mortality with the in-furrow granular treatments applied alone increased and were about equal to those obtained by the combined treatment. At 20 days after seeding, Counter 5G applied alone or in combination with a Furadan Fl or Promet seed treatment and all of the Lance treatments were effective and produced mortalities ranging from 89 to 100%.

The in-furrow granular treatments were generally more effective than the seed dressings in the control of flea beetles and duration of effectiveness. This was reflected in the damage rating and in the numbers of new generation flea beetles collected. However, in many cases there was little apparent relationship between these values and yield response. Foliar sprays generally did not provide control of flea beetles. Only Lance 480 Fl, of the seven foliar sprays tested, provided an acceptable level of mortality 72 h after application.

Laboratory testing of some new strains and formulations of *Bacillus thuringiensis* (*B. t.*) for control of the bertha armyworm showed that a 1:1 combination of commercial Dipel and a β-exotoxin (ABG6162) was effective against the armyworm in terms of mortality, reduced time to death, moth emergence, and feeding cessation. A commercial formulation of a *B. t.* strain recently isolated from the spruce budworm in the United States (SAN415) was effective against fourth instar (L4) larvae. A total of 61 strains of *B. t.* were bioassayed against L4 armyworm larvae. Five have been selected for further study.

The LD_{50} and LD_{95} in terms of numbers of nematodes per fifth instar larvae were determined for three strains of *Steinernema feltiae*, Filipjer, *Heterorhabditis bacteriophora*, Poinar, *S. glaseri*, and *H. heliothidis* against the redbacked cutworm, bertha armyworm, wax moth, variegated cutworm, and the armyworm. *S. feltiae* (Mexican strain) was the most effective both on filter paper and in soil. It was also the most aggressive and multiplied the most in insect cadavers. Soil treated with infective stage nematodes and exposed to direct sunlight maintained full infectivity for 7 days but gradually declined thereafter. Nematodes exposed in soil at 15 and 8% moisture for 72 h at 25°C lost 0 and 94% infectivity, respectively. The more cold-hardy species, *S. glaseri* and *H. bacteriophora*, survived 0°C in soil for 1 month without loss of infectivity whereas *S. feltiae* ("ALL" strain), lost all its infectivity.

Studies of the effects of insecticides on voltage-dependent Ca^{2+} uptake in isolated insect brain synaptosomes and adenosine triphosphate dependent Ca^{2+} uptake in synaptosome membrane vesicles have identified a class of insecticides that affects calcium uptake. The potential of this class of insecticide (type C) to synergize other classes of insecticides that disrupt cyclic adenosine 3′,5′-cyclic monophosphate and cyclic guanosine 3′,5′-cyclic monophosphate metabolism (type A and type G) is being evaluated. Such synergism offers the potential for reducing the rates of insecticide application.

Biological control

The first releases of a new biological control agent for the bertha armyworm were made in the Swan River valley in 1985. A total of 258 adults of a parasitic tachinid fly, *Ernestia consobrina* (Mg.), were released in early August. The parents of these flies were received from Europe in late August 1984 and their progeny were reared on bertha armyworm larvae in the laboratory.

There was no evidence of establishment of the European parasite *Townesilitus bicolor* (Wesm.), from evaluation of 8058 adults of the flea beetle *Phyllotreta striolata* (Fab.) collected at Glenlea and Dauphin, Man., in April–May 1985 and held in the laboratory for parasite emergence. *T. bicolor* had been released each year during 1978–1982 at Glenlea, and in 1982 and 1983 in Dauphin.

A total of 27 740 adults of the pea aphid parasite *Aphidius smithi* Sharma & Subba Rao were released near Oakbank, Man., in a field of commercial seed alfalfa infested with pea aphid. The parasite had been propagated in the laboratory from a colony imported in 1983. Adults of *A. smithi* were collected in June–July 1985 at Glenlea and Lowe Farm, Man., where colonies were released in 1983–1984 and 1984, respectively. These collections indicate that the parasite has overwintered at these two release sites. Adults were also found at Ste. Agathe and St. Adolphe, and probably had dispersed to these sites from Glenlea.

Biology

The suitability of four crop plants as food for larvae of the bertha armyworm, *M. configurata*, was tested in the laboratory. Larval food had significant effects on the rate of larval development, larval and pupal survival, pupal weight, the percentage of females that mated, and the number of fertile eggs per mated female. The canola cultivars (*Brassica napus* 'Regent' and *B. campestris* 'Candle' were approximately equal in suitability as food, lamb's-quarters (*Chenopodium album*) was less suitable, and lentils (*Lens culinaris* 'Chilean' was unsuitable.

Research on the effects of temperature on the development and survival of insect pests was con-

tinued as part of the integrated pest management program. The eggs, all larval instars, pupae, and adults of both the armyworm, *Pseudaletia unipuncta* (Haw.), and the variegated cutworm, *Peridroma saucia* (Hbn.), were tested for survival at zero and subzero temperatures. Although cold tolerance varied with stage and species, no stage of either species survived over 8 weeks at 0°C nor 4 weeks at –2°C. Outbreaks of these species are dependent on adults blown from the south each spring as they are unable to overwinter on the Canadian prairies.

In eggs of the red turnip beetle, *Entomoscelis americana* Brown, embryogenesis occurred at all constant temperatures from 5 to 35°C, but the threshold was near 5°C, the upper limit was near 35°C, and the optimum-temperature range was about 12.5–20°C. Prolonged exposure to temperatures between 5 and 10°C during embryogenesis adversely affected the embryos and resulted in a 12–65% reduction in embryo survival. Prolonged exposure to temperatures between 25 and 35°C also adversely affected the embryos and resulted in a 15–100% reduction in embryo survival and in a retardation of hatching. Growth and development of larvae and pupae occurred at all constant temperatures from 10 to 32.5°C, but the threshold was near 10°C, the upper limit was near 32.5°C, and the optimum was near 27.5°C. Development was accelerated by 6–9% in alternating temperature regimes differing by 10°C, but not in regimes differing by 5 and 15°C. Alternating temperatures increased adult weights, 5–17% for females and 2–10% for males. A three-parameter normal function described accurately the relationship between developmental rate and constant temperature. A computer simulation model based on this equation estimated that the body temperatures of larvae and pupae were elevated above air temperatures by behavioral thermoregulation in nature (by 5–6°C above maximum daily air temperatures). These findings should assist entomologists and extension specialists in predicting survival of red turnip beetle eggs and the time of appearance of adults in the field.

Overwintering survival of pupae of the bertha armyworm, *M. configurata*, was shown to be reduced by low soil temperatures. Soil temperatures in fields can be predicted from air temperature and snow depth but the sensitivity of soil temperature to small differences in snow depth makes predictions for large areas impossible. Comparisons of records of bertha armyworm outbreaks with soil temperature data showed that outbreaks occur only in those parts of the prairies where winter soil temperatures are relatively warm but that soil temperatures themselves do not control the initiation or termination of outbreaks within this area.

Studies conducted in England on the cabbage root maggot showed that exposing diapausing *D. radicum* to –10.2 or –14.8°C during an 80-day experimental period reduced survival to eclosion and the rate of post-diapause development as a function of the duration of exposure. At each temperature, the effects of cold exposure were additive. Cold-induced injuries were not repaired at 2°C. An increased incidence of malformed adults was associated with low survival. Overwintering *D. radicum* parasitized by *Trybliographa rapae* (Westw.) or by *Aleochara bilineata* Gyll. responded to low temperature exposures similarly to unparasitized *D. radicum*. Preliminary studies indicated that the same species at Winnipeg is more cold resistant than the English populations.

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Research Station, Melfort, Saskatchewan

PROFESSIONAL STAFF

S.E. Beacom, B.Sc., M.Sc., Ph.D.	Director
G.M. Bell	Administrative Officer
W. Conrad,[1] B.Sc.	Programmer–Analyst
D.J. Ewanus, B.Sc.	Farm Manager

Forage Production and Utilization

Vacant	Program Leader; Beef cow–calf nutrition, pasture management, forage harvesting evaluation
S.E. Beacom, B.Sc., M.Sc., Ph.D.	Utilization of harvested forages
S. Bittman, B.Sc., M.Sc., Ph.D.	Forage crop evaluation and production
E.Z. Jan, B.Sc., M.Sc., Ph.D.	Forage harvesting systems
D.H. McCartney, B.Sc., M.Sc.	Beef cow–calf and pasture management systems
N. Malik,[2] B.Sc., M.Sc., Ph.D.	Weed control
Z. Mir, B.Sc., M.Sc., Ph.D.	Ruminant nutrition, forage utilization
T. Yeager,[3] B.Sc.	Forage harvesting engineering

Cereal, Oilseed, and Special Crop Production

K.E. Bowren, B.S.A.	Program Leader; Crop production, weed control, tillage, crop rotations
W.F. Nuttall, B.Sc., M.Sc., Ph.D.	Soil fertility, crop nutrition
L. Townley-Smith,[4] B.Sc., M.Sc.	Cereal, oilseed, pulse crop agronomy
A.T. Wright, B.S.A., M.Sc.	Crop evaluation and agronomy

Departure

J.A. Robertson, B.Sc., M.Sc., Ph.D. Transferred to Kamloops Research Station, August 1985	Ruminant Nutritionist

VISITING SCIENTIST

Priya S. Mir, B.Sc., M.Sc., Ph.D. Natural Sciences and Engineering Research Council	Ruminant Nutritionist

[1]Appointed 1 May 1985.
[2]Appointed 20 February 1985.
[3]Appointed 15 May 1985.
[4]Ph.D. trainee.

INTRODUCTION

The Melfort Research Station is located in the Aspen Parkbelt and serves a mixed farming area that includes 10% (4 million ha) of Canada's improved agricultural land. Major problems facing producers are land degradation, weeds, insects and diseases of crops, and a short and unpredictable growing season. Scientists are developing more efficient forage production, harvesting, storage, and utilization systems. A wide range of crops are evaluated and agronomic practices are being developed to optimize production.

The station observed its 50th anniversary. Support was obtained under the Economic Regional Development Agreement (ERDA) for research on forage harvesting systems, oilseed and pulse crop agronomy, and HY 320 and winter wheat production. The Horned Cattle Purchases Act Committee provided funding for a 5-year project to assess pasture species using the "mob-grazing" technique.

The station hosted its first visiting fellow, Dr. Priya Mir, a ruminant nutritionist. Dr. Robertson left to direct the Kamloops station. Dr. N. Malik was recruited to undertake weed control research and Mr. Bill Conrad was appointed as our first programmer–analyst.

For more complete information, readers may contact the Research Station, Research Branch, Agriculture Canada, Box 1240, Melfort, Sask. S0E 1A0.

S.E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Forage crops

Physiological and agronomic responses to drought of three forage grasses. The physiological and agronomic responses to drought of three forage grasses, crested wheatgrass (CWg), smooth bromegrass (Br), and Altai wildrye (AWr), were studied at Melfort as part of a Ph.D. research program for the University of Saskatchewan. CWg was found to have lower water status than Br or AWr in terms of leaf water potential, osmotic potential, pressure potential, and relative water content. It was also found to lose more water than the other grasses for a specific decline in leaf water potential or pressure potential. All species underwent similar osmotic adjustment. AWr had the highest leaf conductance, particularly under high moisture. Leaf conductance showed a gradual response to leaf water potential or pressure potential in all species whereas leaf rolling in CWg was sharply affected by both. CWg grew most rapidly in spring, Br was intermediate, and AWr grew most slowly. Leaf area of Br was greatest whereas leaves of AWr were thickest and developed most slowly, but stayed green longest. Leaves of nonfloral tillers senesced less than those of floral tillers, particularly under drought. Seasonal decline in crude protein was greatest in CWg and least in AWr, in the same relative ranking as leaf senescence. AWr had less root biomass in the 0–35 cm but more in the 70–110 cm soil layers compared with Br and CWg; however, AWr did not take up more deep water than the other grasses. Relative water-use efficiency of the grasses under a specific moisture regime was related primarily to yield, not water uptake. AWr had lower water-use efficiency than Br and CWg. The three species are adapted to drought as follows: CWg grows early in spring and avoids drought by rolling and senescence of its leaves; Br avoids low leaf water status despite maintaining a large leaf area; AWr appears primarily adapted to sites with ample deep water. A model describing four periods during a drying cycle was suggested by this study: rapid growth and water uptake, slowed growth with solute accumulation, changes in rate of development, and rapid death caused by embolism in xylem vessels.

Effect of rapeseed companion crop on subsequent seed yields of alfalfa. The alfalfa cultivar Beaver was established alone or in the presence of the Polish rapeseed cultivar Candle as a companion crop in the following patterns: alfalfa broadcast, rapeseed in 15-cm rows; alfalfa mixed with rapeseed in 15-cm rows; alfalfa in 76-cm rows, rapeseed in 15-cm rows; alfalfa in 76-cm rows cross-seeded with rapeseed in 15-cm rows; alfalfa broadcast alone; alfalfa in 76-cm rows alone. The seeding rates were 2 and 5.5 kg/ha, respectively, for alfalfa and rapeseed. In each of the two experiments carried over 3 (1980–1982) or 4 (1982–1985) years, both rapeseed and alfalfa seed yields were significantly higher when alfalfa was mixed with rapeseed in 15-cm rows compared with yields obtained with the other methods. Alfalfa in 76-cm rows and rapeseed in 15-cm rows resulted in the lowest yields for both crops.

Uptake of N, P, and S by alfalfa herbage. The effect of N, P, and S fertilizers on the quality of alfalfa (*Medicago media* Pers.) herbage in northern Saskatchewan was measured over six growing seasons. Nitrogen at rates of 10, 45, and 67 kg/ha were applied in combination with sulfur at 0, 22, and 45 kg/ha, and with potassium at 20 kg/ha. Other rates for N, P, and S (kilograms per hectare) were 10,0,0; 10,10,0; 22,0,26; and 0,0,0. In general, first-cut alfalfa herbage was lower in protein-N than the second cut with the exception of one year. The lowest N concentration per cut was 3.34% at the Whitefox sandy loam site (Wf fsl, Luvisolic). The highest N concentration in herbage per cut was 3.97% at the Waitville loam site (Wv l, Luvisolic). Only at the Wv 1 site, and only with S fertilizer, was N concentration consistently increased every year. The percentage of applied N recovered in the alfalfa ranged from 48 to 95%. At the Wv l site, sulfur at annual rates of approximately 14 and 19 kg/ha was removed by herbage when the application rates were 22 and 45 kg/ha, respectively. Uptake of N per cut ranged from 78 kg/ha at the Wv l site to 128 kg/ha at the Melfort silty clay site (M sic, Chernozemic). Ratios of 14:1 to 21:1 of N to S in alfalfa herbage were the limits showing S deficiency.

Reseeding roughland pastures. Meadow bromegrass germinated earlier and produced more uniform and thicker stands when sod seeded with a drill developed by Regina Research Station than with the Moore Uni drill or John Deere Power Till drill. Using glyphosate herbicides to completely kill vegetation prior to sod seeding to grass legume stands is economically questionable (herbicide cost $158–226/ha). When seeding broken and reworked roughland pasture, the Prairie Farm Rehabilitation Administration (PFRA) Rangelander drill with flanged, packer wheels and corrugated rollers produced earlier and denser stands than the BC Rangeland seeder or the Manitoba (Brillion type) pasture seeders.

Forage crop handling

Forage harvesting. Under a contract project, a round baler unroller–shredder has been developed by the Agricultural Engineering Department, University of Saskatchewan, and tested and improved at the Melfort Research Station. Different from commercially available round bale processors, the unit uses very low power (7.5 KW with electric motor or 15 KW with tractor) and is able to unroll and shred the round bale completely. The machine has four rollers to support and to rotate the round bale. A shaft with many sickle knives located between the two lower rollers cuts and peels the hay off the bale. The shredded hay is carried away by the conveyor under the rollers. A unit can be built for under $5000.

The Melfort hay tower has been used to dry and store excellent-quality hay since 1971. After 14 years of usage the unit has proven to be very reliable mechanically. The yearly maintenance cost is less than 1% of the capital cost. In 1985, the tower was filled (63 t of dry alfalfa) in five working days. Some heat was used at night to assure proper drying.

Cow–calf management

Cow–calf management. Simmental × Hereford (S × H) cows housed in minimally sheltered lots ate 25% more straw than did Angus × Hereford (A × H) cows in similar or better housing conditions during the first 6 weeks of winter trial. Winter feed costs were $4–6 per head higher and conception rate 4% lower for S × H than for A × H cows. S × H calves were 12.7 kg heavier at weaning than A × H calves (225.5 versus 212.8 kg). Early calving (January–February) cows had higher feed costs ($20) but weaned calves 45 kg heavier than late calving (April–May).

Forage and crop utilization

Farm-grown feeds as protein supplements. Crude protein (CP) and digestible organic matter (DOM) were measured in various feeds provided to livestock. Ground field peas (24.1% CP), ground fababeans (29.0% CP), and ground canola (25.9% CP) added (6%) to a control ration (10.7% CP) of 71% ground crested wheatgrass hay, 25% rolled wheat, and 3% acidulated fatty acids (plus minerals, vitamin A, and an antibiotic) improved rate of gain (average 10.5%) and feed conversion efficiency (average 11.1%) of growing beef calves (unit weight 160 kg) during a 168-day test. The increased value of liveweight gains over feed costs was increased by $9.21, $8.87, and $5.97, respectively, for calves fed the three supplements.

Crossbred steers were fed rations based on ground crested wheatgrass (14.4 CP, 53% DOM, $55/t), ground alfalfa (16.7% CP, 56% DOM, $66/t) or rolled barley (11% CP, 67% DOM, $132/t). Rate of gain was 1.38, 1.38, and 1.56 kg/day, respectively; feed-to-gain ratio was 9.5, 10.5, and 7.7, respectively; dressing was 51.9, 52.5, and 54.3%, respectively; cutability was 59.0, 58.7, and 59.0%, respectively; grade A_1A_2 was 85, 86, and 100%, respectively; average final weights were 539, 540, and 537 kg, respectively; returns to labor were $53.59, $35.52, and $48.85 per head, respectively.

Improving the digestibility of barley straw and of alfalfa. Supplementing ground barley straw or

ground alfalfa with branch-chain amino acids (valine, leucine, isoleucine) or their corresponding fatty acids (isobutyric, isovaleric, and 2-methyl butyric acids with urea added to fatty acid treatments to make them isonitrogenous with amino acid treatments) at 4% of straw and hay dry matter, caused a significant increase in digestibility. The in vitro digestibilities were carried out using two systems, either rumen fluid or rumen fluid followed by pepsin in 0.1 *N* hydrochloric acid. Supplementation with the fatty acids alone or in combination, in both digestion systems, led to an increase in digestibility from 34.8% on the unimplanted straw to 63.1% where all three fatty acids were used. All combinations of amino acids or isoleucine alone increased the digestibility of straws to as high as 62.5%. Digestibility of alfalfa was increased from 72.8% to 89.5% only when valine and leucine were used together in either system. Incubating alfalfa hay in rumen fluid plus pepsin increased ($P < 0.05$) in vitro digestibility for all treatments.

CEREAL, OILSEED, AND SPECIAL CROP PRODUCTION

Intensive cereal management (ICM) for Norstar winter wheat

The ICM package of high fertility, fungicide (Tilt), and growth regulator (Cerone) resulted in a marginally profitable yield increase of 1700 kg/ha on a clay soil. On sandy soil, profitable yield increases were realized from the high-fertility treatments but not from Tilt or Cerone in the presence of high levels of powdery mildew and severe lodging. Tilt and Cerone had an additive effect on Kernel weight, but Cerone shortened the heads and decreased yields.

Control of spot-form of net blotch

In heavily infested net-blotch nurseries, seed treatment, fungicide, and potash significantly reduced disease levels and increased yields of Elrose barley by 30, 38, and 7%, respectively. These treatments only achieved partial control and demonstrate the high potential losses from this disease.

Crop rotations

Effect of crop rotations on grain yields. Analysis of 25 years data from 11 crop rotations on a Black silty clay loam soil at Melfort showed that yields of wheat grown on fertilized fallow under fallow wheat (B); fallow, wheat, wheat (C); and fallow, wheat, wheat, hay, hay, wheat (H) rotations were significantly similar (average 2791 kg/ha). Application of recommended rates of nitrogen and phosphorus fertilizer increased yields of wheat on fallow by 15%. Yields of wheat on stubble were highest on fertilized stubble in the 3-year grain rotation (C) and after forage in the grain forage rotation (average 2426 kg/ha). On an annual basis, inclusion of a grass legume forage crop, plus N and P fertilizer, produced higher stubble yields than fertilizer alone 20% of the time. Stubble yields of wheat in the 3-year rotation (C) averaged 89% of comparable fallow yields. On an annual basis the stubble yields were similar to or higher than fallow yields 32% of the time. In similar rotations, wheat yields on canola and wheat stubble were similar. Application of N and P fertilizer increased stubble wheat yields by an average of 24, 17, and 36% in the 3-year (C), 6-year (H), and continuous wheat (A) rotations, respectively.

The effect of crop rotations on net farm income. In a 25-year rotation study at Melfort, net farm income (expressed as return per hectare of land area) was highest for a fertilized fallow, wheat, wheat (C) rotation ($83–99/ha) and lowest for an unfertilized continuous wheat (A) rotation ($9–11/ha). The fallow, wheat, wheat rotation produced net returns that were 33–34%, 60–65%, and 7–20% higher than a 2-year fallow wheat (B), a continuous wheat (A), and a fallow, wheat, wheat, hay, hay, wheat (H) rotation, respectively, when the crop in each were fertilized. The economic benefit from applying recommended rates of N and P fertilizer averages $11/ha (16%) for the 3-year (C) rotation, $6/ha (9%) for a grain forage (H) rotation, and $21/ha (238%) for the continuous wheat rotation. The lower economic return to fertilizer under the grain forage rotation is attributed to nitrogen and other soil benefits added by the alfalfa and grass crops in the sequence.

PUBLICATIONS

Research

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Research Station, Regina, Saskatchewan

PROFESSIONAL STAFF

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J.D. Wilson,[3] B.S.A.	Information Officer
Vacant	Systems Manager–Analyst
S.P. Yanosik	Library Technician

Biological Control of Weeds

P. Harris, B.S.F., D.I.C., Ph.D.	Head of Section; Insects
M.G. Maw, B.Sc., M.Sc.	Insects
K. Mortensen, B.Sc., Ph.D.	Plant pathogens
D.P. Peschken, B.S.A., M.Sc., Dr.Sci.Agr.	Insects

Weed Ecology and Physiology

G.I. McIntyre, B.Sc., Ph.D.	Head of Section; Physiology, water relations, dormancy
G.G. Bowes, B.S.A., M.Sc., Ph.D.	Range weeds
A.I. Hsiao,[4] B.S.A., M.Sc., Ph.D.	Physiology, dormancy
L. Hume, B.Sc., Ph.D.	Crop losses, ecology
J.H. Hunter, B.S.A., Ph.D.	Control—annual crops
A.G. Thomas, B.Sc., M.Sc., Ph.D.	Surveys, ecology
R.F. Wise	Computer programmer

Herbicide Behavior in the Environment

R. Grover, B.Sc., Ph.D.	Head of Section; Availability, mobility
A.J. Cessna, B.A., Ph.D.	Residues, plants
D.A. Pchajek,[5] B.S.A., M.Sc.	Application technology (Economic Regional Development Agreement)
A.E. Smith,[6] B.Sc., Ph.D., D.Sc., F.C.I.C.	Residues, metabolism, soil

Experimental Farm, Indian Head, Saskatchewan

G.R. Boughton,[7] B.S.A., M.Sc.	Officer in Charge; Seed increase
D.A. Derksen, B.S.A.	Agronomy, special crops
G.P. Lafond,[8] B.A., B.Sc.(Hon.), M.Sc., Ph.D.	Agronomy, cereal crops

Departures

J. Dueck, B.S.A., M.Sc., Ph.D. Seconded to Canadian International Development Agency, Barani Agricultural Research and Development Project, Islamabad, Pakistan, August 1985	Director

L.E. Hurry Transferred to Food Production and Inspection Branch, Saskatoon, May 1985	Administrative Officer
R.K. Schmidt Transferred to Systems and Consulting Directorate, Prairie Region, Regina, December 1985	Systems Manager–Analyst

VISITING SCIENTISTS

S.F. Forsyth, B.Sc., M.Sc., Ph.D. Postdoctorate fellow	Biological control of weeds

Graduate students

R.J. Deschamps, B.Sc.	Wild oat herbicides
R.M.D. Makowski,[9] B.Sc.(Hon.), M.Sc.	Biological control of weeds

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[1]Transferred from Swift Current Research Station, 12 August 1985.
[2]Appointed 30 September 1985.
[3]Appointed 22 April 1985.
[4]On transfer of work to University of California, Department of Botany and Plant Sciences, Riverside, Calif., 29 August 1984 to 31 August 1985.
[5]Appointed 21 May 1985.
[6]On transfer of work to Laboratoire de microbiologie des sols, Institut national de la recherche agronomique Dijon, France, 2 September 1985 to December 1985.
[7]Appointed 1 April 1985.
[8]Appointed 1 October 1985.
[9]On educational leave for Ph.D. training from Research Program Service, Ottawa, since September 1983.

INTRODUCTION

The program of the Regina Research Station focuses on the biology and control of weeds in cultivated crops and pastures. The extensive use of herbicides in prairie agriculture has created a demand for scientific information on efficacy, crop tolerance, persistence in soil, and movement away from the intended target. In recent years, our program has also examined exposure hazards to herbicide sprayer operators and successfully developed means to minimize hazards in handling herbicides. New technology is being developed for the use of plant pathogens and insects for the control of weed species as an alternative to control with herbicides. An Economic Regional Development Agreement (ERDA) project on the technology of herbicide application has provided a major new research initiative.

In addition to the weed research program, the station participates in the South Saskatchewan wheat breeding program. New cultivars of cereals, oilseeds, forages, and pulse crops are evaluated for adaptability to southeastern Saskatchewan. Agronomic experiments develop new information for soil and crop management.

The operations of the Indian Head Experimental Farm are being revitalized through a series of internal changes. The Seed Increase Unit was relocated from Regina to the experimental farm and was fully operational in 1985. This unit is responsible for increase of seed of new crop varieties developed by Agriculture Canada for distribution to the seed industry and for a winter plant-breeding nursery in California. Research programs in special crop and cereal agronomy are being developed by two agronomists recently hired.

Dr. A.I. Hsiao returned from studies of physiology of herbicide activity at the University of California, Riverside, Calif., in August and Dr. A.E. Smith studied methods of determining the fate of herbicides in soil at Dijon, France, from 2 September 1985 to 13 December 1985. Dr. J. Dueck, director, left for a 2-year assignment as deputy director of the Barani Agricultural Research and Development Project at Islamabad, Pakistan, and was replaced by Dr. T.F. Townley-Smith from the Swift Current Research Station in August. M.G.G. Blair became the new administrative officer.

This report contains only brief summaries of research completed in 1985. More detailed information can be obtained from publications listed at the end of this report or from individual scientists. Enquiries may be directed to the Research Station, Agriculture Canada, 5000 Wascana Pkwy., Box 440, Regina, Sask. S4P 3A2.

T.F. Townley-Smith
Director

BIOLOGICAL CONTROL

Leafy spurge and cypress spurge

Approval was obtained to release the spurge-defoliating moth *Minoa murinata* (Scop.) in Canada. This species is restricted to the parts of the spurge zone in Europe with cool summers, so it appears to be well adapted for establishment on leafy spurge on the Canadian prairies. The development threshold for several other western European insects is too high for the prairies and the leaf-tying moth *Lobesia euphorbiana* Frr. did not survive the winter of 1984–1985 in a field cage. Thus, there is a need to obtain agent species from the steppes and Caucasus of the USSR for use on the prairies. Nevertheless, the spurge-root flea beetle *Aphthona flava* Guill. increased at one site in Alberta and a related species, *A. cyparissiae* (Koch), survived at another. Both species require dry sites. A third species, *A. czwalinae* Weise, which prefers moist sites, was released in 1985 and host plant specificity tests were completed on a fourth species, *A. nigriscutis* Foudr. The latter species is likely to be restricted to cypress spurge under field conditions.

Simulated biological control by clipping indicated that defoliation of less than 75% has little effect on the survival of the weed; repeated defoliation is more effective than once a year and the degree of grass competition has a major bearing on whether control is achieved. Thus, it appears that several agents and good pasture management will be necessary to achieve control.

Absinth

Absinth, *Artemisia absinthium* L., is an introduced weed that has escaped from domestication where it was grown for its medicinal properties. It is found in every province and the northern United States and is particularly prevalent in the prairie provinces and the northern great plains.

Euzophera cinerosella (Zell.), a stem- and root-boring moth, was screened in Europe and Canada as a possible biological control agent.

Although the larvae proved very distinctive to absinth, they would also attack native species of *Artemisia*. Because the risk to native species was too great, no releases were made. The weed can, however, be controlled by cultivation and herbicides and is generally a poor competitor.

Perennial sow-thistle

The leaf gall fly *Cystiphora sonchi* (Bremi) was imported from Europe and released in Canada. This fly pupates in the leaves and the soil in the first summer generation but in the soil only in fall. Droughts may cause considerable mortality because only 12% of the larvae emerged into adults after pupation in dry soil (4% moisture). Perennial sow-thistle grows in soil in low areas subject to flooding. Laboratory results indicated that 16% of the larvae can survive flooding for 2 weeks and 3% for 4 weeks. None of the pupae survived 3 weeks of flooding. Thus, flooding might cause considerable but not total mortality. A total of 85 600 laboratory-reared larvae and pupae were released in six Canadian provinces since 1981. Field colonies survived 1 year in Alberta, 2 in Manitoba, and 4 in Saskatchewan. In a pasture, some galls were destroyed by grazing cattle, but the fly survived on low-growing rosettes, pasture margins, and roadsides. The seedhead gall fly *Tephritis dilacerata* (Loew), also introduced from Europe, was released in 1984 in Nova Scotia and produced many galls in 1985. Releases had been made in Canada since 1979 and this is the first overwintering and breeding success.

Diffuse knapweed

Sclerotinia sclerotiorum, naturally occurring on diffuse knapweed in British Columbia, was cultured on autoclaved wheat kernels and applied to knapweed plots in interior British Columbia for two years as a biological control agent. The first year up to 30% of diffuse knapweed plants died from infection and the number of knapweed plants was reduced in these plots for the next 2 years. The second year few plants became infected following a much drier spring. Application of *S. sclerotiorum* in this manner is costly and with the less than adequate infection rate obtained it has no potential for biological control of diffuse knapweed.

Wild oats

Seeds from seven genetically pure lines of wild oats with different levels of dormancy and viability were analyzed for seedborne fungi. All lines had fungi on the seeds, predominantly the saprophytes *Alternaria alternata* and *Cladosporium herbarum*. Pathogenic fungi, isolated frequently, were *Drechslera avenacea*, *Cochliobulus sativus*, and *Fusarium* spp. Only *D. avenacea* was specific to wild and cultivated oats, and could have potential as a biocontrol agent for wild oats. Fungi isolated occurred randomly on seeds of all wild oat lines, and there was no correlation between low viability of seeds and amount of seedborne fungi.

WEED ECOLOGY AND PHYSIOLOGY

Canada thistle

A study was conducted on the effect of humidity on some aspects of the growth and development of Canada thistle. Seedlings were grown in sand culture under controlled conditions at low and high humidities that varied between 30 and 50% relative humidity (RH) and 90 and 100% RH, respectively. The high RH treatment increased stem height by 50% and shoot dry weight by 55% and produced an 80% increase in root dry weight, but had no significant effect on root bud growth. When the root buds were released from correlative inhibition by removal of the parent shoot, increasing the relative humidity from approximately 50 to 100% significantly increased their rate of emergence as shoots and resulted in a twofold increase in the length and dry weight of emergent shoots after 7 days growth. At low RH growth of the root buds was significantly inhibited not only by mature leaves but also by mature stem tissue. The root buds were released from the stem-induced inhibition by keeping the stem at a high humidity. These results, together with supporting evidence from previous investigations, suggest that the correlative inhibition of root buds is due primarily to competition for water between the root buds and the parent shoot.

Weed control data summaries

Since 1976 standard computer forms, each one representing an individual abstract, have been completed by weed researchers from industry, government, and universities in the four western provinces. The forms, after being keypunched into a computer at a central location, are then compiled and edited at the Regina Research Station. A three-volume research report comprising well over 1200 weed control abstracts is produced annually. In 1985, retrieval programs were introduced that summarized information contained in the 1984 and 1985 data banks. Researchers can obtain efficacy and crop tolerance data for selected herbicide treatments, weeds, and crops with the option of selecting the lower and upper

limits for the leaf stage of the selected weed and crop. The successful introduction of the data summary programs in 1985 means that researchers are no longer required to manually summarize the results from each weed control experiment.

Seed dormancy in wild oats

Differing temperature regimes during parental vegetative growth of a nondormant population of wild oats affected the germination behavior of the resulting seeds. A suppression of germination was found in seeds from plants that had experienced low temperatures before anthesis when the matured seeds were incubated at 4°C, but not when they were incubated at 20°C or 30°C. This suggests that temperature can regulate germination behavior by its effects on three stages of the life cycle of wild oat plants, i.e., during vegetative growth, seed maturation, and the incubation period following seed maturation. Such temperature effects may provide flexible strategies for the survival of nondormant wild oat populations.

Experiments conducted found that sodium hypochlorite (NaOCl) is approximately 4–6 times more effective than H_2O_2 in triggering the onset of germination of imbibed wild oat seeds. This suggests that the modes of action for NaOCl and H_2O_2 in the termination of dormancy reside in a modification of the properties of hull and seed coat membranes and in the provision of additional oxygen to the seeds. Considerable experimental support for this hypothesis was obtained in experiments using increased or decreased sensitivity to gibberellin A_3 (GA_3) in NaOCl-treated seeds. NaOCl treatment weakened membrane barriers of the seed coat through a scarification-like effect and thereby produced increased sensitivity to the presence of GA_3. The loss of responsiveness to GA_3 in NaOCl-treated seeds during moist storage may involve the restoration of the integrity of the seed coverings.

Wild oat–barley competition in relation to K^+ supply

Substantial differences were observed among barley cultivars in their ability to compete with wild oats in relation to K^+ supply. Experiments were conducted with eight barley cultivars separately planted with wild oats in sand cultures with two external K^+ concentrations ($K_e{}^+$). The cultivar Fergus was highly competitive at both high and low ($K_e{}^+$, whereas Steptoe was competitive only at high ($K_e{}^+$, and Compana was only weakly competitive with wild oat. The differences between barley cultivars were related to their efficiencies of potassium uptake and utilization.

Crop losses caused by weeds

An experimental model of wheat losses caused by weed communities dominated by green foxtail in Saskatchewan has been developed. Prior to the application of postemergent herbicides the model predicts potential yield losses that would occur if no herbicides were to be applied. The model is unique in that it deals with normal field situations with multispecies weed communities and is applicable when the dominant weed species is green foxtail, with secondary species of stinkweed, lamb's-quarters, wild oats, wild buckwheat, and European sticktight. The model demonstrates that with selective removal of green foxtail there is a change in the relative influence of species in the community on yield loss. This supports the contention that one-weed one-crop models are greatly limited in their ability to predict the competitive effects of weeds on a crop in a normal multispecies situation.

Control of green foxtail with TCA

In western Canada, TCA (trichloroacetic acid) is used for control of green foxtail and other annual grasses in field peas, flax, rapeseed, and the cereals oats and barley. The use of TCA for the control of green foxtail in wheat has not yet been recommended even though TCA is the lowest-cost herbicide now available for the control of green foxtail and could be economically beneficial to wheat producers.

The tolerance of spring wheat to TCA applied alone and tank-mixed with 2,4-D was assessed in field plots for three seasons. Under weed-free conditions, TCA reduced plant height and kernel weight of the wheat but also increased the number of culms that headed. Therefore the final grain yield was unaffected by the herbicide. The tolerance of wheat to TCA was unchanged by tank mixing with 2,4-D.

At harvest time, significant residues of TCA were found in the grain and straw. Milling the treated grain substantially reduced the TCA levels in the resulting bran and flour, and after baking the flour into bread, all the TCA residues were gone.

Although TCA provided effective economical control of green foxtail in wheat and there were no residues in the bread, the residues detected in the grain and straw are expected to prevent this herbicide from ever being registered for use on wheat. This is one more example of ongoing research to assure that only effective environmentally safe pesticides are used to produce food products that are free from residues.

Weed survey of alfalfa

The current weed problems facing alfalfa seed growers in the province of Manitoba were determined by a quantitative field survey and a questionnaire survey. The five most abundant species, quack grass, dandelion, Canada thistle, blue grass, and sow-thistle, were all perennials. Quack grass occurred in 65% of the fields with a mean density of 23.4 culms per square metre. Twenty-seven percent of the fields detailed in the questionnaire responses were established without the use of herbicides and 34% of the older fields were not treated with herbicides for weed control. The use of nonrecommended herbicides was prevalent. The information gained from the survey will assist in the development of improved weed control methods for the 125 pedigreed alfalfa seed growers in Manitoba.

HERBICIDE BEHAVIOR IN THE ENVIRONMENT

Herbicide persistence and degradation in soils

A degradation product of mecoprop-4-chloro-2-methylphenol was extracted from Saskatchewan soils and identified. This degradation product is very volatile and can only be isolated under laboratory conditions where volatility losses can be reduced. Thus, it is very doubtful whether buildup would occur in soils under field conditions.

The experimental herbicidal esters fenoxaprop-ethyl and fenthiaprop-ethyl were found to undergo almost complete hydrolysis to their respective acids in moist prairie soils within 24 h. In dry soils no conversion to the acids occurred. The fate of the two [^{14}C]labeled herbicides was studied under laboratory and field conditions. Each herbicide gave rise to the same transformation products in the field and laboratory soils (a phenetole, a phenol, and a benzazolone). About 10% of the applied fenthiaprop was carried over in small field plots (as the acid) to the next crop year, while the carry-over of the fenoxaprop acid was about 5%.

The transformation of the herbicidal ester haloxyfop-methyl was studied in three prairie soils. In all soils the ester was rapidly hydrolyzed to the corresponding acid, provided that the moisture was in excess of the wilting point. In moist, nonsterile soils, the herbicidal acid degraded according to first-order kinetics with half-lives of 27, 38, and 92 days, respectively in sandy loam, heavy clay, and clay loam soil types.

It has been demonstrated that the rates of breakdown of triallate residues present in a heavy clay field soil that had been treated 6 and 12 months previously were almost identical to those for triallate added freshly to the soil (approximately 40 days at 20°C and 85% of field capacity). To maintain identical environmental conditions, the studies were conducted under carefully controlled laboratory regimes. Since aged residues of triallate break down at the same rate in Regina heavy clay, as do fresh residues applied at the same soil concentrations, it may be assumed that aging processes, which include an increased adsorption of the herbicide to soil colloids, do not significantly affect its microbial degradation.

Herbicide residues in natural waters

A method was developed to determine residues of both neutral and acidic herbicides in water. Recoveries of seven herbicides commonly used on the Canadian prairies ranged from 80–117% at fortification levels of 0.1–1.0 $\mu g/kg^{-1}$. The method has been used successfully to monitor herbicide residues in irrigation return flow waters.

Analytical methods for herbicide exposure assessment

Exposure can be assessed either directly by the use of inhalation and dermal samplers or indirectly by measuring herbicide urinary excretion. Analytical methodology has been developed to determine 2,4-D and dicamba residues in polyurethane foam inhalation samplers, ethyleneglycol-impregnated glass-fiber filter paper dermal samplers, and in urine samples. These procedures have been used successfully to monitor exposure of applicators to 2,4-D using tractor–drawn sprayers.

SEED INCREASE AND DISTRIBUTION

In 1985 Agriculture Canada released to the SeCan Association 3130 kg of Jackson barley, 1500 kg Riel oats, 1294 kg Marion oats, and 2045 kg Saffire safflower. In addition, 300 kg of Lancer wheat and 29 kg of Tribute rapeseed were released to SeCan for further increase under contract. Breeder seed of 44 cereal and forage varieties was distributed to Select Seed Growers for pedigree increase.

The winter nursery in southern California was used by 24 Canadian plant breeders for selection and multiplication.

AGRONOMY

Sunflower tolerance to broad-leaved herbicides

Greenhouse studies were conducted to investigate the cause of crop injury to sunflowers from herbicide-contaminated sprayers. Sunflower tolerance to the broad-leaved herbicides dicamba, MCPA amine, and 2,4-D amine was tested at rates equivalent to 2, 1, 0.5, 0.25, and 0.12% of their respective maximum registered rate in wheat. Reductions in plant dry weight at the maximum rates used were 42, 56, and 49%, respectively; however, when grassy weed herbicides were combined with these broad-leaved weed herbicide residues, dry weight reductions were greatly enhanced. Tests with diclofop-methyl, sethoxydim plus Assist, and fluazifop-butyl plus Agral 90 indicate that although alone these products showed good crop tolerance, when they are mixed with herbicide tank residues, dry weight reductions of up to 86% occur. Diclofop-methyl had the greatest enhancing effect when mixed with these phenoxy herbicides in reducing sunflower tolerance whereas sethoxydim had the least.

Subsequent tests indicate that the herbicidal enhancement of these mixtures is mainly due to the grassy weed herbicides. Growers should be vigilant in cleaning out spray tanks before applying herbicides to a potentially sensitive crop.

Winter wheat

Effects of soil temperature, soil moisture, and seeding depth on the emergence, winter survival, and yield of winter wheat were studied.

Seeding date is a critical factor in the production of winter wheat. Delayed seeding is accompanied by lower air and soil temperatures.

The average time to 50% emergence (ET_{50}) at 5°C is 24.3 days and at 10°C is 10.0 days. The minimum time to ET_{50} occurred at 25°C and was 4.0 days. The overall effects of soil water potential were less than those observed for temperature.

At 5°C, ET_{50} changed from 24.0 to 26.1 days going from soil at field capacity to soil at permanent wilt point. At 5°C, ET_{50} changed from 24.0 to 26.1 days, at 10°C from 9.9 to 10.7 days, and at 25°C from 3.9 to 4.0 days. Seeding depth had a major effect on ET_{50}, regardless of temperature and soil water potential. At 5°C, increasing the seeding depth from 1.25 cm to 5 cm resulted in ET_{50} values going from 22.3 days to 27.2 days. At 10°C, the values went from 8.8 to 11.4 days and at 25°C from 3.6 to 4.8 days. Under field conditions, increasing the seeding depth resulted in greater winterkill and lower yields in certain cases than when seeded at shallow depths. Based on these studies, it is recommended that producers seed their winter wheat at 1.25 cm and as close to the optimum date as possible, regardless of how dry the soil is.

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INTRODUCTION

This report covers the results of work completed in 1985 at the Saskatoon Research Station and the Scott Experimental Farm, 160 km west of Saskatoon. Four research programs are conducted. The oilseed, forage crops, and cereal programs include research on breeding, agronomy, and control of diseases, weeds, and insects. We have the major responsibility in the Research Branch for research on rapeseed–canola and mustard. We, along with the Lethbridge and Kamloops research stations, are an integral part of the branch's research program on development of bloat-safe alfalfa. We have a major responsibility for the development of forage grasses for the northern prairies. The cereal program is mainly concerned with reducing losses from root rot in wheat and barley, and with the breeding of utility wheats. The integrated pest management program deals with the development of control systems for problem insects (i.e., grasshoppers, wireworms, wheat midges, black flies) that are not specifically restricted to any one commodity. A major objective in the program is the minimization of our dependence on insecticides for the control of these pests.

Dr. P.G. Mason, an entomologist, joined the staff to continue the research on black flies. This work was previously conducted by Mr. R.J.H. Fredeen who retired after 38 years of service. Also retired was Dr. R.P. Knowles after 44 years of service. Dr. Knowles is continuing his grass breeding research as a research scientist emeritus.

Previous reports and reprints of publications can be obtained from the Saskatoon Research Station, Research Branch, Agriculture Canada, 107 Science Crescent, Saskatoon, Sask. S7N 0X2.

J.R. Hay
Director

OILSEEDS

Mustard

Breeding and utilization. A new cultivar of *Brassica juncea* L., named Cutlass, was developed at Saskatoon and licensed in 1985. The major advantages of this cultivar are its improvement in quality. Compared to Domo it is higher in sinigrin, the important mustard flavor component, and lower in oil, an unwanted by-product in the Japanese market. Cutlass is also about 3.5% higher yielding than Domo, the cultivar that it is expected to replace.

Canola

Breeding. A new canola cultivar, Tribute, which is tolerant to triazine herbicides, was licensed for production in Canada. This *Brassica napus* L. cultivar is equal in seed yield and oil content to the triazine-tolerant cultivar OAC-Triton, but it is 2.5 days earlier maturing. This earliness is an important characteristic for the canola production areas in western Canada, and will help to overcome problems with late maturity of OAC-Triton. In addition Tribute shows significantly lower chlorophyll content in the mature seed, which is of great importance to the crushers in that it improves oil quality and reduces refining costs. Licensing of Tribute was urgently requested by the canola industry after only 2 years of testing because of its lower chlorophyll content.

Tribute is intended as a replacement for OAC-Triton in western Canada only, since the later maturity of OAC-Triton is less important for eastern Canada. Apart from earlier maturity and lower chlorophyll content, Tribute has the same weaknesses as OAC-Triton when compared with regular canola cultivars such as Westar. Under weed-free conditions Tribute is 30% lower yielding than Westar and has a 3% lower oil content. Tribute's susceptibility to lodging is high. Therefore, Tribute should be grown only under conditions where severe wild mustard or stinkweed infestations occur. Seed of Tribute will be distributed through the SeCan Association.

Biotechnology. Anther experiments in a cytoplasmic male sterile (CMS) *B. napus* genotype were successful. Embryos were produced from young uninucleate microspores in 10% of the cultured anthers and more than 200 haploid and diploid CMS plants were regenerated. The results establish the anther culture technique as a method for producing haploid tissue from post-meiotic CMS genotypes for use in somatic fusion and mutation experiments.

A study on culture filtrates of pathogenic strains of blackleg as selection agents for improved resistance of plant cell cultures in *B. napus* was completed. The results indicate that the phytotoxic substances secreted by the pathogen in the filtrate are secondary determinants of disease, which may severely limit their usefulness in selection schemes done in vitro.

Insects. *Banchus flavescens* Cresson was found to be the most abundant native parasitoid of the bertha armyworm on the prairies. The females deposit their eggs in first-, second-, and third-instar bertha armyworm host larvae. Speed of parasitoid development is adjusted so that the second-instar is completed when the host larva finishes feeding. After the host tunnels into the ground to pupate, the parasitoid develops and kills the host. The parasitoid forms a cocoon and overwinters in the host's earthen cell. In early summer, the parasitoid adults emerge in time to search out canola fields infested by young bertha armyworms.

The Saskatoon and Saint-Jean-sur-Richelieu research stations cooperated in publishing a bibliography on flea beetles that attack cruciferous crops and plants. Although the references are particularly pertinent to Canadian problems, the information will be useful in many countries because crucifer-feeding flea beetles are widely distributed.

Diseases. *Rhizoctonia solani* Kuhn is the main causative agent of preemergence and postemergence damping-off, and seedling and mature plant root rots, which are important diseases of canola in western Canada. A growth chamber inoculation technique was developed and used in evaluating 300 rapeseed–canola (*Brassica napus* L. and *B. campestris* L.) genotypes for their resistance to damping-off and seedling root rot. Although none of the genotypes exhibited complete resistance, five *B. napus* and five *B. campestris* genotypes performed significantly better than either Regent (*B. napus*) or Candle (*B. campestris*), two currently licensed canola cultivars. In artificially infested field plots, the progenies of these genotypes also performed better than the commonly grown cultivars. This is the first report of a reliable inoculation technique for screening canola genotypes for resistance to *R. solani* in the seedling and young plant stage.

Rhizoctonia solani is not a single species but a collection of several genetically isolated, noninterbreeding populations designated as anastomosis groups (AG). *Rhizoctonia* isolates must be characterized into different AGs before any detailed studies are undertaken. Characterization of rapeseed–canola *R. solani* isolates from Saskatchewan showed that 46% of the isolates belonged to the AG2-1 group, which is considered to be a specialized root pathogen of many crucifers; the other 54% belonged to AG4, a group not restricted to crucifers. All five isolates from the Peace River region were assigned to AG2-1. Isolates differed considerably in virulence on *B. napus* 'Westar', in seed inoculation tests. Emergence after 9 days ranged from 0 to 89%. AG2-1 isolates were more virulent than AG4 isolates. The optimum temperature for mycelial growth on potato dextrose agar of four highly virulent AG2-1 isolates was 24°C and that of four highly virulent AG4 isolates was 26°C. The AG2-1 isolates exhibited some growth at 2°C but none at 36°C, whereas the AG4 isolates grew at 36°C and not at 2°C. This is the first report of characterizing canola *R. solani* isolates into anastomosis groups.

Sclerotinia stem rot caused by the fungus *Sclerotinia sclerotiorum* is a serious disease of canola in western Canada, and is particularly destructive in years of above average rainfall. Currently the fungicides, benomyl and iprodione, are registered for use on canola in Canada, and it is expected that vinclozolin will also be registered in the near future. With all three compounds, the recommended rate of application is 0.5–0.6 kg/ha. Application has generally been by fixed wing aircraft at the early bloom stage. In spite of several years of conclusive research showing the efficacy and economic feasibility of commercial aerial spraying of both benomyl and iprodione, fungicides are still not widely used. The slow adoption of this control measure results from the difficulty in predicting the probable severity of infection for each field, as well as the high cost and the narrow time span for aerial application. One answer to these concerns could be to apply the recommended fungicides with high clearance, tractor-mounted sprayers instead of by aircraft. Our research since 1983 has demonstrated that the application of fungicides by ground rigs gives better control at a lower cost than aerial application and is likely to be effective right up until the full bloom stage. Thus, once growers purchase suitable high clearance equipment, ground application of fungicides may become as common as it is in Europe. Work in plots and fields has also shown significant control from ground application of benomyl, iprodione, or vinclozolin at about half of the 0.5 kg/ha rate recommended for aerial application. Furthermore, two applications, each at 0.3 kg/ha, one at early bloom, and one at full bloom, gave good control under low or high disease pressure. Thus, when the weather immediately before bloom is only marginally favorable to disease development, growers have several new options: ground application at 0.3 kg/ha at early or full bloom, ground application at 0.5 kg/ha at full bloom if the weather is wet during early bloom, and ground application at 0.3 kg/ha at early bloom followed by a second similar application at full bloom if the weather turns wet.

Research Station, Saskatoon, Sask.

Certain strains of blackleg, *Leptosphaeria maculans* (Desm.) Ces. & de Not. cause severe damage to canola. Isolates of 15 such strains from Canada, Australia, and England were crossed in all possible combinations in the laboratory. Fertile pseudothecia were produced from Canada × Australia, Canada × England, Australia × England, Australia × Australia, and Canada × Canada crosses but not from single isolates. The existence of heterothellism in the pathogen was confirmed, as single isolates did not produce pseudothecia. Thus, isolates from geographically distant sources are genetically compatible. This is in agreement with the hypothesis that a highly virulent strain has spread around the world from a single source in recent years. A great deal of genetic recombination can occur during the saprophytic phase of the pathogen's life cycle, which takes place on stubble of recently harvested crops. Inadvertent transfer of *L. maculans* from one region to another, such as on seed, could increase the pool of virulence genes in a given area with disastrous results to commercial crops and to breeding programs.

FORAGES

Grasses

Grasses on irrigated pastures. The performance of traditional dryland grasses as well as less hardy grasses became of interest when the South Saskatchewan River irrigation project was developed in 1967. Six bluegrass strains, and one strain each of meadow bromegrass, timothy, orchardgrass, and smooth bromegrass were established at Saskatoon in 1975 and clipped as pasture from 1976 to 1981. Four clippings were made each year, i.e. early June, early July, early August, and mid September. Plots were irrigated by sprinkler irrigation with water pumped from the Saskatchewan River. Yearly applications averaged 370 mm in addition to an average annual precipitation of 336 mm, from 1976 to 1981. Yields of grasses in decreasing order were meadow bromegrass (8.02 t/ha), orchardgrass (7.85 t/ha), timothy (7.15 t/ha), smooth bromegrass (6.95 t/ha), and Delta Kentucky bluegrass (6.54 t/ha), followed by five other lower-yielding bluegrass strains. Meadow bromegrass, timothy, and orchardgrass maintained good stands with little weed growth while smooth bromegrass and bluegrass had considerable growth of weeds. It was concluded that meadow bromegrass was a promising grass for pasture under irrigation in this area. Timothy and orchardgrass may also be useful, providing a reliable irrigation schedule was followed, otherwise winterkill might occur.

Seed-retaining reed canarygrass germplasms. Repeated cycles of mass selection for seed retention in reed canarygrass from 1951 to 1974 resulted in the development of two strains with excellent seed retention and high seed yields. Forage and seed yields of S-8799 were approximately 90 and 300%, respectively, of check cultivars and 85 and 200% for S-8986. Seed of S-8799 was the typical gray–black color of reed canarygrass while seed of S-8986 was yellow. Because forage yields are below those of standard cultivars, these strains will not be licensed but could be used in crossing programs with more vigorous strains to improve seed yields and avoid seed shattering, which is characteristic of reed canarygrass. Yellow-seeded S-8986 also is useful as a recessive genetic marker and has been used in studying isolation requirements. Seed of both S-8799 and S-8986 are being offered to other breeders of this grass.

Bloat-safe alfalfa

Research on breeding a bloat-safe alfalfa cultivar has progressed to the third cycle of selection. A modified nylon bag digestion procedure has been used to select strains with low and high initial rates of digestion. The hypothesis being tested is that the strains with low initial rates of digestion will be bloat-safe.

Herbage from these two strains was fed to rumen-fistulated sheep at the Lethbridge Research Station to determine the differences in rumen metabolism, especially on the metabolic parameters that are related to the occurrence of bloat from fresh alfalfa. Rumen fluid from sheep fed the slow digestion strain had lower concentrations of soluble nutrients, chloroplast membrane fragments, volatile fatty acids, and hydrogen ions compared with sheep fed the fast digestion strain. These results showed that the alfalfa-breeding program was producing the desired effect on rumen metabolism in vivo and that continued selection and breeding of the alfalfa strains was warranted.

Further evidence relating the occurrence of alfalfa bloat to higher levels of chloroplast membrane fragments in the rumen fluid was obtained from work done in cooperation with the Kamloops Research Station. The concentrations of soluble protein, which is generally believed to be the bloat-causing substance in legume forages, did not show any daily changes related to the occurrence of bloat or frothy rumen contents. These results suggest that the chloroplast membrane fragments or a component of them may be responsible for the immediate onset of legume bloat.

In a cooperative test with Kamloops, 7 years of bloat incidence data were summarized showing that minimum and maximum daily air temperatures were lower prior to the occurrence of bloat than when bloat did not occur. However, these differences were small (1.6 and 1.1°C, respectively) and they are not useful for predicting the occurrence of bloat.

Biotechnology

Tissue culture is becoming an increasingly important tool in plant improvement programs where novel techniques are seen as alternative means for the introduction of new genetic resources. Somatic hybridization offers the potential of exchanging genetic material between sexually incompatible species, thus permitting the transfer of new characteristics from wild species to agronomically important crop species. Although rabbitfoot clover, *Trifolium arvense* L., is not important in Canada, its herbage contains condensed tannin, which is reported to prevent pasture bloat in ruminant animals. Such a feature would be desirable in red clover, *T. pratense* L., an important forage legume that can cause pasture bloat. Since attempts at conventional sexual crosses between these two species have not been successful, we are developing protocols for somatic hybridization in *Trifolium* species. Our initial work has involved identification and selection of genotypes of red clover and rabbitfoot clover amenable to in vitro manipulation. Rabbitfoot clover was selected as experimental material because of its high tannin content and close taxonomic relationship with red clover.

Whole plant regeneration from somatic embryos has been achieved on callus derived from hypocotyls of rabbitfoot clover. This has not been reported to date and is one of the initial steps required leading to somatic hybridization attempts using these two species. Future work will involve regeneration from protoplasts of both rabbitfoot and red clover and finding methods to identify and isolate hybrid cells from hybridization experiments.

CEREALS

Common root rot

The occurrence of isolates of fungi with conidia lacking the characteristic dark pigmentation in their walls appears to be a relatively rare event. In 1971 white-spored isolates of *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem were recovered from infected subcrown internodes of wheat growing in plot land that had been infested artificially with two experimentally produced white strains some 15 years previously. In 1972 both white- and tan-spored isolates were recovered from infected subcrown internodes of wheat growing in plots adjacent to those from which the 1971 isolations were made.

Subsequently, an intensive search was made for spore-color mutants in naturally infected material. Approximately 150 000 subcrown internodes were plated out and examined. Albino strains were isolated from single subcrown internodes from each of five separate locations. Thirty albino isolates, including three produced experimentally, were characterized for several attributes. On minimal medium, the spore mass appeared as either white, tan, or gray in color. There were marked differences in colony morphology on a range of media containing different protein hydrolysates. All mutants produced a toxin that inhibited wheat seed germination and all were pathogenic on subcrown internodes of Neepawa wheat, although there was a wide range of reaction in both instances. With one exception, all produced a pink (anthraquinone) pigment. Maximum pigment production was obtained from tan-spored isolates. Both mating types were present in approximately equal frequencies.

INTEGRATED PEST MANAGEMENT

Grasshoppers

Modeling. A mathematical model has been developed to simulate the effect of weather conditions on changes in the densities of population of nymphs and adults of three economic species of grasshoppers. This model has been linked together with another model that generates the effects of defoliation on the yield of spring wheat planted in a stubble field infested with grasshoppers. Computer simulations showed that predicted grain yield was influenced greatly by relationships between growth rate (biomass increment) and the current developmental stage of growth of the plant when the damage occurred. The reduction in grain yield was not proportional to the biomass destroyed by the grasshoppers. The model suggests that economic thresholds for wheat planted in stubble fields infested with grasshoppers should be lower than the thresholds now used in western Canada. According to the model, the danger of economic damage would be particularly acute, if wheat were planted late in a warm, dry season or if grasshoppers were to hatch early, relative to crop emergence of the wheat.

Trap strips. Trap strips of weed growth on summerfallow were evaluated in Saskatchewan in

1982 and 1983 to determine the effectiveness, the costs, and benefits associated with insecticidal treatments of the strips and their effect of the population of grasshoppers the following year.

Trap strips, 10 m wide, containing primarily third-instar migratory grasshoppers, on flixweed were found in concentrations of as much as 4.9 times the initial field density. Dimethoate, sprayed at 400 g/ha, was about 20% more effective than bran-bait formulations containing the insecticide at 200 g/ha. Unlike the field margins that were adjacent to trap strips, three of the unprotected margins (those with no bordering trap strips) required at least one insecticidal application to minimize crop damage.

Field margins that were adjacent to insecticide-treated trap strips contained 60–66% fewer egg pods than margins without trap strips. Summerfallowing also reduced egg numbers significantly.

Insect pathology. An amended description of *Entomophthora erupta* and a description of *Entomophthora helvetica* sp. nov. have been established. *Entomophthora erupta* usually had two to five nuclei per conidium (mean diameter of 3.8 μm), predominantly colonized the abdomen of the host and sporulated on the dorsal surface of the abdomen of the host, usually before death. *E. helvetica*, usually with 8–13 nuclei per conidium (mean diameter of 1.6 μm), colonized the whole interior of the host, killed it in the nymphal stage before sporulation started, and sporulated on all parts of the cadaver. These features, including the pathobiological manifestations, are advocated as important taxonomic criteria at the infrageneric level of the genus *Entomophthora* sensu stricto.

Nosema acridophagus Henry was more virulent than *N. cuneatum* Henry for third-instar nymphs of the migratory grasshopper following oral inoculation with 1.0×10^6, 10^5, 10^4, and 10^3 spores per individual. The lethal times for 50 and 95% cumulative mortality were dose dependent and were significantly shorter for grasshoppers inoculated with *N. acridophagus*, 9.3 and 23.3 days for the 1.0×10^6 and 10^3 doses, respectively, than for those inoculated with *N. cuneatum*, 16.6 and 36.0 days for the 1.0×10^6 and 10^3 doses, respectively. The lethal dose for 50% mortality was also significantly lower for *N. acridophagus*, 5.39×10^2 spores per individual, than for *N. cuneatum*, 2.58×10^3 spores per individual. Grasshoppers inoculated with *N. acridophagus* died earlier and a smaller proportion survived to the adult stage compared with those inoculated with *N. cuneatum*. *Nosema acridophagus* was more infectious at lower doses than was *N. cuneatum*; however, *N. cuneatum* reached an intensity of infection in host tissues which was 2–10 times higher (e.g. 8.0×10^5 spore per milligram of tissue for grasshoppers inoculated with 1.0×10^3 *N. acridophagus* spores versus 3.0×10^6 spores per milligram of tissue for grasshoppers inoculated with 1.0×10^3 *N. cuneatum* spores). Both pathogens appeared to have similar pathogenicity for both individually and group-reared *M. sanguinipes*.

Second- and third-instar nymphs of the migratory grasshopper were more susceptible to *Nosema cuneatum* infection than were fifth-instar nymphs. Lethal times were significantly shorter for second-instar (LT_{50} = 21.8 days, respectively) inoculated with 1.0×10^4 and 10^6 *N. cuneatum* spores per individual than for similarly treated fifth-instar nymphs (LT_{50} = 76.8 and 52.4 days, respectively). A much higher percentage of fifth-instar hosts (73.04 and 29.0%, respectively) were uninfected at the end of the experimental period (40–60 days postinoculation) than were second-instar (1.5 and 0.0%, respectively) and third-instar hosts (4.0 and 0.0%, respectively) inoculated with 1.0×10^4 and 10^6 *N. cuneatum* spores per individual. Fifth-instar nymphs inoculated with 1.0×10^6 spores per individual showed reduced adult longevity. The number of eggs laid per female was not significantly different for inoculated or untreated fifth-instar nymphs. However, the eggs laid by inoculated grasshoppers had a significantly lower dry weight and fewer eggs hatched compared with those laid by untreated grasshoppers. Some 20–30% of the progeny from inoculated fifth-instar nymphs had detectable levels of *N. cuneatum* sporoblasts and spores.

Nutrition. An enzyme kinetics study revealed that the optimum pH for amylase from adult males of the migratory grasshopper was 6.0 and maximal hydrolysis of soluble starch occurred at 50°C. This amylase was activated by Cl and NO_3 anions, but not by the SO_4 anion. With the exception of the maximum velocity of reaction value which was lower, the properties of this amylase were similar to those that have been reported for stored-product insects. The maximum velocity value resembled those obtained with amylases from two carnivorous spiders, the diets of which are also low in starch. The results indicated that the migratory grasshopper is capable of utilizing any dietary starch encountered to fulfill in part its carbohydrate requirement.

In another study amino acids and carbohydrates were tested under laboratory conditions for their effect on the feeding behavior of migratory grasshoppers. The response was measured by allowing starved grasshoppers to feed on glass-fiber filter discs impregnated with the chemicals

and recording the change in the dry weight of the discs. Ribose, glucose, mannose, and trehalose had no influence on feeding: fructose at 0.01 *M* or arabinose, galactose, melibiose, or sucrose at 0.1 *M* increased feeding over that obtained with the control discs; and xylose or sorbose at 0.01 *M* depressed feeding. Each of 11 amino acids deterred feeding even at low concentrations.

Toxicology. The three pyrethroid insecticides, deltamethrin, fenvalerate, and cyfluthrin, were assayed against second-instar nymphs of the migratory grasshopper at five temperatures ranging from 15.6 to 37.8°C. All three showed a negative temperature coefficient of toxicity in that toxicity decreased as temperature increased, but there was also considerable variation between them in the pattern of response. Deltamethrin was the most effective and cyfluthrin the least effective, both in terms of the amount of active ingredient required for 90% mortality and least loss of efficacy with increasing temperature. The extent of the negative temperature coefficient of toxicity was much more pronounced at LD_{90} than at the LD_{50}. Apparent mortality was recorded at 24, 48, and 72 h posttreatment, and with each of these pyrethroids recovery of some grasshoppers took place after 24 h and a few recovered after 48 h. This phenomenon of delayed recovery was greatest at the lower temperatures.

Wireworms

Predation. The feeding preference of the pasture wireworm, *Conoderus exsul* (Sharp), on plant and animal food and its worth as a predator on the Australian soldier fly, *Inopus rubriceps* (Macquart), was investigated in New Zealand. In the laboratory, *C. exsul* fed more on soldier fly larvae than on germinating wheat seed when given a choice. Another wireworm, *Agrypnus variabilis* (Candeze), also found in pastures, showed a preference for wheat seed over soldier fly larvae in these tests.

The level of predation by the wireworms *C. exsul* and *A. variabilis* and by the staphylinid *Thyreocephalus orthodoxus* (Olliff) on *I. rubriceps* larvae, as determined serologically (immuno-osmophoresis) was 10, 20, and 80%, respectively. A predation rate of 12 soldier fly larvae per square metre was estimated for *C. exsul* larvae which were the most abundant predators (65.3/m^2) in the study site.

Wheat midge

Crop losses caused by wheat midge. Losses in yield of spring wheat caused by infestations of the orange wheat-blossom midge *Sitodiplosis mosellana* (Gehin) were determined for 700 000 ha of arable land in northeastern Saskatchewan in 1983. The relationships between kernels infested and the number of wheat midge larvae was such that an average of 1, 2, 3, and 4 larvae per kernel translates to a level of infestation (kernels per head infested) of 38, 58, 78, and 96%, respectively. There was no significant difference between infestation levels from fields sampled at the heading stage of the crop and the estimates of infestation levels for these fields at harvest time.

With 30, 60, and 90% of the kernels per head infested, yields of spring wheat were reduced by 40, 65, and 79%, respectively. The average decrease in yield in the study area was about 30%, which resulted in estimated losses in total gross revenue of about $30 million.

Residue analysis

Rapeseed *Brassica napus* 'Tower' seedlings grown from seeds treated with a lindane seed dressing at 15.7 g/kg had a maximum lindane concentration of 380 ppm in seedlings collected 1 day after emergence. The mean lindane concentration in the seedlings decreased to 2.6 ppm and 0.9 ppm at 7 and 15 days after emergence, respectively. Lindane was detected in the true leaves, at a concentration up to 1.9 ppm, indicating that some upward translocation of lindane had taken place.

Boron trifluoride–methanol, a reagent for the esterifying organic acids, was used as a pretreatment for the extraction of lindance residues from soil. Twenty to 70% more lindane was extracted from field-weathered soils with the boron trifluoride–methanol pretreatment than with hexane–acetone. The lindane that was unextractable by hexane–acetone but was extractable with the boron trifluoride–methanol pretreatment was confirmed by chemical and mass spectral methods.

Pesticide application

In spray application research it is often necessary to change nozzle tips in the field or laboratory or to remove tips for cleaning. A nozzle body was designed that facilitated the removal and installation of spray tips on experimental sprayers without the necessity of using tools.

Comparative studies were carried out to investigate the effectiveness of three drift control devices on a boom-type ground sprayer. Two of these, a porous shroud and a power-aspirated winnower, were found to be effective in reducing spray droplet drift by 80–95%.

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H. Steppuhn, B.Sc., Ph.D.	Subsurface hydrology
M.A. Stumborg, B.E.	Energy
S. Tessier,[10] B.Sc.(Eng.), M.Sc.	Tillage

Forage Production and Utilization

N.W. Holt, B.S.A., Ph.D.	Pasture management
P.G. Jefferson,[11] B.Sc.(Agr.), M.Sc.	Legume breeding and physiology
J. Waddington, B.Sc., M.Sc., Ph.D.	Pasture establishment and physiology

Soils and Environment

C.A. Campbell, B.S.A., M.S.A., Ph.D.	Head of Section; Soil chemistry and fertility
V.O. Biederbeck, B.S.A., M.Sc., Ph.D.	Soil microbiology

H.W. Cutforth,[12] B.Sc., M.Sc., Ph.D.	Agrometeorology, soil physics
A.J. Leyson,[13] B.Sc., M.Sc.	Forage fertility
F. Selles, B.S.A.(Chilie), B.S.A., Ph.D.	Soil fertility
R.P. Zentner, B.S.A., M.Sc., Ph.D.	Economics

Departures

D.M. Bowden, B.S.A., M.S.A., Ph.D. Transferred to Summerland Research Station, 29 November 1985	Director
C.T. Lund Transferred to Prairie Regional Headquarters, 1 March 1985	Systems manager
N.B. McLaughlin, B.Sc., M.Sc., Ph.D. Transferred to Engineering and Statistical Research Institute, 28 June 1985	Equipment design
D.A. Smith Resigned 25 June 1985	Administrative Officer

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[1]Appointed Acting Director, 29 November 1985; also Head of Forage Production and Utilization Section—Grass breeding.
[2]Appointed 16 September 1985.
[3]Appointed 15 October 1985.
[4]On transfer of work to Barani Agricultural Research and Development Project, Pakistan, 15 July 1985.
[5]Appointed acting head of section, 18 February 1985; also member of Cereal Production and Utilization Section—Rye breeding.
[6]On transfer of work to Barani Agricultural Research and Development Project, Pakistan, 18 February 1985.
[7]Appointed head of section, 16 September 1985.
[8]Appointed 25 February 1985.
[9]On transfer of work to Regina Research Station, 16 September 1985.
[10]On Education Leave, Washington State University, Pullman, Washington, 16 August 1984 to 16 August 1987.
[11]On Education Leave, Utah State University, Logan, Utah, 3 September 1984 to 16 August 1987.
[12]Appointed 6 May 1985.
[13]On Education Leave, University of Saskatchewan to May 1987.

INTRODUCTION

The Swift Current Research Station, situated in the semiarid Palliser Triangle of the Canadian prairies, specializes in dryland agriculture. Improvements in cereal and forage cultivars and technology to increase production and utilization efficiency are accomplished through a multidisciplinary approach to research in plant breeding, plant physiology, agronomy, soil and water management, salinity control, nutrition, agrometeorology, equipment design, and agricultural engineering.

Significant progress in plant-breeding programs was achieved with the licensing of HY320 and Lancer wheat and the identification of two new species of grass, *Elymus dahuricus* and *Elymus sibiricus*, as possible forage crops. A detailed review of boron toxicity and deficiency clarified many aspects of managing boron levels in irrigation water.

Mr. G.B. Bacon, information officer, Dr. H.W. Cutforth, agrometeorologist, and Dr. V.I. Stevens, turkey nutritionist, joined the scientific staff in 1985 and Mr. T.V. Carr became administrative officer. Mr. G.E. Parker, information officer, and Mr. G.E. Winkleman, head of Analytical Services, were on leave of work to Canadian International Development Agency (CIDA) to assist the Barani Agricultural Research and Development Project in Pakistan. Mr. F.B. Dyck, Dr. R.P. Zentner, and Dr. D.M. Bowden were involved with a CIDA project in Brazil.

The results of this research are described very briefly in this report. More detailed information can be obtained from the publications listed at the end of this report or from individual scientists. Requests and correspondence should be addressed to the Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

T. Lawrence
Acting Director

CEREAL PRODUCTION AND UTILIZATION

Wheat varieties

HY320 wheat. HY320, a semidwarf wheat licensed in 1985, is the first cultivar to be eligible for grades of the new class, Canada Prairie Spring (red). The specifications for the three end-use suitability factors of kernel hardness, protein content, and gluten strength are each to be at a medium level. HY320 meets this specification except that the kernels are semisoft instead of being medium hard. Test-marketing results conducted by the Canadian Wheat Board and the Canadian Grain Commission indicate that flour from HY320 is acceptable for making flat breads, French breads, steamed bread, and noodles.

HY320 has wide adaptation and has averaged about 30% more grain than conventional hard red spring wheats but is later maturing than the hard red spring wheats. It is resistant to prevalent races of leaf and stem rust, moderately susceptible to root rot, and susceptible to common bunt and loose smut.

Lancer wheat. Lancer, licensed in 1985 for grades of Canada Western Red Spring wheat, has a more solid stem than Leader and equal to that of Canuck and is expected to confer a high level of resistance to the wheat stem sawfly (*Cephus cinctus* Nort.). Lancer also has more resistance to shattering and common root rot than Leader and Canuck. It has yields similar to those of Leader and Canuck. It is adapted to the Brown and Dark Brown soil zones of the Canadian prairies.

Winter rye

Three winter rye (*Secale cereale* L.) cultivars, Cougar, Puma, and Musketeer, were grown in a field experiment for 2 years to determine the effects of drying method and harvest time kernel moisture content (KMC) on the final quality and grade of the grain. Plots were harvested when KMC was in the kernel dry weight range of 950–1000 g/kg. Grain was dried in windrows in the field and artificially in a forced-air oven at 40–45°C. KMC at harvest, test mass, kernel mass, falling number, and germination were determined. Test mass increased as KMC at harvest decreased, especially in the artificially dried treatments. Kernel mass was lower when harvested at high KMC, especially in the windrowed treatments. Falling numbers were affected by harvest time and drying method, but trends were not clear. Germination was reduced by artificial drying at KMC greater than 550 g/kg. Grades were not affected by windrowing at KMC up to 957 g/kg. Artificial drying reduced commercial grades, especially at high KMC. The main degrading factors were presence of immature kernels and low test mass.

Drought physiology

Previous research indicated that excised-leaf water retention capability was related to drought resistance in *Triticum* spp., but no information is available on the heritability of the trait or its relationship to yield under drought conditions. The heritability and relationship to yield of excised-leaf water retention capability was studied in eight durum wheat (*T. turgidum* L. var. *durum*) crosses involving the high retention parent cultivar Pelissier. Fifty random lines from each cross were studied under field conditions in the F_4, F_6, and F_8 generations. Standard-unit heritabilities of initial and initial minus wilted-leaf water concentration were calculated by regressing F_4 on F_6 and F_6 on F_8 values. Heritability of initial leaf water concentration ranged from 0.08 to 0.61 in the F_4/F_6, and from 0.15 to 0.41 in the F_6/F_8. Simple correlations between yield and initial minus wilted-leaf water concentration tended to be low and nonsignificant. Comparisons of the yields of the 10 fastest and 10 slowest water losers within crosses and years, however, showed significant differences in all but three of 20 cases. In two of the crosses water retention was yield-negative in low-drought-stress environments, but yield-positive in a high-stress environment. Retention capability tended to be yield-positive or yield-neutral in the other crosses regardless of environment. Further studies, using a broader range of genetic sources of high water retention, are required in order to develop suitable selection strategies for this retention trait.

Pelleting and pellet hardener in turkey diets

Turkeys of a small white strain were fed on diets of constant energy-to-protein ratio, based on wheat–soya bean meal, with fat added at 0, 30, 60, or 90 g/kg, in mash form or as pellets, with or without the addition of sodium bentonite at 25 g/kg as a pellet hardener. Pelleted diets resulted in greater liveweights than mash at 84 days of age when the diet included no added fat (4.93 versus 4.52 kg mixed sexes) or added fat at 30 g/kg (5.14 versus 4.91 kg), but not with added fat at 60 g/kg (5.17 versus 5.16 kg) or added fat at 90 g/kg (5.27 versus 5.22 kg). Pelleting did not affect feed efficiency to 84 days, but increased carcass fat scores and grades. Sodium bentonite did not affect liveweight, feed intake, or feed efficiency, or pellet durability when the diet contained either added fat at 0 or 90 g/kg, but increased durability of pellets with added fat at 30 or 60 g/kg.

Feed efficiency increased by 1.0% for each 10 g/kg increase in fat incorporated in the diet. Carcass fat scores and grades and carcass skin yields increased with dietary fat level. Effects of pelleting and added dietary fat on carcass characteristics as well as weight gain and feed efficiency should be considered when establishing practical feeding programs for turkeys.

ENGINEERING

Boron toxicity and deficiency

Boron requires special attention among the essential mineral nutrients because although the need for boron by plants is relatively small, the range between deficiency and excess is narrow. This makes management of crop boron nutrition a demanding practice.

There is an extensive body of literature concerning the effects of boron on the growth and yield of plants. However, confusion still exists when one is trying to establish what should be regarded as an acceptable boron concentration in irrigation water. The objective of this study was to review the soil and environmental factors influencing boron toxicity and deficiency in plants with the main emphasis being given to boron toxicity. Some of the topics covered were sources of boron, importance of boron to plants, deficiency and toxicity criteria, factors affecting boron sorption, quantification of boron sorption, boron fertilization of crops, boron toxicity caused by irrigation, and boron equilibrium in soils. Difficulties encountered in appraising boron deficiency and toxicity limits and confusion in the specification of available boron units in soil were also discussed. The review placed great emphasis on soil processes and their effect on boron toxicity. Weaknesses in the data base were identified, and suggested areas requiring further research were delineated.

FORAGE PRODUCTION AND UTILIZATION

Evaluation of grasses for forage crops

Fourteen grass populations were evaluated for stand establishment, persistence, and dry matter yield under dryland conditions. Of these populations, *Agropyron desertorum* was most suitable for hay and *Elymus angustus* for pasture. *Bromus biebersteinii* compared favorably to *Elymus junceus* for pasture, suggesting that the two should be compared under grazing. When grown in mixture with alfalfa, *E. angustus* and *E. karataviensis* tended to maintain a 50:50 grass–legume stand, whereas *A. desertorum*, *A. cristatum* × *A. desertorum* (4*N*), *B. biebersteinii*, *B. inermis*, and *E. junceus* were very competitive and kept

the percentage of alfalfa in the stand low. Both *Elymus dahuricus* and *Elymus sibiricus* showed good initial production and were short-lived, suggesting they might be useful for enhancing the early production from other species sown in widely spaced rows. *Elymus karataviensis* was persistent but low yielding. *Arctagrostis latifolia* and *Deschampsia beringensis* were low yielding and lacked persistence.

Nonoilseed sunflower

Agronomic performance of Sundak nonoilseed sunflower (*Helianthus annus* L.) was evaluated in southeastern Saskatchewan. The results indicated that years, locations, and planting density are all significant factors affecting performance. As plant densities of sunflower were increased from 37 500 to 75 000 plants per hectare at Indian Head from 1975 to 1977, achene (seed) yield and test weight increased linearly with density while percentages of roasting and dehulling seed categories decreased. Row spacings of 30–90 cm affected plant height and seed yield and size, but absolute amounts were not large. Based on 1984 prices of four seed-size categories, highest gross economic returns were favored by the higher plant densities. In a second test at Indian Head and Oxbow in 1979 and Arcola in 1980, a range of plant densities from 22 900 to 76 400 plants per hectare did not significantly affect seed yield or gross economic returns. However, yield and returns tended to be greatest for 50 000 to 60 000 plants per hectare. Percentages of large seed decreased as plant population increased. Because markets generally favor the large-seed-size categories and the price differentials among seed-size categories tend to increase, plant densities of 40 000 to 50 000 plants per hectare might better be recommended to allow for years with greater price differentials.

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Research Station, Beaverlodge, Alberta

PROFESSIONAL STAFF

J.D. McElgunn,[1] B.Sc., M.Sc., Ph.D.	Director
W.H. Marshall	Administrative Officer
Vacant	Computer Systems Manager
Vacant	Librarian

Cereal and Oilseed Crops

R.I. Wolfe, B.S.A., M.Sc., Ph.D.	Head of Section; Cereal breeding
D.L. Woods,[2] P.Pharm., M.Phil, Ph.D.	Rapeseed breeding

Environment and Soils

W.A. Rice,[3] B.S.A., M.Sc., Ph.D.	Head of Section; Microbiology
M.A. Arshad,[4] B.Sc., M.Sc., Ph.D.	Soil physics
A.L. Darwent, B.S.A., M.Sc., Ph.D.	Weed control
J.G.N. Davidson, B.S.F., M.Sc., Ph.D.	Plant pathology
J.S. McKenzie, B.S.A., M.Sc., Ph.D.	Acting Head; Plant survival
P.F. Mills, B.A.	Micrometeorology
P.E. Olsen,[5] B.S., M.Sc.	Microbiologist

Forage Crops and Apiculture

S.G. Bonin, B.S.A., Ph.D.	Head of Section; Grass breeding
D.T. Fairey, B.Sc., M.Sc., Ph.D.	Legume seed physiology
N.A. Fairey, B.Sc., M.Sc., Ph.D.	Forage production
H.G. Najda, B.A., B.Sc., M.P.M.	Grass seed management
D.L. Nelson, B.S.A., M.Sc., Ph.D.	Head of Unit; Apiculture
T.P. Liu, B.Sc., M.Sc., Ph.D.	Apiculture pathology
T.I. Szabo, B.A.E., M.Sc., Ph.D.	Apiculture

Experimental Farm, Fort Vermilion, Alta.

B. Siemens, B.S.A., M.Sc.	Superintendent; Forage crops
G.W. Clayton,[6] B.S.A., M.Sc.	Crop production

Departures

L.P.S. Spangelo, B.S.A., M.Sc., Ph.D. Retired 29 August 1985	Director
W.B. Woytuik Resigned 30 August 1985	Computer Systems Manager
E.T.W. Hau, B.Sc.(Agr.), M.L.S. Resigned 1 November 1985	Librarian
R.S. Sadashivaiah, B.Sc., M.S.C., Ph.D. Transferred to Lethbridge Research Station, August 1985	Rapeseed breeding

VISITING SCIENTISTS

D.W. Bergstrom, B.Sc.(Agr.), M.Sc. Agricultural Research Council of Alberta	Cereal–oilseed agronomy
C. Stefanowsky, B.Sc. Metropolitan Bee Association Santiago, Chile, May to August 1985	Honey bee breeding
A. Vargas, B.Sc. Quillagua, Chile, May to August 1985	Honey bee breeding

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[1]Appointed 1 August 1985.
[2]Appointed 9 August 1985.
[3]On 2 year secondment for the BARD project, Islamabad, Pakistan, May 1985 to May 1987.
[4]On transfer of work to Land Resource Research Institute, Ottawa, until June 1986.
[5]Acting microbiologist, May 1985 to May 1987.
[6]On education leave, University of Saskatchewan, until April 1988.

INTRODUCTION

The Northern Research Group, comprising the research station at Beaverlodge and the associated experimental farm at Fort Vermilion, Alta., continued its responsibility for research on agricultural problems in northwestern Canada. This report presents highlights of research for 1985.

A major accomplishment was the licensing of Jackson barley. This strong-strawed variety is 7% higher yielding and 2 days later maturing than Otal.

Winterkill continues to plague the alfalfa dehydration industry in northern Alberta. Severe stress during the 1984–1985 winter caused an estimated $4.5 million dollar loss to this industry.

Continuity in the rapeseed breeding and nitrogen fixation programs has been facilitated by the transfer of Dr. Don Woods from the Saskatoon Research Station and by the promotion of Mr. Perry Olsen in the existing microbiology program, respectively.

Detailed information can be obtained from the publications listed in this report. Correspondence to individual research scientists should be addressed to the Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta. T0H 0C0, and the Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta. T0H 0C0.

J.D. McElgunn
Director

APICULTURE

Management

Nectar secretion and pollen production of legumes. Twelve cultivars of red clover (*Trifolium pratense*) differed in numbers of inflorescences per unit area of row, and in nectar secretion characteristics, but not in number of pollen grains per anther. Inflorescences contained from 8.1 to 34.0 μL nectar with sugar concentrations ranging from 33.1 to 49.3% (from 4.4 to 14.8 mg sugar per inflorescence) and from 267 to 554 pollen grains per anther. All cultivars began to flower within 2 weeks of one another and continued over a 12-week period.

One cultivar of each of three species of alfalfa (*Medicago sativa*, *M. falcata*, and *M. media*), one cultivar of each of red clover (*T. pratense*), alsike clover (*T. hybridum*), white clover (*T. repens*), and bird's-foot trefoil (*Lotus corniculatus*) were compared for numbers of inflorescences per unit area, nectar secretion, and pollen production characteristics. Seasonal nectar–sugar production of Altaswede red clover was estimated at 883 kg/ha, compared with estimated yields of 254–558 kg/ha for the alfalfa cultivars. Dawn alsike, Daeno white clover, and Leo bird's-foot trefoil had estimated sugar yields of only 44, 24, and 23 kg/ha, respectively. The high nectar yields of red clover in the Peace River region should support a substantial increase in numbers of honey bee colonies.

Nectar secretion and pollen production in canola. Fifteen varieties and breeder's lines of *Brassica napus* and seven varieties and breeder's lines of *B. campestris* differed in characteristics such as number of flowers, amount of nectar, pollen, and seed production. A significantly greater volume of nectar was extracted by a centrifuge method than with a capillary method. The nectar from *B. napus* and *B. campestris* contained 29.8 and 40.3% sugar, respectively. The daily sugar value for each flower of *B. napus* was 0.452 mg and the number of pollen grains per anther ($\times 10^3$) was 15.84 while *B. campestris* varieties had a daily sugar value per flower of 0.285 mg and 15.91 pollen grains per anther ($\times 10^3$). The sugar production figures for *B. napus* and *B. campestris* varieties were 7.06 and 9.47 kg/ha per day, respectively. Daily pollen production was 9.33 and 20.24 kg/ha and seed production was 3049 and 2673 kg/ha, respectively.

The number of *B. napus* flowers per plant significantly correlated with sugar concentration, nectar volume, sugar value, and seed weight per plot. The number of flowers per hectare was significantly correlated with the production of sugar, pollen, and seed. Sugar production and pollen production per hectare were also significantly correlated.

Nectar secretion in dandelion. Nectar secretion was studied in dandelion *taraxacum* spp. growing in a crested wheat–grass field in the Peace River region of Alberta. The average number of flowers produced daily in an area 1 m^2 was 59.2 in 1981 and 8.9 in 1982. Most flowers opened in the morning and closed in the afternoon. Quantity and concentration of nectar was significantly higher in flowers 2 days old than in those 1 day old. Average daily nectar volume, sugar concentration, and sugar value were 7.4 μL

per flower, 55.1%, and 5.2 mg per flower, respectively, in 1981 and 3.7 μL per flower, 42.6%, and 1.9 mg per flower in 1982. Larger flowers produced more nectar. Nectar–sugar concentration and sugar value increased with increasing temperature. High nectar-foraging activity by honey bees coincided with peak nectar–sugar production.

Temperatures in wintering honey bee colonies. Daily winter hive temperatures were recorded in multiple-packs of honey bee colonies (*Apis mellifera*) equipped with different types of hive entrances during the 1979–1980 and 1980–1981 winters. Sixteen hives, each of two Langstroth boxes, were divided into four groups; these were then packed with insulation and tar paper for wintering. In each group, two hives faced north and two south and the same treatment was used within each group. Treatments were: (1) bottom and top entrances (1 × 5 cm each), (2) fully open bottom entrance, (3) bottom and upper-side entrances (1 × 5 cm each), and (4) bottom entrance (1 × 5 cm) and a 2.5 cm diameter auger-hole in the middle of the second chamber. The ambient temperature fell as low as –38.8°C but the lowest hive temperature did not go below a range from –1°C to –14°C.

All colonies in treatments 1 and 4 maintained a temperature of 30°C or higher in the winter cluster throughout both winters. All colonies occupied the upper hive body; colonies in treatment 1 occupied the area close to the top entrance and in treatment 4 the area close to the auger-hole. The temperature of the cluster in colonies in treatments 2 and 3 fell to 28°C or 29°C on 2 days in December 1980. Colonies with the side top entrance (treatment 3) appeared to be unable to move consistently to that entrance. Colonies in treatment 2 appeared to move slowly to the upper hive body; while ambient temperatures remained relatively high they developed rapidly, but with a consequent drop in temperature they lost more cluster size than other colonies. The large quantity of stored food and absence or scarcity of empty cells appeared not to hinder cluster movement.

Pathology

Observation of the protozoan parasite Malpighamoeba mellificae in honey bees. A mixed population of cysts, immature cysts, and trophozoites was observed in the lumen of Malpighian tubules of *Apis mellifera* infected with *Malpighamoeba mellificae*. The most distinct pathological change in the infected tubules was a swelling of the brush border of epithelial cells. In some areas the brush border was broken down into pieces and in some cases it was completely engulfed by the parasites. The microvilli of the brush border were long and slender in noninfected tubules. Nuclei were not found in the infected tubules, but were frequently observed in the noninfected tubules. Numerous secretion globules were observed in the cytoplasm of epithelial cells of noninfected Malpighian tubules, but not in the cells of infected tubules. Epithelial cells in the infected tubules were destroyed and consumed by the trophozoites of *M. mellificae*. Trophozoites possessed protrusions and pits on their surfaces; many also had pseudopodia and apparently consumed the host cell by a mechanism of phagocytosis or endocytosis.

The developmental stages of Malpighamoeba mellificae. Primary trophozoites of *Malpighamoeba mellificae* Prell in the process of penetrating the cell membrane were found among the brush border of epithelial cells of the midgut of *Apis mellifera* L. They were long and slender with an average diameter of 3.68 μm. Their surfaces had some wrinkles and the cytoplasm contained some vesicles. Secondary trophozoites were found in the lumen of Malpighian tubules. Their size was variable and their shapes were highly irregular. Some had pseudopodia. The smooth surface of trophozoites possessed numerous small protrusions and pits. Mature cysts were small and oval-shaped; they measured from 2.65 × 3.62 to 3.4 μm. Their surface was usually smooth but some had wrinkles.

CEREALS

Breeding

Jackson barley. Jackson, a new six-rowed variety of feed barley, has been licensed for the Peace River region. It is 7% higher yielding than Otal and 2.3 days later maturing. It yielded 94% of the feed barleys Diamond and Galt, and 94 and 98%, respectively, of the new malting varieties Argyle and Harrington. It is 6.4 days earlier maturing than Diamond, 7.7 days earlier than Galt, and 8.3 and 9.3 days, respectively, earlier than Argyle and Harrington. Jackson was 15% higher yielding than Gateway 63 and matured 1 day earlier.

It is stronger strawed than Otal and similar to Diamond, Galt, and Bonanza. Its test weight is good, similar to that of Argyle, Empress, and Johnston, and better than Diamond. Seed size is similar to Argyle, Bonanza, and Klondike. It is about 7 cm shorter than Otal and 9 cm shorter than Diamond. It has a rough awn and the head is seminodding to nodding.

Jackson is susceptible to most of the common diseases, as are Olli, Gateway 63, and Otal, with which Jackson is directly competitive. It is some-

what more susceptible to leaf scald, caused by *Rhynchosporium secalis*, than Otal.

Agronomy

Effects of seeding date and fertilizer. The effects of seeding date and nitrogen and phosphate fertilizer on the agronomic characteristics of two rapeseed species *Brassica campestris* L. and *B. napus* L. were studied for a 6-year period at two northwest Alberta locations. Seeding dates were established at weekly intervals from early May to mid June. Two fertility levels were established; a control treatment in which no fertilizer was applied and a fertilizer treatment in which nitrogen and phosphorus were applied to meet the requirements of a 1680 kg/ha crop. Maximum yields were obtained most frequently with seeding periods of mid to late May for *B. campestris* and mid May for *B. napus*. Seeding date had little effect on plant density or seed quality. Nitrogen and phosphate fertilizer reduced plant densities but increased seed yield where nutrient deficiencies occurred.

ENVIRONMENT AND SOILS

Nitrogen fixation

Rhizobium strain identification. The double antibody sandwich enzyme-linked immunosorbent assay (ELISA) is ordinarily applied as an extremely sensitive technique for the detection of minute quantities of antigen among large amounts of contaminating antigen. A very rapid, single antibody-conjugate variation of the ELISA technique suitable for identification of relatively concentrated *Rhizobium* antigen (from either plate count colonies or nodules squashes) was developed. The procedure is complete within one-half work day compared with the double-antibody sandwich ELISA which is more selective of specific antigen, but requires two work days.

Winterhardiness

Winterkill in alfalfa. Alberta's alfalfa dehydration industry lost $4.5 million in 1985 as a direct result of winterkill. This dollar loss represented 26% of the total alfalfa acreage for 1985. A late December snow melt, followed by –40°C air temperatures, killed many plants of adapted varieties already predisposed to winter stresses as a result of the wet soil conditions in the fall of 1984.

FORAGES

Weed control

Delayed seeding for wild oat control. In a 4-year study, rapeseed (*Brassica campestris* L.) was seeded where wild oats (*Avena fatua* L.) had been controlled either by various delayed seeding procedures or by an early spring application of trifluralin with active ingredient at 1.1 kg/ha. The trifluralin treatment provided the best wild oat control. However, allowing wild oats to grow to the two-leaf stage, destroying them with cultivation, and then seeding rapeseed resulted in commercially acceptable control (70% or more) with little or no loss of crop yield. Postponing cultivation until the wild oats reached the three- to four-leaf stage provided control that was almost equivalent to that attained with cultivation at the two-leaf stage but resulted in reduced crop yields. Destruction of wild oat seedlings at the two-leaf stage by paraquat or glyphosate did not improve the level of control over that provided by cultivation.

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[1]Dr. A.L. Schaefer was appointed on 6 August 1985.
[2]Dr. S.D. Morgan Jones was appointed on 7 January 1985.
[3]Mr. K.N. Harker was appointed on 17 June 1985.
[4]Dr. P.A. O'Sullivan was seconded by the Canadian International Development Agency, Indian Drylands Research Project Phase III, on 1 June 1985.
[5]Dr. J.S. Taylor was appointed on 2 January 1985.
[6]Mr. J.E. McIsaac was appointed on 26 August 1985.

INTRODUCTION

The Lacombe Research Station and the Soils and Crops Substation at Vegreville are responsible for regional agricultural research in the central Alberta parklands. Specifically, programs include soil reclamation and development of cropping practices for Solonetzic soils of east-central Alberta; breeding new, high-yielding, disease-resistant feed barley and oat varieties for domestic use and export; and developing soil fertility, soil management, weed control, and cropping systems for barley, oat, and rapeseed production in the parklands. The station has regional responsibility for production and disease research of annual and perennial forage crops, for developing and evaluating hay management systems that will improve the quality of stored forages, developing management systems and evaluating new forage species and plant growth regulators to extend the pasture season, all of which will be used by beef and dairy farmers to optimize milk and beef production per hectare. The Lacombe program also includes research responsibility for regional and national programs in meats, with integrated supporting programs in pork and beef production that include developing and evaluating different muscle types of meat animals; assessing the effect of nutrition, management, and environmental stressors on growth; assessing performance and subsequent carcass quality as well as the technical research aspects of the beef cattle and swine record of performance (ROP) testing programs. The meats research includes developing and evaluating new procedures and techniques for improving the effectiveness of national departmental beef and swine carcass grading programs. The research also involves 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 at the retailer level. Consideration is also given to cooking quality and other factors related to consumer acceptance of the final product. Three new scientists joined the staff in 1985. Dr. J.S. Taylor, a plant physiologist, will be working on herbicide interactions in the control of weeds in cereals and oilseeds and cereal growth regulators. Dr. A.L. Schaefer, an animal physiologist, will be studying growth and development in pigs and beef cattle as related to subsequent meat quality. Dr. S.D. Morgan Jones, a meat scientist, joined the meats group as section head and will be responsible for carcass quality evaluation and processing methods. Mr. A.H. Martin, recognized for his long-term contribution to national meat-grading standards and studies on factors affecting carcass quality, retired in June 1985. Dr. P.A. O'Sullivan, a weed scientist, was seconded by the Canadian International Development Agency for 2 years as team leader of the All India Dryland Research Project, Hyderabad. Dr. Carol Pierson, a visiting scientist, joined the meats group to head up a research project developing new grading standards for lambs.

This report summarizes the highlights of research completed in 1985. 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 SCIENCE

Beef cattle

Effect of zeranol implantation on feedlot bulls. Thirty-six crossbred bull calves were assigned to each of four treatments: castration at 2–4 months, zeranol implantation from 2–4 months, zeranol implantation from 5–7 months, no castration or implantation. Steer calves gained 20% more slowly than bull calves during a 140-day feedlot test but zeranol implantation did not improve the rates of gain achieved by bulls nor did it affect their linear measurements at the beginning or the end of the feedlot test. In terms of feed efficiency, too, steers were inferior to bulls (by about 15%) but zeranol treatments did not improve bull performance. Zeranol treatments did reduce scrotal circumference and impair testicle consistency prior to day 84 in the feedlot test (approximately 10 months of age). But the increase in scrotal circumference from feedlot day 84 to day 140 was as high for zeranol-treated bulls as for entire bulls and the early differences in testicle consistency decreased as the feedlot test proceeded. These results suggest that zeranol implantation exerted a pronounced effect on the development of masculine characteristics during the preweaning and early postweaning periods, which diminished or even disappeared during the later postweaning period.

Blood composition of different beef breed types. Two studies were conducted to examine the blood composition of cattle of different breed types. The first study involved 357 aged crossbred cows including Hereford × Angus in addition to crosses of Charolais, Simmental, and Limousin with Hereford, Angus, and Shorthorn. Sixteen blood characteristics were measured from June and September blood samples. The second study used 23 Shorthorn cow–calf pairs from a line selected for yearling weight and 25 cow–calf pairs from a corresponding unselected control line of Shorthorns. These cow–calf pairs were bled 11 times starting at calving and then at 28-day intervals thereafter, with 11 blood characteristics measured. The crossbred cows differed significantly in hemoglobin, packed cell volume, triiodothyronine, thyroxine, urea nitrogen, glucose inorganic phosphorus, alkaline phosphatase, creatinine, uric acid, and serum total protein. Increased yearling weight in Shorthorns resulting from selection was associated with higher blood creatinine levels at maturity ($P < 0.05$) and during pre- and post-weaning growth ($P < 0.01$). These results support the view that variation in blood composition is under genetic control.

Swine

The development of a halothane susceptible strain of pigs for meat quality research. The porcine stress syndrome (PSS) is a condition in which the pig dies of malignant hyperthermia as a result of stress. Strains of pigs known to be susceptible to the condition are also more likely to produce pale, soft, exudative (PSE) pork. Halothane sensitivity is an inherited condition in which exposure to halothane anesthetic induces malignant hyperthermia and death very similar to that observed in PSS. Halothane sensitive pigs also exhibit a high incidence of PSE pork. The Lacombe Research Station began in 1980 to develop a halothane-positive strain of pigs that could be used as a dependable source of PSE carcasses for meat quality research. It was assumed that the condition is caused by a single recessive genetic factor and our results have been consistent with this assumption. The strain was based on a population of Peitrain × Lacombe crossbred pigs with an initial gene frequency of 0.25. Under our testing and selection program, the gene frequency was increased to more than 0.95 by 1984. The penetrance of the condition has been high (0.97–0.99). The incidence of PSE pork from this strain is also high: 70% compared with 10% for Lacombe pigs that do not carry the gene for halothane susceptibility. With its value as a source of material for pork quality research well established, the gene for halothane susceptibility is now being introduced into a Lacombe genetic background to reduce the genetic difference between it and the normal Lacombe strain that serves as a control in our PSE research.

MEAT RESEARCH

Physiology and meat quality

Effects of zeranol and shipping treatment on the blood profiles and carcass quality of bulls and steers. Zeranol has long been used as a growth promotant in steers and has recently been suggested as a means of reducing the incidence of dark-cutting carcasses in bulls. Differences in 19 blood components among control and implanted bulls were minor, but zeranol delayed testicular growth in implanted males. Steers had cortisol levels 2.5 times those found in bulls, whereas bulls had higher levels of serum creatinine. These findings reflect the higher rate of protein synthesis in bulls compared with steers. Moderate preslaughter stress (mixing and trucking 160 km) compared with minimal preslaughter stress (no mixing and trucking only 4 km) resulted in an increase for ten blood components and a decrease for three others, and these results are being further investigated as an objective method to measure stress. Zeranol had a minor influence on the carcass composition of control and implanted bulls. However, bulls implanted with zeranol produced carcasses with darker meat, higher 24-h pH, and lower meat expressible juice than bulls or steers for the moderate stress treatment. Zeranol resulted in little alteration of overall meat palatability for bulls, but did produce some potentially important differences in the components of flavor and texture. Differences in meat palatability were found between bulls and steers which were attributed to textural properties. It was concluded that zeranol influenced testicular growth in bulls but did not reduce the incidence of dark-cutting carcasses in bulls subjected to moderate preslaughter stress.

Meat microbiology

Homologous bacteriophage control of Pseudomonas growth and beef spoilage. The effects of homologous bacteriophages (phages) upon the growth of a beef spoilage pseudomonad and the retail case life of beef were examined under conditions of simulated retail display. It was shown that the treatment of *Pseudomonas*-inoculated steaks with high titer phage lysates (108 phages per millilitre) resulted in a 1–2 log reduction in the level of bacterial contamination and a 2 log increase in phage numbers after 4 days of retail

display. These changes were accompanied by a marked decrease in discoloration of the steak surface and a concurrent improvement in retail appearance. Steak case life was also shown to be positively and linearly correlated ($r = 0.985$, $P < 0.001$) with phage concentration within the range of 10–108 phages per millilitre. At the highest concentration of phages tested (108 phages per millilitre) steak case life was significantly increased from 1.6 to 2.9 days. Dose–response data showed that phages could not produce a significant increase in retail case life until the concentration of phages applied to the meat surface approached 103/cm^2. Furthermore, the meat had to be populated with a minimum of homologous spoilage bacteria of 102/cm^2 of surface before phages could significantly improve keeping quality. It was concluded that phages could multiply on the steak surface and have the potential for the biological control of beef spoilage.

Meat quality

New Canadian pork quality standards. A color-illustrated bulletin, developed recently at the Lacombe Research Station in cooperation with the Food Production and Inspection Branch, describes a new two-part scoring system for the evaluation of pork quality: one part for color (1 = extremely pale to 5 = extremely dark) and another for structure (1 = extremely soft–exudative to 5 = extremely firm–dry). These new pork quality standards were tested using the *longissimus dorsi* muscle of commercial pigs. They were effective in segregating carcasses into relatively discrete quality groups. Pork quality, assessed using the new standards, was highly correlated ($R_2 = 0.6$–0.85) with other methods for evaluating pork quality including objective color, percentage transmission, expressible juice, and pH at 24 h after slaughter. Although subjective color score was highly correlated with structure score, a notable exception to this trend was the existence of a relatively common, but previously undescribed, quality category that was characterized by a severely adverse structure score, but with color only slightly paler than normal. The new standards offer improvement in precision and versatility, as well as a more interpretable estimation of pork quality.

Meat processing

Effects of antioxidants on rancidity development and palatability of frozen bacon. The efficacy of four antioxidants for retarding rancidity development and maintaining the palatability of frozen bacon slices was examined. The antioxidants, i.e. ascorbic acid (AA), butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate (PG), were incorporated into a dry sugar–bacon cure, alone or in combination. Results indicated that combinations of BHA, BHT, and PG was the only antioxidant treatment that was effective for extending the frozen storability of bacon slices from the standpoint of flavor, desirability, and overall palatability. Bacon slices cured in the presence of this antioxidant combination remained acceptable for approximately 84 days longer during frozen storage than bacon cured in the absence of antioxidants.

Carcass grading

The effect of ribbing site on fat thickness measurements and the prediction of beef carcass composition. Minimum fat thickness at the cut surface of the 12th rib has been used to specify carcass fatness and hence yield grade in the Canadian beef-grading system. In March 1984, the point of ribbing was changed from the interface of the 11–12th rib to the 12–13th rib, so that the Canadian carcass-breaking procedures would more closely conform to international standards. Minimum fat thickness taken at the location specified for use under Canadian beef-carcass-grading procedures was 1.6 mm less, averaged over all carcasses (409) at the 13th rib, compared with the same measurement taken at the 12th rib. Prediction equations for estimating carcass lean or fat content had similar precision using fat thickness measurements from either ribbing site. In conclusion the reduction in fat requirements for the different yield classes within the Canada A grade in conjunction with the change in ribbing site was found to be justified.

CROP MANAGEMENT AND SOILS

Weed research

Influence of chlorsulfuron on green foxtail control with diclofop-methyl. Greenhouse (1984 and 1985) and field (1982 and 1983) experiments were conducted to investigate the effect of a chlorsulfuron and diclofop-methyl tank mixture on the control of green foxtail. Diclofop-methyl at 0.7 kg/ha gave at least 95% control of the green foxtail. However, the addition of chlorsulfuron to the diclofop-methyl at 0.02 kg/ha reduced the control of green foxtail by 20–50%.

Broad-spectrum weed control in cereals with diclofop-methyl tank mixtures. Greenhouse (1984) and field (1984 and 1985) experiments were conducted to investigate the effect of adding linuron at 0.2 kg/ha to a tank mixture of diclofop-methyl (0.8 kg/ha) and chlorsulfuron (0.001 kg/ha). The three herbicides were applied in various

combinations to determine wheat and barley tolerance and the control of green foxtail, tartary buckwheat, and false cleavers. Linuron alone provided only a slight suppression of the green foxtail. However, the antagonistic action of chlorsulfuron on green foxtail control with diclofop-methyl was overcome when linuron was added to the mixture. The control of tartary buckwheat and false cleavers was at least as great in the three-way mixture as in any of the two-way mixtures.

Soil fertility

Fate of fall-applied N fertilizers in central Alberta soils. Fall-applied nitrogen (N) is often less effective than spring-applied N fertilizers in increasing yields of cereal crops in parts of the Prairie Provinces. Five field experiments were conducted in north-central Alberta using ^{15}N-labeled fertilizers to determine the amount of mineral N lost over the winter by denitrification, leaching, and immobilization. Potassium nitrate and urea were mixed into the soil and ammonium sulfate was placed in a band. All were applied at N rates of 112 kg/ha in fall or in early winter. The plots were sampled to a depth of 120 or 150 cm in late May. The N losses through denitrification early in the spring averaged 67% from potassium nitrate and 38% for urea. Wet soils in the fall (as simulated by adding 50 mm of water to the soil in one experiment) increased the over-winter losses of mineral N from 41 to 74% when compared with naturally drier soils. About 7–49% of the applied N became immobilized (a reaction whereby mineral N is converted by soil bacteria to an organic form that is not immediately available to plants). Ammonium sulfate produced the most immobilized N.

CEREAL BREEDING, PATHOLOGY, AND FORAGES

Cereal pathology

Stem melanosis of Park wheat responds to plant- and soil-applied copper. Stem melanosis symptoms in Park wheat increased significantly with the addition of zinc, nitrogen, phosphorus, or potash singly or in combination, whereas the addition of copper alone or copper with any other element prevented symptoms from developing. These data indicated that a copper deficiency in the soil may be aggravated by adding other major or minor elements to such soils. Wheat plants in plots receiving copper also developed less common root rot than those not receiving copper. Low levels of copper in the soil caused significantly more melanistic symptoms in Park than in the cultivars Neepawa or Sinton, cultivars with some tolerance to copper deficiency. Copper deficiency in the soil reduced the yield of Park wheat more than those of the other cultivars. Adding copper to the soil, however, increased the yields of all wheat cultivars significantly. Copper applied to the foliage or mixed with the soil before seeding was more effective than the same amount of copper banded 4 cm to the side of the seed at sowing in reducing stem melanosis and increasing yields in Park wheat. The copper in these tests was applied as copper sulfate or copper chelate. Copper sulfate was the most effective means of applying copper.

Forage crops

Faba beans. Faba beans, an ancient crop, have been introduced into Canada and commercially produced for about 10 years. Being a legume, they do not require nitrogen fertilization and fix more nitrogen than most other legumes. When harvested as whole-plant forage in central Alberta, they produce dry matter at an average yield of 5 t/ha compared with oats, which produces dry matter at 8 t/ha. However, because of the high protein content (17%) they produce more protein per unit area than any other silage crop. The varieties Aladin, Herz Freya, and Outlook produce similar silage yields, and Diana somewhat less. All of the licensed varieties produce good yields of silage, but are too late maturing to consistently produce seed in short seasonal areas. Breeding for early maturity, begun at Lacombe in 1975, has produced early lines, two of which are being tested in cooperative tests.

They are somewhat lower in seed yield than late varieties, but when yields per day of growth period is used, the early lines are comparable with licensed varieties. A second phase of this work is the reduction of the tannin content of seed of early faba beans. Tannins are responsible for reductions in feed efficiency. Therefore low tannin content, along with sufficient earliness, should allow for the production of feed supplements in short-seasoned areas to replace imported supplies.

Limitations to whole-plant silage yield in barley. Barley is used extensively for whole-plant silage in central Alberta. In 1983 and 1984 research was conducted into the limitations to the attainment of maximum digestible yield (MDY). Limiting factors in barley MDY could be nutritional, functional (limited by the process), genotypic, or morphological in nature. Eight six-rowed barley cultivars of variable height and maturity were harvested weekly, seven times, beginning at their respective heading dates. Several yield and quality parameters were measured coincidentally over the duration of the experiment.

Whole-plant yield doubled, but in vitro digestibility was unchanged, presenting little or no limitation to attainment of MDY. Time to MDY preceded time of maximum kernel weight by at least 1 week in both years. Percentage of dry matter (PDM) is a functional limitation because, for optimum quality, silage should be ensiled at 35% dry matter, a level that occurred at about 90% of MDY. Ensiling at 35% dry matter necessitates cutting at 30% dry matter, a level that coincides with 80–85% of MDY and varied over the years. Harvesting for optimum PDM for silage production requires cutting 10–14 days prior to maximum kernel weight; therefore, the growing season is not fully utilized. Cultivar traits associated with high MDY, determined using multiple regression techniques, were time from planting to MDY, 50%; dry matter yield at heading, 10%; and height, 6% (expressed as a percentage of the variability in MDY). Therefore, given that time of harvest should precede time of kernel maturity and MDY, digestible yield could be improved by planting later-maturing barley cultivars than those normally grown for grain.

Cereal breeding

Cereal varieties. The high-yielding, early-maturing, sprouting tolerant grain oat variety, OT740, has been licensed under the name Jasper and was released to SeCan in 1985. The new variety originated from a Cavell–Gemini cross made in 1975 and has performed well in regional and cooperative trials. The major attributes of Jasper are excellent yield-maturity index; high bushel weight; and an excellent combination of high protein, high fat, and low hull contents. The new variety is expected to be in commercial production in 1987.

The oat cultivar Cascade (licensed in 1979) occupied 38.5 and 22.4% of the 1985 oat hectarage in Alberta and Saskatchewan, respectively. The six-rowed feed barley cultivar, Diamond, has also moved rapidly in commercial hectarage. Hectarage under this variety increased from 2.3% in 1984 to about 4.3% of the total barley hectarage in Alberta in 1985. The hectarage under the hard red spring wheat cultivar Park decreased from approximately 389 700 ha in 1984 to about 356 800 ha in 1985.

SOILS AND CROPS SUBSTATION VEGREVILLE

Solonetzic soils

Amelioration of irrigated Solonetzic soils. A 4-year study to determine the effects of gypsum and lime in combination with ammonium nitrate or ammonium bisulfite was completed with bromegrass on an irrigated Brown Solonetzic soil near Enchant, Alta. The relatively low rate of gypsum of 18 $kg.ha^{-1}$ in combination with irrigation improved the sodic condition in the Bnt horizon, which improved plant growth. Lime amendments did not improve the soil condition or influence plant yield. Application of the ammonium nitrate with gypsum increased yield of bromegrass but did not alter the chemical properties of the soil to an extent greater than gypsum alone. Ammonium bisulfite was a less efficient nitrogen source but did substantially alter the soil's chemical properties compared with addition of gypsum alone. Generally, the adverse soil chemistry associated with the sodic Bnt horizon of Solonetzic soils was improved by gypsum applications under irrigation. Chemical properties of soil such as soluble sodium, sodium adsorption ratio, and electrical conductivity were decreased, while exchangeable Ca and the ratio of exchangeable Ca to Na were increased, compared with the unamended soil. Water penetration in the Bnt horizon was improved by the gypsum amendment. Plant growth gave a positive response to the addition of gypsum.

PUBLICATIONS

Research

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Research Station, Lethbridge, Alberta

PROFESSIONAL STAFF

Administration

D.G. Dorrell, B.S.A., M.Sc., Ph.D.	Director
E.E. Swierstra, B.S.A,, M.S.A., Ph.D.	Assistant Director
S.B. Arnason, B.S.A.	Head, Administration
B.D. Clark	Administrative Officer, Finance and Materiel Management
H.A. Doddridge	Acting Personnel Officer
W.H. Mains, B.Sc.(Eng.), M.Sc.	Facilities Management Engineer

Scientific Support

H.S. Chung, B.Sc.	Programmer/Analyst
C.M. Cutler,[1] B.A., M.L.S.	Area Coordinator, Library
B.S. Freeze,[2] B.S.A., M.Sc.	Bioeconomist
G.C. Kozub, B.Sc., M.Sc.	Statistician
J.C.M. L'Arrivée, B.S.A., M.Sc., Ph.D.	Technical Information Officer
D.W. Pang, Dip.C.S.	Computer System Manager
C.M. Ronning Mains,[1] B.A., B.L.S.	Librarian
G.B. Schaalje,[3] B.S., M.S.	Statistician
L.J.L. Sears, B.A.	Scientific Editor

Animal Parasitology

W.O. Haufe, B.A., M.Sc., D.I.C., Ph.D.	Head of Section; Bioclimatology
R.W. Baron,[4] B.Sc., Ph.D.	Immunology
R.H. Robertson, B.A., M.Sc.	Serology
J.A. Shemanchuk, C.D., F.E.S.C., B.Sc., M.Sc.	Biting-fly ecology
J.L. Shipp, B.Sc., M.Sc., Ph.D.	Black-fly ecology
W.G. Taylor, B.S.P., Ph.D.	Pesticide chemistry
J. Weintraub, B.A., M.S.	Cattle-grub ecology
J.M.B. Yeung, B.Sc., Ph.D.	Pesticide metabolism

Animal Science

J.E. Lawson, B.S.A., M.S.A.	Head of Section; Beef cattle breeding
C.B.M. Bailey, B.S.A., M.S.A., Ph.D.	Animal physiology
D.R.C. Bailey, B.Sc., Ph.D.	Beef cattle breeding
K.-J. Cheng, B.Sc., M.Sc., Ph.D.	Rumen microbiology
G.H. Coulter, B.Sc.(Agr.), Ph.D.	Reproductive physiology
R. Hironaka, B.Sc., M.Sc., Ph.D.	Animal nutrition
L.A. McClelland,[5] B.Sc., M.Sc.	Sheep breeding
G.J. Mears, B.Sc., M.Sc., Ph.D.	Animal physiology
R.C. Phillippe, B.Sc.	Bacterial culture collection

L.M. Rode, B.S.A., M.S., Ph.D.	Animal nutrition
J.A.P. Vesely, B.S.A., M.S.A., Ph.D.	Sheep and dairy cattle breeding

Crop Entomology

D.L. Struble, B.A., M.A., Ph.D.	Head of Section; Insect attractants
J.R. Byers, B.S.A., M.Sc., Ph.D.	Cutworm ecology
W.A. Charnetski, B.Sc., M.Sc., Ph.D.	Insecticides
A.M. Harper, B.Sc., M.Sc., Ph.D.	Aphids
B.D. Hill, B.Sc., M.Sc., Ph.D.	Residue chemistry
D.L. Johnson, B.Sc., M.Sc., Ph.D.	Rangeland insects
K.W. Richards, B.Sc., M.Sc., Ph.D.	Insect pollinators
B.D. Schaber, B.Sc., M.Sc., Ph.D.	Forage crop pests
G.H. Whitfield, B.Sc., M.Sc., Ph.D.	Potato and sugar beet pests

Plant Pathology

F.R. Harper, B.Sc., M.Sc., Ph.D.	Head of Section; Cereal leaf diseases
R.L. Conner, B.S.A., Ph.D.	Cereal diseases
D.A. Gaudet, B.Sc., M.Sc., Ph.D.	Snow molds
H.C. Huang, B.Sc., M.Sc., Ph.D.	Forage and special crops diseases
G.A. Nelson, B.Sc., M.Sc., Ph.D.	Potato and bacterial diseases
D.W.A. Roberts, B.A., Ph.D.	Cold-hardiness physiology

Plant Science

S. Smoliak, F.S.R.M., B.Sc., M.S.	Acting Head of Section; Dryland pastures
J.R. Allan, B.Sc., M.A., Ph.D.	Aquatic plant physiology
P. Bergen, B.S.A., M.Sc., Ph.D.	Weed control
R.E. Blackshaw,[6] B.Sc., M.Sc.	Weed control
M.R. Hanna, B.S.A., M.S.A., Ph.D.	Forage legume breeding
M.S. Kaldy,[7] B.Sc., M.S., Ph.D.	Food science
G.A. Kemp, B.Sc., Ph.D.	Vegetable breeding
D.R. Lynch, B.Sc., M.Sc., Ph.D.	Potato breeding
M.D. MacDonald, B.Sc., Ph.D.	Corn breeding
D.J. Major, B.Sc., M.Sc., Ph.D.	Crop physiology
K.W. May, B.Sc., M.Sc., Ph.D.	Barley breeding
J.R. Moyer,[8] B.Sc., M.Sc., Ph.D.	Weed control
H.-H. Mündel, B.S.A., M.S., Ph.D.	New crops, Hard red spring wheat breeding
R.S. Sadasivaiah, B.Sc., M.Sc., Ph.D.	Soft white spring wheat breeding
J.B. Thomas, B.Sc., M.Sc., Ph.D.	Winter wheat breeding
E.D.P. Whelan,[9] B.S.A., M.S.A., Ph.D.	Wheat cytogenetics
W.D. Willms, B.S.F., M.Sc., Ph.D.	Rangeland ecology

Soil Science

D.C. MacKay, F.C.S.S.S., B.Sc., M.S., Ph.D.	Head of Section; Plant nutrition
G.J. Beke, B.S.A., M.Sc., Ph.D.	Hydrology
J.M. Carefoot,[10] B.S.A., M.S.A.	Irrigation agronomy
C. Chang, B.Sc., M.Sc., Ph.D.	Soil physics
J.F. Dormaar, B.S.A., M.S.A., Ph.D.	Organic chemistry
N. Foroud, B.Sc., M.Sc., Ph.D.	Irrigation engineering
B.W. Grace, B.Sc., M.Sc., Ph.D.	Agrometeorology
H.H. Janzen, B.S.A., Ph.D.	Dryland agronomy
R.M.N. Kucey, B.Sc., Ph.D.	Soil fertility
C.W. Lindwall, B.Sc., M.Sc., Ph.D.	Agricultural engineering
T.G. Sommerfeldt, B.Sc., M.S., Ph.D.	Drainage engineering

Departures

J.B. Bole, B.S.A., M.Sc., Ph.D. Transferred to Pacific Region, 27 October 1985	Plant nutrition
G.A. Grigat, B.Sc., Ph.D. Deceased 11 July 1985	Animal nutrition
M.J. McCormick, B.A. Transferred to Pacific Region, 29 March 1985	Personnel Officer
R.J. Morrison, B.Sc., Ph.D. Resigned 22 February 1985	Spring wheat breeding
R.J. Rennie, B.S.A., M.Sc., Ph.D. Resigned 25 September 1985	Soil microbiology
D.B. Wilson, B.Sc., M.S., Ph.D. Retired 28 June 1985	Head, Plant Science Section

VISITING SCIENTISTS

D. Beyer, M.Sc. Doctoral candidate, Beyreuth University, Germany-Canada Biotechnology Exchange Agreement, February to September 1985	Nitrogen fixation
P. Chaiwanakupt, B.Sc. IDRC-CDA Cooperative Project, Department of Agriculture, Bangkok, Thailand, May to October 1985	Nitrogen fixation
J. Chiquette, M.Sc. Agriculture Canada research scientist training fellow, August 1984 to December 1986	Rumen microbiology
D.K. Jain, Ph.D. Natural Sciences and Engineering Research Council postdoctorate fellow, September 1984 to September 1986	Nitrogen fixation
M. Krunić, Ph.D. University of Belgrade, Yugoslavia, August 1985	Leafcutter bee management
H. Kudo, D.V.M., M.V.S., Ph.D. Postdoctorate fellow, September 1981 to March 1986	Rumen microbiology
R. Mutalib, D.V.M., M.Sc. Universiti Pertanian Malaysia, March to August 1985	Anaerobic biotechnology
M.C. Oswal, Ph.D. CIDA senior fellow, All-India Dryland Research Project, April to October 1985	Soil physics
P.J. Scholl, Ph.D. Seconded from United States Department of Agriculture to the Canada–U.S.A. sterile insect release project on warble flies, March 1982 to February 1987	Integrated pest management and warble fly ecology

C. Siripaibool, M.Sc. International Development Research Centre–Control-droplet application Cooperative Project, Department of Agriculture, Bangkok, Thailand, May to October 1985	Nitrogen fixation
V. Bala Subramanian, Ph.D. Canadian International Development Agency Senior Fellow, All-India Dryland Research Project, April to October 1985	Crop physiology
S. Wakamura, Ph.D. Shikoku National Agricultural Experimental Station, Japan, July to September 1985	Pheromone analysis

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On educational leave, Oregon State University, September 1984 to August 1987.
[3]On educational leave, North Carolina State University, August 1985 to August 1988.
[4]On transfer of work, Centre de Recherches de Tours, Nouzilly, France, August 1985 to August 1986.
[5]On educational leave, Massey University, Palmerston North, New Zealand, January 1984 to January 1987.
[6]On educational leave, University of Guelph, January 1983 to January 1986.
[7]On transfer of work, United States Department of Agriculture Fruit and Vegetable Chemical Laboratory, Pasadena, California, September 1985 to August 1986.
[8]On transfer of work, Tanzania–Canada Wheat Project, Arusha, Tanzania, August 1985 to September 1987.
[9]On transfer of work, Grasslands Division, Department of Scientific and Industrial Research, Palmerston North, New Zealand, September 1984 to September 1985.
[10]On educational leave, University of Alberta, September 1982 to November 1985.

INTRODUCTION

The research station at Lethbridge, in southern Alberta, is located at the center of one of the most diverse agricultural regions in Canada. A wide variety of crops is grown on both dry and irrigated land, and a major part of Canada's beef cattle industry is established on the farms and ranches within and around the region.

Station scientists conduct fundamental and applied research in six disciplines to support 13 Research Branch objectives. In addition to the 500-ha site at Lethbridge, the station conducts research at a 17 000-ha ranch and beef cattle breeding station near Manyberries, a 400-ha ranch near Stavely in the foothills of the Rocky Mountains, and a 130-ha irrigation substation at Vauxhall. Crop production and improvement research deals with the breeding and genetics of 12 different species or crop kinds, the study of the biology and control of a wide range of plant diseases and insect pests, and the development of improved agronomic practices related to soil fertility, tillage, and water use. Related studies on physical, chemical, microbiological, and hydrological aspects of soil provide guidance for the introduction of methods to maintain or improve the soil resource.

Livestock research is concerned with evaluating the effects of breed or selection methods on the improvement of beef or dairy cattle, and breed and management on sheep productivity. Other studies on nutrition and physiology contribute to the development of efficient methods of beef cattle production. The station is also a major center for the study of arthropod pests of livestock.

During 1985, Dr. D.B. Wilson, head of the Plant Science Section, retired after a long and productive career and was replaced on an acting basis by Mr. S. Smoliak; Drs. J.B. Bole, R.J. Morrison, R.J. Rennie, and Mr. M.J. McCormick resigned to assume other duties; and the staff lost a good friend and scientist with the death of Dr. G.A. Grigat. Several new scientists were appointed: Dr. P. Bergen, weed scientist; Dr. L.M. Rode, animal nutritionist; Dr. R.S. Sadasivaiah, soft white wheat breeder; and Dr. J.M.B. Yeung, analytical chemist. Mr. D.W. Pang was appointed as computer and information systems manager. Our scientists hosted visiting scientists; participated on graduate students' thesis committees, international secondments, and exchanges; and served on numerous provincial, national, and international committees.

Several of our clients participated directly in our research activities; Farming for the Future of Alberta Agriculture partially funded 14 projects and the Western Grains Research Foundation funded four projects.

The short reports that follow give results of some recent research and illustrate the types of studies that are under way. Further information may be obtained from publications listed at the end of the report or from scientists. Correspondence or requests for reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

D.G. Dorrell
Director

ANIMAL PARASITOLOGY

Biting flies

Evaluation of a portable CO_2 generator as a source of CO_2 for the dry-ice baited silhouette trap. The dry-ice baited silhouette trap has been shown to be an effective method for sampling populations of adult black flies. This trap, however, must be examined daily to replenish the dry ice bait, which is not always readily available in rural areas. The portable CO_2 generator does not require daily servicing and is compact (1.5 kg). The effectiveness of silhouette traps provided with a CO_2 generator was compared with that of silhouette traps, unbaited or baited with dry ice in a pasture situation in central Alberta. The dry-ice baited silhouette trap sampled significantly greater numbers of black flies than any of the other traps examined and the CO_2 generator trap sampled greater number of black flies than the unbaited silhouette trap. Thus, the CO_2 generator was not as effective as dry ice for attracting black flies but it could be useful in remote areas where dry ice is not available.

Repellents for biting flies. To study relationships between chemical structure and insect repellent activity, 15 heterocyclic oxazolidine derivatives of citronellal, a naturally occurring insect repellent, were synthesized, characterized, and tested in laboratory bioassays with three species of mosquitoes. Citronellal is capable of existing as (+) and (−) isomers so the experimental compounds could be isolated as mixtures of (±) isomers or in nearly pure (+) and (−) forms. To

determine the purity of the derivatives, high resolution gas chromatography was investigated, using capillary columns that were developed for separating (+) and (−) amino acids. These columns were found to be useful to separate some of the isomers in the synthetic oxazolidines and therefore were valuable to determine the (+) and (−) content of the samples. In general, the best mosquito repellents were found with samples that had been prepared from (+) citronellal. The experimental samples were usually less effective than R-69 insect repellent (Citronyl™, S.C. Johnson and Son), an oxazolidine derivative prepared from (±) citronellal. However, samples of R-69 that had been prepared from (+) citronellal possessed a broader spectrum of mosquito repellent activity than the registered product.

Cattle protection from biting fly attack. Fenvalerate, deltamethrin, (IR)-*cis*-permethrin, (IR)-*trans*-permethrin, and (IS)-*trans*-permethrin, applied topically to the entire body surface of steers with active ingredients at a rate of 1 mg/kg of body weight, provided 70% or better protection from black flies for 16, 9, 8, 6, and 6 days, respectively. The (IS)-*cis* stereoisomer of permethrin was ineffective as a protectant against black flies. One polyvinyl chloride ear tag containing 10% permethrin in each ear of steers provided protection from black flies for up to 13 days under field conditions. Polyvinyl chloride ear tags containing fenvalerate were not effective.

Application of chemicals to cattle. A dual-cloud electrostatic sprayer developed by the Applied Electrostatics Laboratory, University of Western Ontario, under contract to Agriculture Canada was found to be effective in applying permethrin aerosol spray to cattle under pasture and farmyard conditions to protect them against black flies. This sprayer has the following advantages: it is light, easy to operate, and can be mounted easily on a half-ton truck or all-terrain vehicle; it emits very fine droplets that are electrostatically charged, permitting coverage of the body with small amounts of spray without having to restrain animals; there is minimum waste of expensive chemical and minimum impact on the environment; very little time is required to spray a herd of cattle; and a fine spray knocks down some of the flying black flies to provide immediate relief. A disadvantage of this sprayer is that it is noisy and produces an air blast that frightens cattle, especially in open pastures. However, cattle soon become accustomed to the noise and air blast when they learn that relief from black fly attack follows treatment.

Breed tolerance to black fly attack. Yearling Hereford, Angus, Galloway, Highland, Holstein, Ayrshire, Charolais, and Highland–Shorthorn cross steers, paired for uniformity in weight and temperament, were compared to detect differences in tolerance to black fly attack. Results from this comparison indicated that Highland, Highland–Shorthorn crosses, and Galloway breeds received significantly fewer bites than Hereford, Angus, Charolais, Ayrshire, and Holstein steers. The longer, denser haircoat on the Highland, Highland–Shorthorn crosses, and Galloway steers is believed to be a deterrent to black flies on these breeds of cattle. If the cattle industry is to expand in the black fly-infested areas, the use of long-haired breeds of cattle may be one component of integrated management.

Horn flies

Benefits from ear tags in productivity of cattle. Experiments were conducted on a ranch in southern Alberta to evaluate the productivity of the cow–calf unit in breeding herds in response to treatment with pesticidal ear tags to control infestations of horn flies, *Haemotobia irritans* (L.). Optimum economic productivity was found to depend on the effectiveness of tags in establishing fly-free grazing (FFG) conditions and maintaining them without interruption during the complete summer grazing period. It was achieved when animals were tagged before the first overwintering horn flies emerged from diapause in spring. Results of experiments showed that present formulations of pesticide in tags will support the required FFG conditions for 85–90 days. Management of herds for maximum gains throughout the summer grazing period requires replacement of tags at least once during the summer. Rates of gain in weight of animals under FFG conditions on dry range conformed with the 16% improvement of production projected from controlled experiments on irrigated pastures.

ANIMAL SCIENCE

Beef cattle

Sires' progeny compared on two energy levels. To start a selection study, two 108-cow lines were formed within each of the Angus and Hereford breeds. Fourteen bulls were designated for breeding use in each breed. Each bull was bred to an equal number of cows in each line over a 3-year (or 4-year) period to make the progeny in the two lines more genetically similar before selection began. Progeny from one line of each breed were fed a two-thirds concentrate to one-third hay (3132 kcal/kg) diet and those from the second line a 100% roughage (2225 kcal/kg) diet. Sire × diet interactions were not significant, indicating that

sires ranked similarly for average progeny performance on the two diets. This may mean that high energy diets do not have to be used on sire progeny tests. That observation might apply also to individual performance tests where the use of diets with only moderate energy can reduce the digestive disturbances or deleterious effects on reproduction caused by high energy diets.

Selection for postweaning gain. In a long-term selection study, replacement cattle were selected on the basis of their outstanding gain in a 168-day feedlot test. One line of each of the Angus and Hereford breeds was fed an 80% concentrate to 20% forage diet and the second line a 100% forage diet. After 10 years of selection, progeny of selected bulls were compared with progeny of foundation bulls. Evidence of selection progress was particularly strong in the lines tested on the concentrate diet where the progeny of the selected bulls exceeded those of the foundation bulls in postweaning gain by 5.7% in the Hereford and 10.8% in the Angus. In the Angus, the advantage carried through so that in weight-per-day of age and adjusted final feedlot weight, progeny of selected bulls exceeded those of foundation bulls by 6.5%. The first indication of a correlated response was in birth weight, where progeny of selected Hereford bulls in both lines had 5% lighter birth weights than progeny of foundation bulls.

Energy in the diet affects reproduction. Bull calves were obtained from two strains of each of Angus and Hereford cattle for which replacements were selected on the basis of superior postweaning growth on high or medium energy diets. Bulls were fed either the high (80% grain + 20% forage, HED) or medium (100% forage, MED) energy diet. In 1981, MED bulls had 21% greater daily sperm production per gram testicular parenchyma (DSP/g) than did HED bulls. Compared with HED bulls, DSP for MED bulls was 8 and 34% greater in 1980 and 1981. Bulls on the MED from weaning to 15 months of age exceeded HED bulls by 66% for caput-corpus epididymal sperm reserves (CCESR) for Herefords (Angus response same on the two diets) in 1980, 88% for CCESR for both breeds in 1981, and 32 and 76% for caudal ESR in 1980 and 1981. Thus, sperm production and reserves of young Angus and Hereford bulls will be much superior if bulls are selected and managed on medium rather than high energy diets.

Intake of diets differing in digestible energy and form of hay. Ten groups of 16 steer calves were fed diets with hay-to-concentrate ratios of 77:23, 68:32, 59:41, 49:51, and 40:60 until they reached 475 kg. At each ratio, one group received cubed hay and one received long (baled) hay. The DE intake per unit metabolic weight ($W^{0.75}$) of diets containing long hay increased as the proportion of concentrate was increased from 23 to 41% then leveled off when concentrate was increased further. With the cubed hay, DE/$W^{0.75}$ declined as the proportion of concentrate in the diet increased from 23 to 41% then increased as the proportion was increased to 51 and 60%. The feed to gain and DE to gain ratios declined and the rate of gain and carcass fat thickness increased as the proportion of concentrate increased in both long and cubed hay diets. Both forms of hay and hay-to-concentrate ratios must be considered when predicting feed and DE intakes.

Rumen microbiology. In order to assess the contribution of individual bacterial species to the overall process of cellulose digestion in the rumen, pure culture and co-cultures of two cellulolytic bacteria (*Ruminococcus albus* and *Bacteroides succinogenes*) and noncellulolytic bacteria (*Borrellia* spp.) have been studied. In studies of in vitro barley straw digestion, *Borrelia* co-cultures surpassed pure cultures of cellulolytic organisms in dry matter digestion, volatile fatty acid generation, and in the production of lactic acid, succinic acid, and ethanol. Co-cultures of *Borrelia* with *B. succinogenes* formed "clear zones" on cellulose–agar medium while pure cultures of *B. succinogenes* did not. These results show that *Borrelia* and cellulolytic bacteria interact and enhance the degradation of cellulosic materials.

Dairy cattle

Crossbred and purebred performance. The additive, maternal, and heterosis effects on kind of birth (normal or abnormal), placental condition, and percent of male or female dead calves from purebred and crossbred cows were of minor importance. The number of dead calves from purebred cows did not depend on whether an individual calf was purebred or crossbred or if it was born in first, second, third, or fourth lactation. However, Holstein calves had higher mortalities and a greater number of abnormal births than those out of Ayrshire or crossbred cows. Placental condition did not vary among the genetic groups of cows. Rebreeding rate, defined as percentage of cows pregnant for the second time based on the number of heifers calving for the first time, less the number of heifers culled for reasons other than reproduction, was 88% for Holstein and crossbred cows and 78% for Ayrshire cows. By the end of three lactations, 63% of the Holstein and crossbred cows and 77% of the Ayrshire cows were culled. Days to first service, services per conception, calving interval, and gestation

period were similar for each genetic group of cows.

Profit-maximizing linear program model. Feed intake and milk production and composition data from a trial with five groups of dairy cows each fed a different level of concentrate were combined with literature values to develop a linear program model for dairy cows. The linear program model evaluates production responses to different levels of concentrate feeding under varying price levels for feed and milk to formulate the most profitable diet that meets nutritional requirements.

Dairy cattle and sheep

Rumen protozoa. The composition of rumen ciliate populations was surveyed in 11 Holstein cattle and 6 sheep in the Lethbridge Research Station experimental herd in order to distinguish features of species distribution in a Canadian environment. A total of 28 ciliate species were identified in cattle and 17 in sheep. The average number of ciliates per milliliter of rumen contents was 6.9×10^4 in cattle and 19.0×10^4 in sheep. The average number of species appearing per host was 20.5 in cattle and 13.8 in sheep. Of the ciliate species detected in this examination, species of the genus *Entodinium* appeared most frequently both in cattle and sheep. *Diplodinium polygonale, Eodinium lobatu, E. monolobum, Eremoplastron rostratum, Ostracodinium clipeolum, O. mammosum*, and *Ophryoscolex purkynjei* were not detected in sheep. In contrast, *Ophryoscolex caudatus* was not found in cattle. From these data, it appears that the ciliate fauna of cattle and sheep in this particular Canadian environment are similar to those reported in Japan.

Sheep

Crossbreeding. Crossbred lambs (973) of eight genetic types including Dorset × 3/4 Dorset (DD), Dorset × 3/4 Finn (DF), Finn × 3/4 Dorset (FD), Finn × 3/4 Finn (FF), Romanov × 3/4 Dorset (RD), Romanov × 3/4 Finn (RF), Romanov × Western (RW), and Western × Western (WW) were compared for growth performance, survival rate, and carcass quality. The RW cross proved to be superior for most traits. Their lambs were second heaviest at birth after the western lambs (4.0 versus 4.3 kg) while the lightest lambs were the Finn crosses, DF and RF (both 2.9 kg). All crosses of lambs had about the same survival rate (88–89%). RW lambs were superior in weaning weight (19.5 kg) followed by the DD lambs (19.2 kg). The lightest lambs were DF and RF crosses (15.5 and 15.8 kg). RW lambs were also the fastest growing lambs in the feedlot (0.27 kg/day) and reached market age first (97 days), while the slowest growing lambs were RF and DF crosses (0.25 kg/day), both needing 116 days in the feedlot. Finn or Romanov rams did not produce inferior carcasses (lower weights and grades). Thus, under Canadian conditions, profit would not be reduced for the producer by using rams from these two breeds as terminal sire.

Growth hormone, insulin, and fetal growth. Plasma concentrations of growth hormone (GH) and insulin were monitored in 11 chronically cannulated ovine fetuses and their mothers during the last month of gestation to determine the role of these hormones in fetal growth rate. Maternal plasma GH and insulin were independent of stage of gestation and lamb birth weights. Fetal plasma insulin was episodic in nature, independent of stage of gestation and tended to be higher in fetuses that were heavier at birth. Fetal plasma GH was only slightly episodic in nature, was tenfold higher than maternal levels at 116 to 124 days gestation, and increased by approximately another 25% prior to parturition. Fetal plasma GH was negatively correlated with lamb birth weights, and in twins, was less in the twin that was heaviest at birth. Lower GH concentrations in faster growing fetuses suggest a more rapid metabolic clearance of GH by their tissues. Evidently, circulating fetal GH and, possibly, insulin help determine ovine–fetal growth rate.

CROP ENTOMOLOGY

Grasshoppers

Population studies. Southern Alberta experienced another heavy grasshopper infestation as the area infested by the adult population increased by 1.45 times that of 1984. The infestation was comparable to the previous record high numbers of 1962 and 1933. At least 600 000 ha were treated for control and the estimated crop losses and cost of insecticides were about $20 million in Alberta. The potential population for 1986 appears to be reduced due to cool, wet weather in August and September, which is their normal oviposition period. A grasshopper egg survey in October showed that the number of eggs laid in infested sites averaged only 40 eggs per square metre, compared with well over 100 eggs per square metre in 1984. The actual area infested in 1986 is not expected to decrease dramatically, but it appears that the number of adults will be about one-half of the 1985 level.

Cutworms

Population studies. Southern Alberta experienced the most severe outbreak of pale western

cutworm since 1931. The infestation was accurately predicted by a pheromone-trap moth survey conducted over a 13 000 km^2 area since 1978. Because of unusually warm weather the larvae hatched in mid March, which was one month earlier than normal, and populations of 50–100 larvae per square metre were common. Severe damage occurred in both winter wheat and spring-seeded crops. As in 1984, the most severe infestations occurred in crops seeded on stubble indicating that cutworms should be considered as a serious risk factor under continuous cropping. In all of Alberta, an estimated 200 000 ha were treated for cutworm control and treatment costs and crop losses were about $13.6 million. Pheromone-trap monitoring in autumn 1985 showed a 20% increase in the moth population compared with 1984, which indicates a potentially heavy infestation in southern Alberta in 1986.

European corn borer

A survey with pheromone-baited traps showed that the population in the Medicine Hat area increased by 1.6 times that of 1984 and reached a level comparable to that present in Manitoba in 1984. Small numbers of moths were captured for the first time in the sweet corn growing area near Taber and Lethbridge. Insecticides were not applied for larval control on irrigated grain and silage corn in the Medicine Hat area and there were minimal crop losses. However, the fresh market sweet corn in the same area was treated with insecticides.

Insecticide residue chemistry

Residue dissipation studies. The dissipation of deltamethrin soil residues was determined after different methods of application. When deltamethrin was pipet-applied, dissipation was first-order if degree-days above 0°C (deg-day$_0$) rather than days were used as the independent variable. The half-life was 724 deg-day$_0$ indoors and 758 deg-day$_0$ in the field. When deltamethrin was boom-sprayed, a biphasic first-order plot was observed. A two-compartment model was developed that predicts an initial fast loss of residue followed by a slower first-order degradation. This model gave a good fit to the data and predicted DT_{50} values of 463 and 192 deg-day$_0$ from ground and aerial boom applications, respectively. An outdoor petri-dish experiment confirmed that the 0–7 days dissipation was faster when deltamethrin was boom-sprayed and a surface loss process was indicated. It is postulated that the high water volumes with pipet application washed the deltamethrin into the soil and, with less surface loss, dissipation was slowed. This research demonstrates that the method of application can influence residue dissipation. The two-compartment model will greatly improve the accuracy of residue predictions for biphasic dissipation.

Forage crop pests

Biological control. A fungus, *Verticillium lecanii* from Mount Allen in the Kananaskis region of Alberta, was pathogenic in the laboratory to the green peach aphid, the pea aphid, the rose grass aphid, and the spotted alfalfa aphid, as well as grasshoppers and the predatory damsel bug. The fungus was not pathogenic to the oat bird cherry aphid, adults of a lady bird beetle, or the larvae of the European corn borer. As *V. lecanii* has a wide host range, its efficacy against target and nontarget species of insects should be thoroughly investigated to determine its potential as a biological control agent.

Leafcutter bees

Parasitism. Incidence of parasitism by *Pteromalus venustus* Walker in populations of the alfalfa leafcutter bee in western Canada from 1970 to 1984 was found to average around 1%. Some bee populations exceeded 50% parasitism and this presumably reflects differences in management practices among beekeepers. An average of 17.4 parasite adults emerged from each infested host cocoon and the ratio of males to females was 1:1. The range of temperatures for greatest survival of the parasite (30–32°C) coincided with the recommended incubation temperature for cocoons of the leafcutter bee. Survival and rate of development decreased at 36°C. At temperatures of 10 and 15°C there was no larval development after 180 days of incubation. Development data fitted a four-parameter development model. Linear regression of development rate versus temperature provided estimates of base temperature and development time in degree-days for the egg, larval, pupal, and combined stages. Only 4.7 days are required to complete pupal development and 11.9 days to complete another generation at 30°C. Thus, unless the first generation of adult parasites is successfully controlled during incubation, parasitism and emergence of a second generation are possible before the leafcutter bees emerge.

Special crop pests

Sugarbeet root maggot. Coldhardiness and overwintering survival of the sugarbeet root maggot was investigated. Mature third instar larvae can supercool to −11°C but mortality may occur at temperatures above this point, especially under extended periods (6 months) of low temperatures. There were significant differences in the vertical distribution of larvae in the soil; the majority of larvae were observed to occur at a depth of 10–

20 cm in September, 5–15 cm in January and February, and 0–15 cm in April. Survival and pupation of larvae in the field averaged 87 and 74%, respectively, and there were no significant differences in larval survival at soil depths of 5–30 cm during the winter. High overwintering survival of the larvae is attributed to their low supercooling points, freezing tolerance, and their ability to move within the soil to take advantage of the thermal damping properties of soil throughout the year. It is unlikely that fall tillage practices can reduce the overwintering survival of sugarbeet root maggot larvae.

PLANT PATHOLOGY

Potatoes

Ring rot. Terminal stem cuttings were taken from Russet Burbank potato plants infected with ring rot bacteria and showing mild symptoms of the disease. None of the plants derived from these cuttings or from two successive stem-cutting propagations showed signs of the disease. Small tubers from mature plants of the last stem-cutting propagation were planted in the field and produced plants free of ring rot and the disease was not detected in other tuber propagations over the next 3 years. By this stem-cutting technique, seed lines or new cultivars of potatoes that become accidentally infected with ring rot bacteria can be freed of the pathogen quickly and effectively.

Wheat

Black point. Black point is one of the most common causes of downgrading soft white spring wheat in western Canada. A recent field study, conducted at locations in each of the three Prairie Provinces, demonstrated that several hard red spring and utility wheats had black point resistance comparable to that found in the resistant line SWS15. Further tests of the most resistant cultivars established that the cultivar Glenlea had a significantly lower incidence of black point than SWS15 when inoculated with either a mixture of isolates of *Alternaria alternata* or isolates of *Cochliobolus sativus*. The results of this study suggest that Glenlea would be a useful source of black point resistance for a breeding program.

Cottony snow mold. The development of microsclerotia in winter wheat infected with nonsclerotial strains of the cottony snow mold pathogen has been investigated. Microsclerotial cells originated through swelling of terminal and intercalary projections in elongate hyphae to produce small, spherical cells. The spherical cells increased in number through prolific budding to form aggregations embedded in a mucilaginous matrix. Microsclerotia were also observed in naturally infected fall rye. They probably serve as survival structures for nonsclerotial strains of the cottony snow mold pathogen.

Inheritance of coldhardiness. Rescue, Cadet, and each of 42 reciprocal chromosome substitution lines derived from these two spring wheat cultivars were tested for coldhardiness. Tests were performed after hardening under a 16-h day for 8 weeks with day–night temperatures of 6°C/4°C or after 7 weeks in the dark at 0.8°C followed by 8 weeks at –5°C. Chromosomes 2A, 5A, and 5B carried loci modifying coldhardiness after 8 weeks at 6°C/4°C under 16-h light per day whereas chromosomes 6A, 3B, 5B, and 5D were involved in regulating hardiness in the dark after 7 weeks at 0.8°C followed by 8 weeks at –5°C. These results suggest that the two tests should give slightly different rank orders for hardiness of cultivars and that the two tests have different genetic and biochemical bases.

Sorghum

Grain sorghum is considered to have potential as a new crop in southern Alberta but poor seedling emergence has discouraged its promotion and development. Tests under controlled conditions have shown that chilling injury per se is not the cause of reduced emergence but that stresses caused by low temperatures or heavy soils enhanced the pathogenicity of soil- and seed-borne pathogens. *Fusarium* species isolated from Alberta soils were pathogenic to sorghum at low temperatures. Various seed-borne fungi were prevalent in seed lots produced in southern Alberta and their presence partially accounted for poor seed viability and seedling vigor. A seed-borne bacterium, *Pseudomonas syringae*, was also associated with poor seedling vigor in seedlots produced in southern Alberta. The incidence of the bacterium in seedlots varied from 8 to 67% (average 38%). In growth chamber studies at 20°C, sorghum seedlings from seed inoculated with strains of *P. syringae* developed stunted, discolored roots and coleoptiles when placed on moist filter paper or when sown in autoclaved or untreated field soil. Stunting of the root and coleoptile probably contributes to poor seedling emergence under field conditions and may predispose the seedling to seed- and soil-borne fungal pathogens.

Forage crops

Transmission of Verticillium albo-atrum by alfalfa pollen. A laboratory study indicated that alfalfa pollen is susceptible to in vitro infection by *V. albo-atrum*, the causal agent of verticillium

wilt of alfalfa. Infection occurred in 24 h when pollen grains were mixed with spores of *V. albo-atrum* and incubated on potato dextrose agar media. The pathogen penetrated more readily through the germinative pores than through other parts of the pollen wall. The invading hyphae proliferated rapidly to fill the entire cell lumen and eventually the infected pollen ruptured. An outdoor study confirmed that the infection of alfalfa pollen by *V. albo-atrum* occurs in the field. Numerous alfalfa pollen grains collected from alfalfa leafcutter bees in a diseased field were found to be infected with *V. albo-atrum*. These findings suggest that the alfalfa leafcutter bee is an important agent for transporting *V. albo-atrum*-infected alfalfa pollen to alfalfa stigmas during pollination. In consequence, this insect may contribute to the introduction of the pathogen to alfalfa seeds.

Survival of Verticillium albo-atrum in manure or in digestive tracts of sheep. Alfalfa stems naturally infected with the alfalfa wilt pathogen, *V. albo-atrum*, were buried indoors in cow manure packs and in an outdoor manure pile. Stems were recovered at intervals over 6 weeks and examined for viable *V. albo-atrum* in the tissue. The survival rate of the pathogen in stems buried at 10–60 cm deep for 1 week was 0–26% but it was 54–90% in stems buried near the surface of the manure pile. In the outdoor experiment, *V. albo-atrum* was viable in 93% of the stems near the surface of the manure pile after 6 weeks. This suggests that when diseased alfalfa hay is fed to animals, the manure should be piled up and stored for at least 1 week and that manure from the outside of the pile should not be spread in the field.

When alfalfa hay infected with *V. albo-atrum* was fed to sheep, the pathogen was present in feces collected within 2 days after feeding commenced. *V. albo-atrum* was absent in feces collected 2 or more days after the animals were returned to a diet free of the pathogen. This finding suggests that the transfer of *V. albo-atrum* from the feeding area to the field can be prevented by feeding the animals for at least 3 days on a diet of undiseased hay before releasing them into an alfalfa field to graze.

Field crops

Biological control of sclerotinia diseases. Laboratory investigations using light and electron microscopy indicate that *Talaromyces flavus* is a destructive hyperparasite of *Sclerotinia sclerotiorum*. In dual culture, hyphae of *T. flavus* grew toward and coiled around the host hyphal cells. The coiling effect intensified as the hyphae of *T. flavus* branched repeatedly on the host surface. Tips of the hyphal branches often invaded the host by direct penetration of the cell wall without formation of appressoria. Infection of host cells by *T. flavus* resulted in granulation of the cytoplasm and collapse of the cell walls. Preliminary results from field trials indicate application of *T. flavus* to the soil reduced incidence of sclerotinia wilt in sunflower.

PLANT SCIENCE

Cereal crops

Effect of different plot borders on grain yields in barley and wheat. An experiment to determine if the type of plot border affected the relative yield of barley and wheat genotypes was grown on irrigated and dry land on or in the vicinity of the Lethbridge Research Station from 1981 to 1983. Ten genotypes of barley (*Hordeum vulgare*) and 10 genotypes of wheat (*Triticum aestivum*) were grown with four types of plot borders. The plot borders consisted of: control—six rows of each genotype were planted and only the four inside rows were harvested; unbordered—four rows of each genotype were planted with one uncropped row on either side; winter wheat border—four rows of each genotype were planted with one row of winter wheat on either side; spring cereal border—four rows of each genotype were planted with one row of the other spring cereal (barley for wheat plots and vice versa) on either side. Plot yields increased as border competition decreased. However, the ranking of the different genotypes was not influenced by the type of plot border, except when a highly competitive barley genotype was used as a border with wheat. It was concluded that the type of plot border was of relatively little importance in selection for yield, as long as the border was not more competitive than the plot.

Vernalization and photoperiod response characteristics of a reciprocal substitution series of Rescue and Cadet hard red spring wheat. A reciprocal substitution series between Rescue and Cadet hard red spring wheats was used to identify chromosomal differences for vernalization response, basic vegetative phase, and photoperiod sensitivity. A greenhouse technique was used to provide estimates of these variables. Genes affecting vernalization were found on chromosomes 2A, 5A, and 5B. Chromosomes 2A and 5B also affected the length of the basic vegetative phase. A gene on chromosome 3B affected photoperiod sensitivity.

Corn

Effect of temperature on in vitro kernel growth of flint and dent maize hybrids. Most maize (*Zea*

mays L.) hybrids grown in short-season areas are flint–dent endosperm types. The so-called flint hybrids are believed by some to have faster growth rates than dent hybrids at low temperatures. This study was conducted to determine the feasibility of using the in vitro kernel growth technique to investigate the effects of temperature on growth of northern flint and dent maize hybrids. Kernels of three hybrids in one experiment and five hybrids and three inbreds in a second experiment were cultured in vitro on a defined medium at 15, 20, 25, or 30°C. The kernels were removed after 2–7 weeks in culture and dry weights were determined. The dent endosperm hybrid 'King K1108' had the highest rate of kernel growth at all temperatures, whereas the European flint–dent hybrid 'Limagrain LG1' had the slowest rate of growth. The Canadian flint–dent hybrid 'Pioneer 3995' had an intermediate rate of growth. In one experiment, the differences were more pronounced at low temperatures than at high temperatures. Kernels of inbreds were difficult to culture in vitro, and the growth rates of their kernels were never greater than those of the F_1 progenies. The comparison of flint and dent hybrids suggested that a more extensive study of the major groups of maize would result in detection of differences in growth rates of kernels at different temperatures.

Forage crops

Effects of stocking rate on a rough fescue grassland vegetation. A study was conducted to examine the effects of four stocking rates on the vegetation in a Rough Fescue Grassland in southwestern Alberta. Stocking (expressed in animal units per month, AUM) at a light rate (1.2 AUM/ha) for 32 years did not affect range condition. However, a modest increase in stocking rate (1.6 AUM/ha) led to a marked decline in range condition. This was associated with a change in the composition of rough fescue (*Festuca scabrella*) from 38 to 21% of basal area. Rough fescue was nearly eliminated with a stocking rate of 2.4 AUM/ha. Rough fescue was replaced by Parry oat grass (*Danthonia parryi*), which increased from 24% at 1.2 AUM/ha to 48% at 2.4 AUM/ha. However, stocking at 4.8 AUM/ha resulted in severe deterioration of the grassland. This required annual adjustment of the stocking rate to avoid animal losses. The recommended stocking rate for good condition range in the area is 1.6 AUM/ha. Recovery of the vegetation within the exclosures, from the time of their construction, to a stable range condition, took from 14 years in the lightly grazed field to more than the length of the study in the very heavily grazed field. The duration required for recovery was related to the original range condition of the exclosures.

Productivity of Russian wildrye and crested wheatgrass and their effect on prairie soils. Crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) and Russian wildrye (*Elymus junceus* Fisch.) are used extensively as seeded pastures in the Prairie Provinces of Canada. Rangeland plowed in 1954 was planted to the two grasses in 1955. Herbage was harvested over a 25-year period, root weights were determined in 1977, and soil samples were obtained in 1965 and 1978 from the two seeded pastures and from adjacent native rangeland from each of three replicates. Forage production from the seeded pastures was greatest 4 years after seeding. Averaged over all years, crested wheatgrass yielded 113% more and Russian wildrye yielded 47% more forage than did native rangeland. Total root weight in the surface 15-cm layer of soil was greater on the native rangeland pasture than on the seeded pastures. Soils from native range pastures generally contained more organic carbon and, less sodium and had lower pH and sodium adsorption ratios than the soils from Russian wildrye pastures seeded 10 and 23 years before the soils were sampled. The organic C content and pH value of the soils obtained from crested wheatgrass pastures decreased during the 23-year period while those of soils from the native range did not change.

Recovery of vegetative cover and soil organic matter during revegetation of abandoned farmland in a semiarid climate. Much of the farmland in the Canadian prairie region has been abandoned over the years and allowed to revert to weedy cover and eventually to grassland. While some of the changes in vegetation during plant succession have been documented, limited information is available on changes in soil characteristics. Therefore, a study was conducted to assess the vegetative cover and soil transformation under similar semiarid climatic conditions with an annual precipitation of about 310 mm on three sites abandoned in 1925, 1927, and 1950 as compared with adjacent native range. Total C and N, water-stable aggregates between 1.0 and 5.0 mm, and polysaccharide content increased, while chelating resin-extractable C, humic acid to fulvic acid ratios, caloric content of the rootmass, and dehydrogenase activity decreased in the successional sequence. Nevertheless, more than 55 years will be required to allow soil to return to native range standards under moderate grazing by livestock. Revegetated range may have to be subjected to lighter grazing pressures than usual to allow the vegetation to continue to increase its rootmass and thus the soil chemical properties.

Seedling establishment with glyphosate. Glyphosate is a broad-spectrum herbicide that may be used to kill existing vegetation and permit the establishment of introduced species from seed. Little information is available on either the direct or indirect residual toxicity of glyphosate on germinating seeds and seedlings. Consequently, several experiments were conducted to determine the effect of glyphosate on the establishment of forages from broadcast seed. Forage establishment was severely depressed when glyphosate was applied at high rates (20 kg/ha). Applying glyphosate within recommended rates had little effect on forage establishment. However, establishment was related to time of seeding. Success of forage establishment decreased with increasing interval between glyphosate application and seeding after 8 days. Autoclaving the soil improved establishment where sod had been killed by earlier glyphosate or freezing treatment.

Plant litter. Studies were conducted to determine the effects, on herbage yield, of removing mulch and standing dead plant litter during plant dormancy for up to three or more consecutive years. This information is required to obtain a better understanding of the implications of dormant season grazing on forage production. Mulch and standing litter were harvested at 1-, 2-, or 3-year frequencies in both the fescue prairie and mixed prairie communities. Plant response was measured annually as the yield of herbage produced. Herbage yields decreased as the annual frequency of mulch and litter harvests increased in the mixed prairie but not in the fescue prairie. In the mixed prairie, yields declined to 43% of the control after 3 years of treatment. Removing mulch and standing litter from rough fescue plants resulted in shorter but a greater number of tillers than in the control. The results imply that dormant season grazing would have no negative effect on forage yield in the fescue prairie but, rather, it might enhance plant vigor by stimulating tillering in grasses. In the mixed prairie, however, grazing during dormancy might be expected to decrease forage yields as a result of removing litter.

Oilseed crops

Saffire safflower. Saffire is a safflower cultivar (licensed 3 April 1985) developed at the Lethbridge Research Station with financial support from an Alberta Agriculture farming for the future grant. As such, this cultivar is deemed to be held jointly by the federal and provincial governments. Saffire is the first Canadian safflower cultivar and is intended for the dryland southern prairies. It combines early maturity, high sclerotinia head rot resistance, good yield, and a bright white to creamy white seed. Saffire is intended mainly for the birdseed market. Because of its relatively low oil levels, the oilseed market would be a secondary market. With its heat and drought resistance, associated with a deep tap root that can utilize soil moisture from considerable depths, safflower can now provide farmers with an alternate opportunity for cash income. Furthermore, flexibility in dryland crop rotations is enhanced, particularly in relation to weed and disease control.

Potatoes

After-cooking darkening. An investigation was undertaken to measure the concentration of citric acid and potassium in Russet Burbank tubers grown in the major production areas of Alberta in order to establish the relationship between these tuber constituents and chlorogenic acid. This was necessary to identify locations in the province where a problem with after-cooking darkening may be encountered. A previous study of the chlorogenic acid content of Russet Burbank potatoes in Alberta revealed a trend for tubers produced in north-central Alberta (Edmonton and Lacombe) to have a higher chlorogenic acid content than those produced in the south (Brooks and Vauxhall). An increase in the ratio of citric to chlorogenic acid content is known to be associated with a decrease in the tendency for potato tubers to darken after cooking. Tuber citric acid and potassium contents were higher in southerly locations than in central locations. The trend for citric acid is the reverse of that for chlorogenic acid established in a previous study. Thus, potatoes grown at southern Alberta locations have a higher citric to chlorogenic acid ratio than those grown in central locations, suggesting that they would be less subject to after-cooking darkening.

SOIL SCIENCE

Water and climate

Assessment of irrigation efficiency. A technique has been developed to accurately determine the efficiencies of water distribution, water conveyance, and water use in an irrigation system. The flow rates from two stream-gauging sites under dynamic and fluctuating conditions and normal district operation are calculated continuously. The gross amount of water used, which includes various losses for a given number of days, is determined. The amount of the field irrigation applications during the selected period is assessed, and irrigation efficiency is then calcu-

lated. The calculated efficiency is called the distribution efficiency if the selected stream-gauging sites are on a distributary canal. It is called the system efficiency if the sites are located on a main canal. In situations where no water is withdrawn or diverted from the canal the conveyance efficiency is calculated. When the technique was applied to a distributary canal in the Lethbridge Northern Irrigation District, distribution efficiencies of 63 and 56% were obtained for lined and unlined portions of the canal, respectively. This technique eliminates the numerous and impractical measurements from many farm ditches as required by the "traditional" method.

Assessment of climatic factors affecting irrigation. Many climatic factors affect the yield and quality of irrigated crops. The strong synergistic effects of nitrogen and water availability were demonstrated to emphasize that maximum response to nitrogen fertilizer can be achieved only when irrigation is optimized. With evaporation rate three times greater than precipitation during the growing season, crop water deficits present special problems in southern Alberta. It is incorrect to suggest that the irrigated areas of southern Alberta can expect to receive, on average, the mean amount of precipitation. Where crop water and nutrient stress are minimized with irrigation and fertilizers, it is often suggested that the major factor limiting yields is the accumulation of growing degree-days (GDD). Data from southern Alberta do not support this claim. The GDD concept is most useful in defining those areas in which new crops and varieties might successfully be grown. Such climatic factors as untimely precipitation, which may interfere with spring seeding or fall harvesting operations, and others such as hail and frost, can seriously reduce crop yield and quality. Each risk factor may be weighted and mapped.

Managing peak demands for irrigation water. Under ordinary farm management practices, two late-season, small-grain silage crops received insufficient irrigation water to maintain plant-available soil water at recommended levels. Water use by the July-sown barley crop differed markedly from that by the mixed oats–barley regrowth. The slow early growth rate of the crop reflected the low early water requirements of barley. Barley water use peaked about 4 weeks later than the early August peak use of the oats–barley regrowth. Barley had a considerably lower level of peak water use than the regrowth crop but maintained an appreciable water requirement until the growing season ended in late September. The water use curve for barley, except for being lower, was very similar to that reported for spring barley. The July-sown barley exhibited more extensive disease and nutritional disorders than the regrowth crop, but yields of both were sufficient to harvest for silage. Production of two grain-silage crops per growing season or staggered seeding dates appeared to be feasible management options for shifting peak water demands in irrigated areas of southern Alberta.

Soil management and conservation

Comparison of three sources of N fertilizer. Field studies were conducted comparing urea (UR), ammonium nitrate (AN), and anhydrous ammonia (AA), as well as the method and time of fertilizer addition, for efficacy in producing increased barley yields. When broadcast and incorporated into the top 3 cm of soil, AN produced 10–15% greater yields than UR at N addition rates similar to those used by farmers. However, when the three fertilizers studied were placed in a concentrated band 15 cm below the surface and 30 cm apart, no significant differences were observed in the resulting yields. Fall addition of N, if done after soil surface temperatures were below 5°C, did not result in yield losses when compared with spring applications, except at rates exceeding 100 kg/ha. Decreased yield responses to broadcast UR were found to be due to increased susceptibility of UR to ammonia volatilization in high pH soils (up to 45% of UR-N lost as ammonia within 10 days). Liquid and acidic forms of UR fertilizers were not significantly better than granular UR. Volatilization losses were greatest if a thatch of straw was present on the soil surface.

Cattle feedlot manure as a substitute for commercial fertilizer. Cattle feedlot manure, valued for its N and P content, can be an economic substitute for commercial fertilizer. A feedlot operation of 500–1000 heads of cattle, using a farm tractor with a front-end loader and manure spreader on a single-axle truck, can haul manure up to 15 km and recover all costs. Feedlots of less than 500 heads, using a pull-type manure spreader and a front-end loader on a farm tractor, can haul up to 15 km, if noncash and labor costs are disregarded. Alternatively, with a custom corral cleaner, at $140.00 an hour, the hauling distance is 18 km. However, on a yield benefit basis, the break-even distances increase dramatically for some crops. For instance, for corn, at $89.00 a tonne, the distance increases to 90 km and for sugarbeets at $44.00 a tonne, the distance increases to over 200 km. A need for more research to determine the economic optimum rate of manure application was identified.

Recovery of soil on abandoned farmland in a semi-arid climate. Many of the level grassland

fields in southeast Alberta and southwest Saskatchewan were cultivated early in this century. However, some 1.6 million hectares of land have since been abandoned and have now reverted to grassland. Under semiarid (annual precipitation of about 310 mm) conditions and moderate grazing (to provide a 50% carryover of forage) by livestock, more than 55 years will be required for the soil to return to standards similar to native range even though the oldest field used was only cultivated for 15 years. Total below-ground biomass was still greater under native range than under the revegetated range. There was increased aggregation in the smaller-sized (>1.0-mm diam.) water-stable aggregate fraction during the early stages of revegetation. The proportion of larger-sized (<1.0-mm diam.) water-stable aggregates increased with time. Initially, mineral matter was temporarily held together in small aggregates by organic substances of low molecular weights. With time, as increased quantities of root exudates supplied by the increasing below-ground biomass increased the polysaccharide levels in the soil, the size of the water-stable aggregates increased as well.

Zero tillage for winter wheat. Three rotations, winter wheat–fallow, winter wheat–barley–fallow, and continuous winter wheat were compared using conventional and zero tillage seeding practices for 6 years at Lethbridge. Over the first 4 years of the study, the yield from the no-till continuous winter wheat plots (2631 kg/ha) was 78% of the winter wheat yield and 113% of the spring wheat yield in conventionally tilled summerfallow rotations. However, in the last 2 years of the study, heavy infestations of downy brome in the continuous winter wheat rotation (irrespective of tillage treatment) has required substitution of spring wheat for winter wheat. Continued competition from downy brome and drought during the last 2 years resulted in poor yields of spring wheat (649 kg/ha), which were only 29% of the winter wheat yields from the conventionally tilled summerfallow rotations. In all three rotations there has been a significant yield advantage of about 10% with zero tillage over conventional tillage. The yield advantage was attributed to better soil moisture conditions at seeding time which permitted shallower seeding and more vigorous plant growth compared with that with conventional tillage. Over the 6-year period the total production and net returns were the greatest with no-till winter wheat in the winter wheat–barley–fallow rotation. The economics of chemical fallow compared favorably with that of cultivated fallow because a low rate of atrazine was used to provide residual weed control during the summerfallow season and only one application of glyphosate or paraquat was required for preseeding weed control.

Biotechnology

Biocides and N_2 fixation. The use of seed-applied pesticides to control seed and root diseases is an integral part of the production of pea, lentil, and fababean. Unfortunately, the use of these chemicals may be incompatible with the need to inoculate these legumes with *Rhizobium leguminosarum* to ensure adequate nodulation and N_2 fixation. Thiram, metalaxyl, and DL-Plus did not harm N_2 fixation in these legumes. Captan and captan-containing compounds such as B-3 (33.5% captan) and Evershield (29.5% captan) reduced N_2 fixation. DL-Plus (15% captan) was not harmful suggesting that pesticides containing more than 30% captan may not be compatible with seed-applied *R. leguminosarum*. Captan was consistently harmful but is the best broad spectrum pesticide for use with these legumes. Thus, it will be necessary to select superior rhizobia strains that are tolerant to recommended rates of captan.

Mutating bacteria. Captan and captan-containing pesticides (B-3, Evershield, and DL-Plus) reduce nodulation, N_2 fixation and yield in field bean, yet both the pesticide and the rhizobia must be applied to the seed before planting. Spontaneous mutants of *Rhizobium phaseoli* were selected in the laboratory for their ability to grow in a microbial medium containing 100 ppm of Captan. Evaluations in a controlled environment chamber and the field indicated that all mutants were less sensitive to commercial rates of Captan 50W (2.0 g/kg seed) than either parent strain or commercial multi-strain inoculant. Inoculation of captan-treated seed with these mutants 24 h prior to seeding did not affect N_2-fixing activity or yield. Assessment of the effect of pesticides on the N_2-fixing symbiosis and the captan-tolerance of *R. phaseoli* strains using the acetylene reduction assay or ^{15}N isotope dilution at levels of ^{15}N natural abundance was similar. The existence of mutants of *R. phaseoli* tolerant to seed-applied captan but unaltered in symbiotic properties makes the combined use of captan as a seed protectant and seed-applied rhizobial inoculation fully compatible.

N_2 fixation by grain legumes. The amount of N_2 fixed by soil or inoculated *Rhizobium leguminosarum* in association with annual grain legumes such as lentil, fababean, pea, and chickpea is not known. Without this information, the agronomic significance of improvements in N_2 fixation through rhizobial strain and legume

cultivar selection is difficult to assess. N_2 fixation was estimated by ^{15}N isotope dilution in irrigated annual grain legumes in response to inoculation with commercial multi-strain *R. leguminosarum* inoculant on two Typic Haploboroll soils for 2 years. Within a crop species, lentil, fababean, and pea cultivars adapted to western Canada did not differ in their ability to benefit from symbiotic N_2 fixation. When inoculated, the N_2 fixed averaged 176, 84, 216, and 185 kg/ha for chickpea, lentil, fababean, and pea, respectively. The percentage of plant N derived from the atmosphere averaged 82, 67, 85, and 79% respectively for the same crops. Response to inoculation was dependent on the crop. Uninoculated chickpea had no nodules or N_2-fixing activity; inoculation increased N_2 fixation in fababean by 19–67% and in lentil by 5–16%, depending on the site. Peas did not respond to inoculation. Continued inoculation benefits will be dependent on selecting rhizobial strains that are highly competitive against indigenous soil rhizobia.

Soil salinity

Nutrition of barley growing in saline soils. A greenhouse experiment was conducted to examine the influence of soil salinity on the growth and nutrient uptake of barley. Barley yields were adversely affected when soil salinity exceeded 0.6 S/m. This yield decline was associated with a reduced uptake of Ca, and in plants growing under extreme salinity, Ca concentrations in the plant tissue were well below critical levels. A strong direct correlation was observed between yield and the Ca concentration in the plant tissue. This relationship may serve as a criterion for selection of barley lines with improved salt tolerance and for the diagnosis of salt stress in a growing barley crop. Development of remedial practices to correct the apparent Ca deficiency may facilitate improved barley yields under saline conditions.

Water and climate

Movement of nitrate-nitrogen in irrigated sandy soils. Downward movement of nitrate-nitrogen (NO_3-N) in irrigated sandy soils was studied on land broken from native grass and irrigated in 1975. Two soils with different texture profiles were located in the study area. A check site for each soil was chosen on adjacent uncultivated land. The NO_3-N content of soil cores taken at intervals to at least 150 cm was found to be higher in cultivated land than in check soils and averaged 50 kg/ha from 90 to 210 cm. The amount of NO_3-N in the soil did not increase during the 4-year period of study. This amount is attributable to the downward movement of NO_3-N from the high initial mineralization of organic-N in the newly broken soil. Annual N fertilizer application appeared to contribute very little to leaching losses of NO_3-N even in these sandy soils.

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Pacific Region
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PREFACE

The Pacific Region, created in 1983, consists of five research stations, an experimental farm, and three substations that serve the agricultural industry in British Columbia. It has a staff of 270 people, including 60 research scientists.

Pacific Region Headquarters achieved full staff in 1985 with the appointment in August of Dr. J.B. Bole, formerly of the Lethbridge Research Station, as program specialist, and Mr. R.Z. Rivers, formerly of Fisheries and Oceans, as research economist in July. The position of director changed at four of the five research stations. Dr. J.M. Molnar was transferred from the Saanichton Research Station to Agassiz to replace Dr. J.E. Miltimore who retired. Dr. C.J. French was appointed acting director at Saanichton. Dr. D.M. Bowden, formerly of Swift Current, was appointed director of the Summerland Research Station upon the retirement of Dr. G.C. Russell. Dr. J.A. Robertson, formerly of Melfort, replaced Dr. J.D. McElgunn as director of the Kamloops Research Station.

Soil management and conservation research involves assessing the extent to which fertilizer, tillage, and water management limit crop production in south coastal British Columbia. More efficient techniques have been developed for determining sulfur status of soils and for applying agricultural chemicals through irrigation systems.

Biotechnology research at the Vancouver Research Station has developed monoclonal antibodies for sensitive diagnosis of virus diseases of plants. Genetic manipulation involving recombinant DNA is used to enhance resistance to diseases and pests. This basic research is leading to breakthroughs in protection of small fruits, vegetables, and potatoes. Tissue culture techniques are being developed at Saanichton for efficient virus indexing of grapes and for breeding kiwi fruit more suited to the Canadian climate.

Plant protection research at Saanichton has resulted in biological techniques that control greenhouse insect pests and diseases while minimizing pesticide use. Integrated pest management (IPM) systems are being developed at the Vancouver and Summerland research stations that control virus diseases through better understanding of virus–host and virus–vector relationships. IPM systems for insect control in horticultural crops are being improved. Basic studies of the structure and composition of viruses and their mechanism of establishment and multiplication are conducted so that virus diseases can be better controlled.

Beef and forage research at the Kamloops Research Station and Prince George Experimental Farm includes multidisciplinary studies on animal nutrition, cow–calf systems, range management, toxic plants, and locally produced feedstuffs. Dairy research at the Agassiz Research Station seeks to identify more precisely the nutrient requirements for growth and lactation of dairy animals. Poultry research at Agassiz is aimed at developing a dietary management system that reduces the incidence of sudden death syndrome and leg disorders in laying and broiler chickens.

Vegetable management research has involved the use of protected environments or new propagation systems for overwintering and extending the production season of field vegetables. Research to support the registration of systemic pesticides and to develop improved weed control practices has increased asparagus production in the Frazer Valley by tenfold.

Tree fruit research is conducted at the Summerland Research Station. New varieties of apples, peaches, and cherries have been released. Fertilizers and growth-controlling chemicals have been tested and improved orchard floor management practices have been recommended. New strawberry and raspberry selections have been made at Vancouver.

Ornamental research at Saanichton has developed soil temperature and lighting regimes to facilitate winter production of *Alstroemeria*, an important product for the cut flower industry. Supplementary lighting and CO_2 enrichment regimes to stimulate rooting of various woody ornamental species have been released.

Food processing research has improved the processes for production of apple and pear juices. Guidelines released on display conditions for broccoli in retail stores will double the shelf-life.

Further information can be obtained directly from the relevant research station or from Pacific Region Headquarters, #425 - 750 Cambie Street, Vancouver, B.C. V6B 4V5.

S.C. Thompson
Director General

PRÉFACE

La Région du Pacifique, créée en 1983, se compose de cinq stations de recherches, d'une ferme expérimentale et de trois stations satellites qui servent le secteur agricole de la Colombie-Britannique. Elle compte des effectifs de 270 employés, dont 60 chercheurs.

L'Administration centrale de la Région du Pacifique a complété son personnel en 1985 avec la nomination de M. J.B. Bole en août, anciennement de la Station de recherches de Lethbridge, comme spécialiste chargé des programmes, et de M. R.Z. Rivers en juillet, anciennement de Pêches et Océans Canada, comme économiste de la recherche. Quatre des cinq stations de recherches ont changé de directeur. M. J.M. Molnar a été muté de la Station de Saanichton à celle d'Agassiz pour remplacer M. J.E. Miltimore qui a pris sa retraite. M. C.J. French a été nommé directeur suppléant à Saanichton. M. D.M. Bowden, anciennement de Swift Current, a été nommé directeur de la Station de Summerland lorsque G.C. Russell a pris sa retraite. M. J.A. Robertson, anciennement de Melfort, a remplacé M. J.D. McElgunn comme directeur de la Station de Kamloops.

La recherche sur la gestion et la conservation des sols comprend l'évaluation du niveau auquel les engrais, le travail du sol et la gestion de l'eau limitent les productions végétales sur la côte sud de la Colombie-Britannique. Des techniques plus efficaces ont été mises au point pour doser la teneur en soufre des sols et épandre des produits chimiques agricoles par les systèmes d'irrigation.

Les recherches en biotechnologie effectuées à la Station de Vancouver ont permis de mettre au point des anticorps monoclonaux pour le diagnostic de viroses des plantes. Les manipulations génétiques faisant appel à la technique de recombinaison de l'ADN servent à accroître la résistance aux maladies et aux ravageurs. Ces recherches fondamentales débouchent sur des innovations en matière de protection des petits fruits, des légumes et des pommes de terre. La Station de Saanichton met actuellement au point des techniques de culture des tissus pour assurer l'efficacité de l'indexage des raisins selon les virus et pour sélectionner des variétés de kiwi mieux adaptées au climat canadien.

Les recherches sur la protection des plantes effectuées à Saanichton ont permis de mettre au point des techniques biologiques capables de lutter contre les ravageurs et les maladies des serres tout en réduisant le plus possible l'utilisation de pesticides. Des systèmes de lutte antiparasitaire intégrée sont actuellement mis au point aux stations de Vancouver et de Summerland pour lutter contre les maladies virales par une meilleure compréhension des relations entre le virus et l'hôte, et entre le virus et le vecteur. Les systèmes de lutte antiparasitaire intégrée contre les insectes des cultures horticoles sont actuellement améliorés. Des recherches fondamentales sur la structure et la composition des virus, et sur leur mécanisme d'établissement et de multiplication, sont effectuées de façon à pouvoir mieux lutter contre les viroses.

Les recherches sur les bovins de boucherie et les fourrages effectuées à la Station de Kamloops et à la Ferme expérimentale de Prince George comprennent des études pluridisciplinaires sur la nutrition des animaux, les systèmes de naissage, la gestion des parcours, les plantes toxiques et les aliments du bétail de production locale. À la Station d'Agassiz, les recherches sur les animaux à lait ont pour objet d'identifier avec plus de précision les besoins nutritifs capables d'assurer la croissance et la lactation de ces animaux. Les recherches sur la volaille visent à mettre au point un système de gestion de la ration capable de réduire la fréquence du syndrome de mort subite et les troubles des pattes chez les poulets de ponte et à griller.

Les recherches en matière de gestion des cultures légumières ont porté sur l'utilisation d'environnements protégés ou de nouveaux systèmes de multiplication pour l'hivernage et la prolongation de la saison de production des légumes de plein champ. Les travaux visant à justifier l'homologation de pesticides endothérapiques et à mettre au point des pratiques améliorées de désherbage ont permis de multiplier par dix la production d'asperges dans la vallée du Fraser.

La Station de Summerland effectue des recherches sur les fruits de verger qui ont permis de mettre au commerce de nouvelles variétés de pommiers, de pêchers et de cerisiers. Les chercheurs ont testé des engrais et des régulateurs de croissance chimiques, et ont recommandé des pratiques améliorées de gestion des sols de verger. De nouvelles sélections de fraisiers et de framboisiers ont été faites à Vancouver.

Les travaux sur les plantes ornementales effectués à Saanichton ont permis de mettre au point des régimes de température du sol et d'éclairage visant à faciliter la production hivernale de *Alstroemeria*, produit important pour le secteur de la floriculture (fleurs coupées). Des régimes d'éclairage supplémentaire et d'enrichissement du sol destinés à stimuler l'enracinement de diverses espèces ornementales ligneuses ont été mis au commerce.

Dans le domaine de la transformation alimentaire, les travaux ont permis d'améliorer les pro-

cédés de production de jus de pommes et de poires. Les directives publiées sur les conditions d'étalage du brocoli dans les magasins de détail permettront de doubler sa conservabilité à l'étalage.

Pour obtenir de plus amples renseignements, on peut communiquer directement avec la station de recherches concernée ou s'adresser à l'Administration centrale de la Région du Pacifique, 425-750 rue Cambie, Vancouver (C.-B.) V6B 4V5.

S.C. Thompson
Directeur général

Research Station, Agassiz, British Columbia

PROFESSIONAL STAFF

J.M. Molnar,[1] B.S.A., M.Sc., Ph.D	Director
A.R. Maurer, B.S.A., M.Sc.	Assistant Director
D. Neve, B.A.	Administrative Officer
D.H. Frey, B.Sc.	Analyst Programmer
J. Lockyer,[2] B.A., M.L.S.	Librarian

Animal Science

L.J. Fisher, B.S.A., M.Sc., Ph.D.	Head of Section; Dairy cattle nutrition
W.T. Buckley, B.S., Ph.D.	Ruminant mineral biochemistry
Vacant	Animal physiology, meat studies
E.E. Gardiner, B.S., M.S., Ph.D.	Poultry nutrition
J.R. Hunt, B.S.A., Ph.D.	Poultry physiology
Vacant	Animal behavior

Crop Science

P.W. Perrin, B.Sc., Ph.D	Head of Section; Postharvest physiology
N.P. Ames-Gottfred,[3] B.S.A., M.S.A.	Forage breeding and management
J.A. Freeman, B.S.A, M.S.A., Ph.D.	Small fruits management; Weed control
S. Freyman,[4] B.Sc.(Agr.), M.S.A, Ph.D.	Weed control
S.G. Fushtey, B.Sc., M.Sc., Ph.D.	Turf management
J.C.W. Keng, B.Sc., M.Sc., Ph.D.	Soil, water, and crop management
C.G. Kowalenko, B.S.A., M.Sc., Ph.D.	Soil biochemistry and fertility
A.R. Maurer, B.S.A., M.Sc.	Physiology of vegetable crops

Departures

R.J. Forrest, B.S.A., M.S.A., Ph.D. Deceased 1 October 1985	Animal physiology; meat studies
J.E. Miltimore, B.S.A., M.Sc., Ph.D. Retired 4 October 1985	Director
M.C. Vidal, B.A., M.L.S. Resigned 30 April 1985	Librarian

VISITING SCIENTIST

R.C. Newberry, B.Sc., Ph.D. National Research Council of Canada visiting fellow, 1983 to July 1985	Poultry behavior

[1]Appointed 7 October 1985.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]On educational leave, University of Guelph, October 1984 to December 1986.
[4]Appointed 30 September 1985.

INTRODUCTION

The Agassiz Research Station has a mandate to conduct research in both plant and animal science.

The Animal Science Section is responsible for research on dairy cattle nutrition, including ruminant mineral biochemistry, physiology of beef cattle, response of beef cattle to various dietary sources, and meat quality. The poultry program includes nutrition, physiology, and animal behavior. Although the section serves the livestock industry of British Columbia, it is also recognized nationally as a center of excellence.

The Crop Science Section has a broad mandate to undertake research on vegetable management and physiology, postharvest physiology, management of small fruits, weed control, turf and forage management, and breeding. These programs are supported by soils research on a wide variety of fertility and soil management problems.

In the past year, the station constructed a new research feed mill, which will provide new opportunities in livestock nutrition and research and where newer, more economical feedstuffs will be developed. This is the only research facility of its kind in British Columbia.

After 37 years of service with the department, including 12 as director of this station, Dr. J.E. (Jim) Miltimore retired on 4 October 1985. The beef research program suffered a setback as a result of the untimely death of Dr. R.J. (Bert) Forrest on 1 October 1985.

Further information regarding the research program and results achieved may be obtained by requesting copies of the listed publications and other informal reports. Requests should be directed to the Research Station, Research Branch, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0.

J.M. Molnar
Director

ANIMAL SCIENCE

Whey–canola meal in starter rations for calves. Thirty-two male Holstein calves were subdivided into four groups at 35 days of age and used to measure the feeding value of an evaporated whey–canola meal feedstuff (EWC), fed in combination with either a grain-based starter ration or chopped hay. Maximum intake of the EWC was 84 and 90% of total dry-matter intake respectively. There was a marked increase in the molar proportions of butyrate and valerate in the rumen fluid of calves fed EWC. Plasma urea levels were lower, and phosphorus, potassium, and copper levels were higher when EWC was fed. The digestibility of the EWC-based diets was higher than for either the grain- or hay-based diets. Bloat was a problem when EWC was fed in conjunction with a grain but not with the starter ration based on chopped hay. It was concluded that an evaporated whey–canola meal feedstuff fed with chopped hay would be a suitable diet for young calves.

Responses of roaster chickens to alternating light. Treatments in which light alternated from side to side within pens at regular intervals altered the spatial distribution of chickens and increased their activity in comparison with chickens kept under continuous (conventional) lighting, but had no effect on growth, feed conversion, incidence of leg disorders, total mortality, or mortality caused by sudden death syndrome. Differences between strains of chicken were found for all of these parameters. It was concluded that alternating light provided no advantage over continuous light for roaster production.

CROP SCIENCE

Control of postharvest fruit rot of raspberries by field sprays. Trials were conducted in 1984 and 1985 to evaluate the efficacy of the active ingredients in vinclozolin (0.5 and 0.75 kg/ha) and captan (1.7 kg /ha) for the control of postharvest fruit rot in raspberries. *Rhizopus*, *Botrytis*, and *Penicillium* were the main contributors to postharvest rots. In 1984 both fungicides controlled *Penicillium* but captan was significantly better than vinclozolin. In 1985 only captan controlled *Penicillium*. In both years only captan controlled *Botrytis*. Neither fungicide controlled *Rhizopus*. There was a trend for vinclozolin efficacy to increase with rate.

Effect of chemical removal of primocanes on several raspberry cultivars. Research was begun in 1981 on a 4-year-old raspberry planting to determine recommendations for primocane removal as a labor-saving method, using dinoseb, for the newer Pacific Northwest cultivars (Chilcotin,

Haida, Meeker, Nootka, Skeena) in comparison with the long established cultivar Willamette. In 1981 all plots received one application of chemical when the primocanes averaged 15 cm in height. In 1982, 1983, 1984, and 1985 both single and multiple follow-up treatments were applied to all plots that had only one application in 1981.

Cultivars responded differently to treatments when replacement canes and yield were considered. All treatments resulted in increased yield for all cultivars. Greatest yield effects were recorded for Skeena, probably because of reduced incidence of cane disease.

The use of metribuzin for weed control in asparagus. Trials were conducted over a 4-year period using metribuzin as preemergence, early postemergence, and delayed postemergence (rescue) treatments in seedling and established asparagus plantings. When applied preemergence to direct-seeded asparagus, metribuzin gave better weed control at Agassiz (coastal region, silt loam), with only common groundsel escaping, than at Summerland (interior region, sandy) with common groundsel, redroot pigweed, and black nightshade escaping. The active ingredient (a.i.) in 1 kg/ha caused some injury to asparagus at Summerland but not at Agassiz. In preemergence trials with transplants at Agassiz, metribuzin gave good control of broadleaved weeds and annual bluegrass, but except for the highest a.i. rate (2.0 kg/ha), poor quackgrass suppression. In the early postemergence trial metribuzin gave good broadleaved weed control but was weak on quackgrass. Metribuzin tested as a rescue treatment (delayed postemergence) on well-established weeds gave good to excellent broadleaved weed control but barnyard grass control was poor. Of 18 cultivars only five showed slight injury (chlorosis) after spraying. Yields were not affected.

A modified apparatus for sulfate sulfur analysis. Sulfur deficiencies have recently been identified in the lower Fraser Valley, but further research is required for efficient treatment. Analysis of sulfate sulfur in both soil and plant samples is essential for this research. The hydriodic acid reduction method is used extensively for these analyses, but the original method requires 1–2 h for a single distillation. A new apparatus was designed and tested, with sulfate determinations successfully accomplished in just 6 min. In addition to the advantage of time, the new apparatus is simpler to make (both apparatus are custom built out of glass) and thus costs less. It also allows total sulfur analyses to be done after sodium hypobromite digestion. Total sulfur analyses after sodium hypobromite could not be done with the original apparatus.

Response of vegetables to row covers. Trials with plastic row covers conducted at Agassiz in 1985 have shown that the benefits of growing heat-loving crops under mini tunnels and floating mulches can be obtained even in hot, dry seasons. Unlike results of previous years, control plots grown without row covers had a high survival rate and produced marketable crops. Crops of pepper, zucchini, cucumber, and muskmelon gave greater and earlier yields when grown under row covers than when unprotected. Mini tunnels tended to produce greater yields than floating mulches.

Cause and control of snow mold in turf in British Columbia. Diagnostic surveys and control trials were conducted over a period of 3 years (1982–1985) at a number of sites in the region between Revelstoke in the north and Trail in the south. Snow mold in golf-green turf was found to be caused by one or more of three fungal species, namely *Gerlachia nivalis*, *Typhula incarnata*, and *T. ishikariensis*. *G. nivalis* was the dominant pathogen in the region, but *T. incarnata* was usually present and *T. ishikariensis* was found at one site only, near Trail.

Among 21 different fungicides tested, quintozene applied at the a.i. rate of 90 g/100 m^2 gave the best control, with no apparent advantage when dosage was increased to 120 g. Other registered fungicides that gave satisfactory control were Rovral with a.i. at 90 g and Daconil at 300 g. Easout at 90 g and Tersan 1991 at 60 g gave good control where *Gerlachia* was highly dominant but failed completely in one instance. Subsequent laboratory analysis revealed that the pathogen in this instance was resistant to benzimidazole fungicides. The fungicide Arrest yielded inconsistent results, with satisfactory control where disease incidence was low but unsatisfactory control under high disease pressure, even when applied at the rate of 350 g of a.i., 25% higher than the maximum recommended on the label. A number of experimental fungicides, namely Bayleton, BCI-100, CGA 64251 (Banner), and DPX H6573 gave encouraging results.

Comparison of vegetable-storage systems. Three storage rooms, each with a volume of about 37m^3 and a useable storage capacity of about 4 t were equipped with different refrigeration–humidification systems for fresh vegetable storage. The rooms were constructed side by side and were similar in all other respects. One room was equipped with a Humifresh filacell unit, the second was jacketed, and the third contained an

oversized, but otherwise conventional evaporator and a centrifugal humidifier.

Results over three storage seasons showed mean monthly moisture losses of 1.9%, 0.9%, and 0.1% for the filacell-equipped, jacketed, and humidifier-equipped storages, respectively. Moisture loss varied among the vegetables tested. In filacell storage, carrots, parsnips, and beets lost over 2% moisture per month, rutabagas lost about 1.6% per month, and cabbages lost less than 1% moisture per month. Differences were less marked in other storages. Rutabagas retained the best marketability over the 6-month storage period, with a mean of 97% marketable vegetables after storage. An average of almost 80% of the cabbages were marketable, whereas about 70% of the carrots, parsnips, and beets were marketable after 6 months. Parsnips retained the best marketability (74%) in the jacketed storage, whereas carrots (76% marketable) and beets (74% marketable) kept best in either jacketed storage or the humidifier-equipped room. Neither cabbages nor rutabagas showed differences in marketability between the storage rooms. Consequently, the least costly system should be recommended for these crops.

Retail display and overnight storage of fresh broccoli. The quality of fresh broccoli during simulated retail display was evaluated using contact cooling (ice) and air cooling separately and in combination. Chlorophyll and ascorbic acid were best maintained with air cooling, whereas weight was best maintained with ice cooling alone. In air-cooled display units, ice placed both on top of and beneath broccoli heads resulted in more rapid loss of chlorophyll and ascorbic acid than did bottom-icing alone.

The effect of three different overnight storage practices was also evaluated. Broccoli was left uncovered in display cases, covered with wet burlap in display cases, or removed in cartons to a 4.5°C walk-in cooler and left overnight. There was no significant difference between the treatments in the resultant ascorbic acid concentrations or color ratings after four days. However, there was a significant difference in moisture loss. Broccoli left in cases uncovered overnight lost an average of 12.8% moisture, whereas broccoli placed in the 4.5°C cooler lost 9.4% moisture. Covering with wet burlap was the best treatment in which an average of 4.8% moisture was lost after 4 days.

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Research Station, Kamloops, British Columbia

PROFESSIONAL STAFF

J.A. Robertson,[1] B.S.A., M.Sc., Ph.D.	Director
K.J. Robinson[2]	Administrative Officer
W. Majak, B.Sc., M.Sc., Ph.D.	Biochemistry
A. McLean, B.S.A., M.Sc., Ph.D., F.A.I.C., F.S.R.M.	Range ecology
P. McCaughey,[3] B.Sc., M.Sc.	Forage agronomy
D.A. Quinton, B.S., Ph.D.	Range management
D.G. Stout, B.S.A., M.Sc., Ph.D.	Plant physiology
A.L. van Ryswyk, B.S.A., M.S.A., Ph.D.	Soil science

Prince George Experimental Farm

W.L. Pringle, B.S.A., M.S.F.	Superintendent, forage
K. Broersma, B.S.A., M.Sc.	Forage agronomy, soils

Departure

L. Rode, B.Sc., M.S., Ph.D. Transferred to Lethbridge Research Station 1 November 1985.	Animal nutrition

[1]Appointed 12 August 1985.
[2]Appointed 5 April 1985.
[3]BI–RES training program, 15 October 1985.

INTRODUCTION

The research programs at the Kamloops Range Research Station and the Prince George Experimental Farm are designed to serve the ranchers and managers of the diverse range and farmlands of the southern and central interior of British Columbia. Research is focused on developing and transferring new technology in the fields of range management, plant ecology, poisonous plants, bloat, winterhardiness, forage agronomy, quality of conserved forages, and animal nutrition. The results included in this brief report cover only a portion of the current program but serve to indicate the diversity of the research activities.

During 1985, a number of staff changes occurred at both Kamloops and Prince George. Dr. J.A. Robertson, formerly of the Melfort Research Station in Saskatchewan was appointed director replacing Dr. J.D. McElgunn, who accepted the position of director of the research station at Beaverlodge, Alberta. Mr. Paul McCaughey was added to the staff at Kamloops as a Ph.D. trainee in the area of forage agronomy. Dr. Lyle Rode was transferred to the Lethbridge Research Station. His excellent contributions to the beef research program at Prince George will certainly be missed.

Further information on our research activities is available from the Research Station, Research Branch, Agriculture Canada, 3015 Ord Road, Kamloops, B.C. V2B 8A9, or the Experimental Farm, R.R. 8, RMD 6, Prince George, B.C. V2N 4M6.

J.A. Robertson
Director

RESEARCH ACTIVITIES

Pasture bloat in cattle

Rumen-fistulated cattle were fed fresh alfalfa herbage daily during three growing seasons. Two hours after feeding, the incidence of bloat and ruminal frothiness was recorded and samples of feed and rumen fluid were collected for analyses of chlorophyll and soluble protein. These constituents were examined in relation to the bloat-causing potential of alfalfa and the occurrence of froth in rumen contents. Chlorophyll in rumen fluid was higher on days when the alfalfa caused bloat, compared with days when bloat did not occur ($P < 0.01$). Chlorophyll was also higher in frothy rumen fluid than in normal rumen fluid ($P < 0.01$). Soluble protein concentrations in rumen fluid were adequate to stabilize foams in vitro but did not show any daily changes related to the frothiness of rumen contents. The soluble proteins could be involved in froth formation but another factor, perhaps a component of the chloroplast membranes, appears to be responsible for the immediate onset of frothiness.

Allelopathy in diffuse knapweed

The allelopathic potential of knapweed (*Centaurea diffusa*) was investigated in field and pot trials. Field studies failed to show any phytotoxic effects from diffuse knapweed litter. In pot trials, knapweed seedlings did not inhibit seed germination or seedling development of three rangeland grass species. Under rangeland conditions, knapweed did not appear to influence soil microbial activity or affect levels of soil phenolics. Phenolic acids or sesquiterpene lactones were not detected in root exudates of knapweed. These results suggest that allelopathy is not a significant factor in the spread of knapweed. Other factors, such as prolific production of viable seed, tolerance to drought, and the absence (until recently) of native predators, combine to give knapweed a significant competitive advantage over most species of native vegetation.

Long-term recovery of grasslands

Exclosures constructed to exclude cattle have been in place in the southern interior of British Columbia for 14–50 years. They were built on poor-condition range to record the changes in plant species in the absence of grazing. The sites were grouped within the ponderosa pine (*Pinus ponderosa*)—bluebunch wheatgrass (*Agropyron spicatum*), and the rough fescue (*Festuca scabrella*)—bluebunch wheatgrass zones. During the first decade after fencing, the principal change in the plant cover was an increase in vigor and forage yield of the productive species. In the ponderosa pine—bluebunch wheatgrass zone, bluebunch wheatgrass reached dominance within 23 years. Two sites appeared to be close to optimum condition within 33 years of fencing. Rough fescue reached dominance on most sites within 30 years of fencing, but its percentage cover continued to increase for the next 20 years. Most unproductive species and annuals were reduced to minor components within the first 10 years.

Live weight gains and nutrition of cattle on interior British Columbia ranges

Cattle performance and nutritional intake were monitored for cattle grazing the grasslands and Douglas fir forest zones. The spring-grazing system on the grasslands followed the progression of plant growth from lower to upper zones, so that cattle were grazing at comparable plant development stages in all zones. The fall-grazing system was one of concurrent grazing in all zones.

In general, the average daily gains (ADG) of cows and calves were poorest when grazing the lower grassland zone, intermediate in the middle grassland zone, and highest when grazing the upper grassland and forest zones. The overall ADG of cows with calf at side during spring grazing on the grasslands were 0.32 kg, 0.57 kg, and 0.97 kg, respectively, for the lower, middle, and upper grassland zones. During fall grazing, ADG for the lower, middle, and upper grassland zones were 0.17 kg, 0.4 kg, and 0.54 kg, respectively. Cows grazing summer range in the forest zone had an ADG of 0.25 kg during July, 0.55 kg during August but –0.02 kg/day during September. Calf gains were 0.85 kg, 0.96 kg, and 0.99 kg, respectively, for the lower, middle, and upper grassland zones during the spring; 0.97 kg, 1.02 kg, and 0.83 kg, respectively, during July, August, and September in the forest; and 0.66 kg, 0.70 kg, and 0.78 kg, respectively, for the lower, middle, and upper grassland zones in the fall.

The differences in weight gains observed among the zones can be partly explained by the differences in nutrition available in each zone. Cattle gains were generally directly proportional to the amount of nitrogen, phosphorus, and magnesium in cattle diets. Deficiencies of nitrogen, phosphorus, magnesium, copper, zinc, and selenium were identified in cattle diets in all zones.

Cattle diets on ranges forested with Douglas fir

The average diet of cattle grazing forested summer ranges in the dry belt of the Douglas fir (*Pseudotsuga menziesii*) zone of interior British Columbia was found to consist of 70% grasses, 14% forbs, and 7% browse. Diets of cattle grazing continuously over the summer were about 65% similar to diets of cattle grazing on a rotation basis. Weather patterns and the availability of forage on wet meadows had a considerable effect on cattle diets from year to year. During dry years, cattle diets during August were made up of 60% sedges from wet meadows. This forage source was not available during wet years when meadows remained flooded.

Pinegrass (*Calamagrostis rubescens*) was the single most important dietary item, accounting for 55% of the diet. Bluegrasses (*Poa* spp.) were important foods (6% of the diet) during August. Bluebunch wheatgrass (*Agropyron spicatum*) and rough fescue (*Festuca scabrella*) constituted 7 and 13% of the diet, respectively, during September. Aster (*Aster* spp.) and arnica (*Arnica cordifolia*) were the most used forbs; willow (*Salix* spp.) and spirea (*Spireae lucida*) were the major browse species consumed by cattle. Usage of these species was low, ranging from 1 to 3% of monthly diets.

Diets of mule deer on upper grassland and lower Douglas fir ranges

The diet of mule deer (*Odocoileus hemionus*) foraging on the bluebunch wheatgrass (*Agropyron spicatum*) and rough fescue (*Festuca scabrella*) grasslands and on the lower Douglas fir (*Pseudotsuga menziesii*) forest ranges was evaluated. The diet of deer during the time period from December to February consisted of 36% forbs and 64% browse on the grassland. During the same period of time, the diet of deer in the forest consisted of 2% grasses, 5% browse, 4% lichens, and 89% browse. Bearberry (*Arctostaphylus uva-ursi*), sagebrush (*Artemisia* spp.), aspen twigs (*Populus tremuloides*), Douglas fir bark, rose (*Rosa* spp.) hips, and snowberry (*Symphoricarpus albus*) were foods used by deer during the December–February period only. As forbs became available in the spring, their portion of the diet increased to 65% for deer foraging on the grassland and 53% for deer foraging in the forest zone. As the growing season advanced, forbs became less available and thus less prevalent in the diets of deer, which then consumed more browse.

Pinegrass tiller pull-up during grazing

Pinegrass (*Calamagrostis rubescens* Buckl.) tiller pull-up (removal, other than by cropping, of an entire tiller or of the aerial portion of a tiller) during grazing was quantified. As many as 48% of the tillers were pulled up during only one grazing pass by a cow. Following repeated passes by a cow, up to 75% of the tillers were pulled up. This tiller pull-up can be partitioned into two categories, uprooted and torn. Uprooted refers to entire tillers, usually united in a tuft, that are pulled up with rhizome and root tissue still attached. The torn category comprises the aerial portions of tillers that are severed at or near the base of the leaf sheath. More tillers are normally uprooted than are torn during grazing.

Clipping studies are frequently employed to simulate the effects of grazing. Although clipping largely simulates herbage removal by cropping, the technique was not intended to simulate pull-

up. A comparison of the response of pinegrass to either grazing or clipping revealed that during the year of herbage removal, new tillers were initiated by grazing but not by clipping. Despite this difference, deterioration of a pinegrass stand was similar when either clipped or grazed biweekly to a target stubble height of 5 cm. It is proposed that development of new tillers following grazing compensates for tillers lost by pull-up and that clipping studies should have application when assessing the effects of grazing on pinegrass.

Alfalfa stand persistence and fall growth

Stand persistence of eight alfalfa (*Medicago sativa* L.) cultivars in the interior of British Columbia was correlated to fall growth. A similar relationship has been reported for alfalfa winter survival and fall growth in other parts of North America. One other alfalfa cultivar, Anik, did not fit this relationship, since it had little fall growth and low stand persistence. Recognizing that exceptions to the relationship do occur, fall growth measurements will provide a useful tool for predicting persistence and winter survival of new genotypes being considered for interior British Columbia.

Plant frosthardiness and electricity

Frost damage to plants is believed to occur as a result of freezing injury to membranes, especially plasma membranes. Evidence has been obtained that suggests that in some instances, this membrane damage may be caused by electricity. Differences in electrical potential of sufficient magnitude to cause lysis of the plasma membranes occur during rapid freezing of isolated protoplasts. For example, survival of rye (*Secale cereale*) protoplasts was inversely related to the magnitude of the potential difference. In addition, protoplasts from cold-acclimated rye plants tolerated higher electric fields than protoplasts from nonacclimated rye plants. However, cold acclimation does not significantly alter membrane capacitance. For this reason, the charging time of the membrane is not altered. Therefore, cold acclimation increases the stability of the plasma membrane to electric fields rather than decreases the electrical voltage that develops across the plasma membrane.

Nitrogen for irrigated silage corn

Recommendations for nitrogen fertilizer requirements of irrigated silage corn were developed in a cooperative study with the British Columbia Ministry of Agriculture and Food. The 9-year study included 3 × 3 × 3 factorial field trials, involving three application rates of each of N, P, and K, at 10 locations on alluvial soils in major valleys of the southern interior of British Columbia. Significant yield responses were obtained only for nitrogen application. Without nitrogen, soils at the 10 locations produced yields that ranged between 40 and 100% of the maximum possible for those locations. Corresponding NO_3-N soil test values were 5 and 34 μg/mL, respectively. A table of recommended rates of N fertilization for 5% increases of percentage-of-maximum yield above 80% over a range of soil test values was developed.

Pulp mill fiber waste used as cattle feed

Experiments were conducted to evaluate the nutritive value of Kraft pulp mill fiber waste (PMF). The PMF contained 19.2% dry matter (DM) and, on a DM basis, 98.3% organic matter (OM), 89.7% acid detergent fiber (ADF), 96.0% neutral detergent fiber (NDF), 0.26% nitrogen (N), and 2.5% acid detergent lignin. Nylon bags containing PMF, alfalfa (mid bloom), or timothy (anthesis) were incubated in the rumen of steers for 4, 8, 12, 24, 36, and 48 h. DM disappearance was lower for PMF than for either timothy or alfalfa after incubation for 4, 8, and 12 h. After 24 h, DM disappearance of PMF was similar to timothy but less than alfalfa. By 36 h, DM disappearance of PMF was greater than alfalfa and timothy.

In a second experiment, PMF was substituted for timothy–clover silage at 0, 12, 24, 36, and 48% of total DM and fed to steers in a 5 × 5 Latin square to determine voluntary DM intake (DMI) and digestion coefficients for DM, N, and ADF. DMI decreased and DM digestibiltiy (DMD) increased linearly with increasing levels of PMF in the ration. Intake of digestible DM was similar at all levels of PMF. Predicted DMD of 100% PMF was 79.3%. Digestibility of N and ADF increased linearly with increasing levels of PMF.

These data indicate that PMF may have potential as a forage substitute for beef cattle in central British Columbia and may have a positive associative effect on digestibility when mixed with grass–legume silage.

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Miscellaneous

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Saanichton Research and Plant Quarantine Station Sidney, British Columbia

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INTRODUCTION

Saanichton Research and Plant Quarantine Station is the research center for ornamentals and greenhouse vegetables in British Columbia, with responsibility for the national postentry quarantine program. Research is conducted in floriculture, greenhouse and field vegetables, nursery plant production, virus eradication, tissue culture, and biological control of pests and diseases.

Greenhouse technology research includes energy conservation, utilizing solar energy, thermal blankets, and a computerized climate control system. Requests for information or publications should be addressed to the Saanichton Research and Plant Quarantine Station, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

C.J. French
Acting Director

ORNAMENTALS

Management

Comparison of Osmocote and Nutricote slow-release fertilizers for production of containerized nursery stock. Field trials assessed the effectiveness of Nutricote 16:10:10 (Type 40:Type 180, 3:1), Osmocote 17:7:12, and Osmocote 18:6:12 for production of containerized woody ornamentals. Two methods of application, dibbling and incorporation, were also compared. Nutricote and Osmocote 18:6:12 produced superior growth compared with Osmocote 17:7:12 on *Thuja occidentalis* 'Pyramidalis', *Juniperus horizontalis* 'Youngstown', *Cornus alba* 'Elegantissima', and *Eunonymus* 'Emerald Gaiety'. Little difference was found between dibbling and incorporation of fertilizer. For salt-sensitive plants, *Camellia japonica* 'Blood of China', and five cultivars of *Rhododendron*, there was little difference between fertilizers. Dibbling produced far superior growth compared with incorporation for all three formulations.

Effects of CO_2 mist and low intensity supplementary lighting on rooting of woody ornamentals. CO_2 mist and low irradiance night lighting were investigated during spring (February–May) propagation of eight cultivars of woody ornamentals. Supplementary lighting was provided from 2000 to 0400 h at 6.5 $\mu E\ m^2\ s^{-1}$. CO_2 mist at 7 s every 10 min gave an average atmospheric level of 1100 ppm. CO_2 enrichment stimulated rooting of *Picea abies* 'Pygmaea'. Supplementary lighting stimulated rooting of *Thuja plicata* 'Zebrina', *Juniperus chinensis* 'Old Gold', *Camellia japonica* 'Blood of China', and *Rhododendron* 'Unique'. Interactions between CO_2 mist and night lighting were observed in *Camellia japonica* 'Lady Clare'. No effect of supplementary lighting or CO_2 were observed in *Picea pungens* 'Moerheim' or *Rhododendron* 'Vulcan'.

Winter flowering of Alstroemeria. During the second year, greenhouse production of *Alstroemeria* 'Regina' soil temperatures were reduced to 10.5–11.5°C for 13 weeks starting at three dates: (A) 18 June 1984; (B) 16 July 1984; and (C) 13 August 1984 fourth treatment received no cooling (NC).

Flowering shoots harvested (per 0.45 m^2) from September 1984 to March 1985 were (A) 92; (B) 66; (C) 72; and (NC) 4 under high intensity supplementary lighting. Corresponding yields under low intensity lighting were (A) 64; (B) 32; (C) 15; and (NC) 5. Soil cooling to 10°C for 13 weeks in the summer was necessary to stimulate subsequent winter flowering of Regina.

Micropropagation of Alstroemeria. Rhizome tips of *Alstroemeria* 'Alsaan' were established in vitro on a semisolid medium of Murashige and Skoog (M & S) salts supplemented with glucose, vitamin B, indole-3-acetic acid, kinetin, and zeatin.

During the initial 2 weeks, cultures became established better in the dark than under a 16-h photoperiod. Transfer of cultures to a liquid medium of similar composition enhanced shoot development. Roots were regenerated in vitro by reducing the M & S concentration of the liquid medium and adding indole-3-butanoic acid. Rhizome tip cultures containing apical meristem rooted better than those without. Some losses were observed at each step of culture; most rooted plantlets were successfully acclimated.

Diseases

Viruses infecting ornamentals. Viruses isolated from *Alstroemeria* 'Orange Beauty' and *Nandina domestica* 'Nana-purpurea' were identified as tomato ringspot (TomRSV) and nandina mosaic (NMV) viruses, respectively. This is the first record of TomRSV infecting *Alstroemeria* and of NMV in Canada. An antiserum to a potexvirus isolated from *Daphne cneorum* was pro-

duced. The antiserum detected the potexvirus at low concentrations using enzyme-linked immunosorbent assay (ELISA). During a survey of commercial stocks in the greater Victoria area, the potexvirus was detected in 28 of 29 samples from *D. cneorum*. Properties of this virus suggest it is identical to daphne virus X, previously reported only from New Zealand.

SMALL FRUIT

Management

Production of kiwi fruit. After the 1984 harvest, vines were trained and pruned to form a single straight trunk and a single strong leader along the center vine in each direction. This resulted in an increase in the 1985 yield; the best cultivar yielded 29 kg of fruit per plant compared with 18 kg in 1984. Average fruit weight was 97 g and harvesting date was again at the end of October. One of the small (22 g) fruited cultivars yielded 1100 fruits on a single vine. Grafted Chico-Hayward and Abbot cultivars fruited for the first year with attractive, oval-shaped fruits. A new planting has been started, and three training systems are under test. These consist of Pergolas, on which the fruiting arms can be retained longer and more permanently than on the current T-bar system. The other system is an A-frame trellis in which plants are trained to form a V-shaped canopy with a close-planting arrangement.

Evaluation of nutrient film technique (NFT) strawberry production on an A-frame structure. June- and ever-bearing cultivars were transplanted into NFT with and without rockwool support in white vinyl gutters on an A-frame 1.8 m high and 1.5 m wide at the base. The planting density was 28 plants per square metre of floor area. The results indicate that it is possible to force NFT strawberries under glass with yields 2.6 kg/m^2. The June-bearing cultivars produced lower yields, but had better fruit size, quality, and taste than the ever-bearing cultivars.

Micropropagation of kiwi fruit using nonaxenic shoot tips. Kiwi fruit (*Actinidia chinensis* Planch.) shoot tips were surface-sterilized and cultured on a Murashige and Skoog basal medium with two surviving bacterial contaminants. Growth was greater in liquid compared with agar-solidified medium. More shoots were obtained with 125 mL compared with 50, 250, or 500 mL Erlenmeyer flasks. A concentration of 2 mg l^{-1} n^6-benzylaminopurine (BAP) was optimal. Shoots from proliferating cultures were dipped in 0.05% IBA and rooted in a peat–vermiculite–perlite mix. Of 907 plantlets produced, 93% were acclimated successfully. Productivity was comparable to axenic meristem culture.

Cold storage of kiwi fruit shoot tip cultures in vitro. Kiwi fruit (*Actinidia chinensis* Planch. 'Hayward') shoot tip cultures were stored at 8 or 4°C in the dark for 52 weeks. Survival was almost 100% at 8°C, but decreased substantially after 24 weeks at 4°C. The relative fresh weight of shoot tips stored at 8°C increased eight-fold after 52 weeks of storage, whereas shoot tips stored at 4°C gained less than half their initial fresh weight. Subsequent shoot production when cultured again was also favored by storage at 8°C.

VEGETABLES

Management

Tomatoes in NFT. The tomato cultivars Dombito, Parabell, and Vision were planted in an NFT system in the fall of 1984. After 10 weeks, both Parabell and Vision produced more fruit than Dombito. However, total fruit weight produced by the three cultivars was similar. Further tomato trials in NFT were conducted in the spring with six cultivars (Simona, Dombello, F181, Caruso, 83W356, and Sylvia). There was no difference between the total fruit weight produced after 10 weeks. Simona had the highest average fruit weight and the highest percentage of No. 1 fruit, making it the preferred cultivar under these conditions.

Tipburn of lettuce in NFT. Tipburn in lettuce is related to plant growth rate. Two trials attempted to reduce growth rate through a reduction of nitrogen in the nutrient solution. Four nitrogen concentrations (nitrogen at 60, 85, 110, and 135 ppm) produced heads of a similar size at harvest, with decreasing severity of tipburn associated with an increase in nitrogen concentration.

Effect of row covers on the production of overwintering cauliflower, asparagus, and strawberries. The potential for early production of crops with the aid of row covers and mulches was investigated on strawberries, asparagus, and zucchini, and overwintering cauliflower. Treatments consisted of a nonwoven polyester (Reemay), a slitted polyethylene film (xiro), clear polyethylene, and black mulch. The xiro and the clear film had a poor air exchange rate, and day air temperatures were higher under these covers compared with Reemay. Covered plants produced a higher earlier yield than the control, were more vigorous, and had a higher stomatal conductance and transpiration rate than uncovered plants. However, only

early yield was increased. Floating row covers, requiring no hoops, were an advantage during application and removal.

Diseases

Control of clubroot in winter cauliflower. A field infected with clubroot (*Plasmodiophora brassicae*) was treated with methyl bromide (50 g/m^2), Basamid (dagomet at 30 g/m^2), Benlate (drench at planting), and compared with an untreated control. On the subplots, polyethylene was left for 4 weeks on the soil as a solarization treatment. The maximum mean soil temperature at depths of 5, 12, and 20 cm increased to 40, 34, and 29°C, respectively, under the film, which was 9, 7, and 6°C higher than the corresponding uncovered control. Methyl bromide and the Basamid had additional herbicidal effects, and the solarization also had some effect. Only 13% of the plants were harvestable in the control and 30% when drenched with Benlate, whereas 79 and 83% were harvested when soil was sterilized with methyl bromide or Basamid, respectively.

Solarization doubled the harvested yield in the Benlate and control treatments.

Biological control of greenhouse tomato crown and root rot. Crown and root rot (caused by *Fusarium oxysporum* f. sp. *radici lycopersici*) has become widespread in British Columbia crops and is rapidly developing resistance to fungicides. Some resistant tomato varieties (all containing the same single, dominant gene) are commercially available, but none are suitable to local conditions. A survey for biological control agents has identified nine bacteria commonly found in soils with potential for disease control.

Verticillium lecanii for control of greenhouse whitefly on long English cucumbers. A strain of *Verticillium lecanii* was tested against greenhouse whitefly in humidified (H) and non-humidified (NH) greenhouse sections containing long English cucumber (cultivar Farbiola). Whitefly populations were sampled every 7 days for 35 days. In the NH section, relative humidity ranged from 40% to 60%, whereas in the H section, relative humidity was in excess of 90% for 12 or more hours per day. In the H section, 80% of nymphs and 65% of adults were infected after 14 days. The corresponding figures for the NH section were 55% and 25%, respectively. In untreated NH areas, whitefly populations increased fivefold after 30 days, whereas in treated NH areas, adults increased from 75 to 125 per plant. In untreated H areas, adults increased from 75 to 450 per plant, whereas in treated H areas, they decreased from 75 to 20 per plant. The results indicate that *V. lecanii* could be a useful adjunct to *Encarsia formosa* and yellow sticky traps. The humidity required to achieve useful mortality because of *Verticillium* alone could result in severe plant disease problems in greenhouses.

GREENHOUSE ENERGY CONSERVATION STUDIES

Greenhouse energy conservation studies. Two different solar heating systems and three thermal screens are being tested in three commercial-sized glass greenhouses. Data on systems cost and energy savings from the first phase of testing have been analyzed by an independent agricultural economics consulting firm. The earth thermal storage (ETS) solar heating system was concluded to be the most economically feasible technology examined. In southwestern British Columbia, this system is economical with natural gas heating at interest rates as high as 15%. If oil is used for heating, the solar system will pay for itself in 2.8 years, assuming current relative fuel costs. The solar shed design is also economical when oil is the fuel being used. However, natural gas heating requires an interest rate at or below 5% before this solar system is feasible. Thermal screens are not economically advantageous on the basis of natural gas fuel savings alone. If oil is used, these devices will be economically feasible with interest rates of 15% or less.

PLANT QUARANTINE

Virus indexing of tree fruit and grape. In 1985, 77 varieties of tree fruits and 9 of grapes were received from noncertified sources for virus indexing. There are currently 98 grape varieties and 72 tree fruit varieties in the heat therapy program, and this year, six *Malus* clones, five *Prunus* clones, and one *Pyrus* clone were released. Tissue culture has expanded to include propagation of heat therapy shoot tips from grapes as well as routine propagation of cherry rootstocks. A number of woody host indicators are being used routinely for indexing in the greenhouse or controlled environments resulting in a shortened virus detection time. New green graft techniques are also being evaluated for early detection of some grape viruses.

PUBLICATIONS

Research

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Research Station, Summerland, British Columbia

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F.L. Banham, B.S.A.	Stone fruit insects
J.E. Cossentine, B.Sc., M.S., Ph.D.	Integrated control
V.A. Dyck, B.A., M.Sc., Ph.D.	Management of codling moth
R.D. McMullen, B.Sc., M.S., Ph.D.	Pear pest management
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N.E. Looney, B.S., M.S., Ph.D.	Pomology–plant physiology–growth regulators
M. Meheriuk, B.Sc., B.Ed., M.Sc., Ph.D.	Fruit storage and biochemistry
H.A. Quamme, B.S.A., M.Sc., Ph.D.	Orchard management–hardiness
A.G. Reynolds, B.Sc.(Agric.), M.Sc., Ph.D.	Grape management

Soil Science and Agricultural Engineering

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P.B. Hoyt, B.Sc., M.S., Ph.D.	Soil chemistry and management
A.L. Moyls, B.A.Sc., M.S., Ph.D.	Agricultural equipment—development and assessment
G.H. Neilsen, B.Sc, M.Sc., Ph.D.	Soil fertility and plant nutrition
P. Parchomchuk,[1] B.A.Sc., M.S.	Agricultural equipment—development and assessment

Departures

L.G. Denby, B.S.A., M.S.A. Retired July 1985	Viticulture–grape breeding–tree varieties and training
G.C. Russell, B.S., M.S., Ph.D. Retired October 1985	Director
J.T. Slykhuis, B.S.A., M.Sc., Ph.D. Retired May 1985	Stone fruit virus diseases

VISITING SCIENTIST

O.L. Lau,[2] B.S., M.S., Ph.D.	Pomology and viticulture

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[1]On educational leave, University of California, Davis, Calif.
[2]British Columbia Tree Fruits Research Associate since July 1976.

INTRODUCTION

The Summerland Research Station is located in the Okanagan Valley in the southern interior of British Columbia. The research program is concerned with solving problems of production and utilization of tree fruits and grapes with the objectives of providing high-quality products to the consumer and improving production efficiency. Substations are located at Kelowna to the north and at Creston to the east. During 1985, Dr. G.C Russell, director of the station, Dr. J.T. Slykhuis, plant pathologist, and Mr. L.G. Denby, horticulturist, retired after many years of productive service. Dr. D.M. Bowden, formerly director of the Swift Current Research Station, was appointed director. Dr. R.D. McMullen became associate director, and Dr. A.J. Hansen replaced him as head of the Entomology–Plant Pathology Section. New scientists joining the staff were Dr. J.E. Cossentine, in integrated pest control, and Dr. A.T. Paulson, in food processing technology. This report contains brief statements of some of the major research achievements attained at this establishment during 1985. Further information may be obtained from the publications listed at the end of this report or from individual scientists.

Requests for further information or reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Summerland, B.C. V0H 1Z0.

D.M. Bowden
Director

ENTOMOLOGY–PLANT PATHOLOGY

Timing sprays for control of codling moth

The first spray applied to apple and pear trees in the spring for codling moth control is difficult to time correctly because of variable weather conditions. A grower could spray up to 10 days too soon or too late when following current recommendations. A new method of timing the first spray has been widely tested in the Okanagan region, and found to be much more accurate than the present method.

The new method involves accumulating heat units above 10°C (degree-days) from the beginning of moth emergence, as indicated by sex pheromone traps, in spring. Degree-days are calculated from minimum and maximum temperatures observed in or near orchards. Our research in numerous orchards over a 3-year period showed that codling moth eggs begin to hatch when about 140 degree-days have accumulated. Spraying at this time will efficiently kill hatching larvae that would damage fruit.

Spraying according to degree-days removes much of the guesswork from timing sprays for codling moth, improves the efficiency of insecticide treatments, and minimizes the number of applications required. Detailed instructions on how to calculate degree-days and use them in timing sprays for codling moth are now available.

Fumigation of apples for export to Japan

To improve the stability of the apple industry in the Okanagan Valley, new markets for fresh apples are being sought. Apple exports to Japan may be possible if quarantine regulations against the entry of live codling moths can be satisfied.

Research has shown that common cold storage of apples alone kills codling moth adults and eggs in 1 month and moths at other stages in 3–5 months. The addition of methyl bromide fumigation greatly increases the mortality rate of all stages, larvae requiring only a low dose to achieve 100% kill. A disinfestation procedure of 3 months in controlled atmosphere storage followed by fumigation at 32 g/m^3 for 2 h at 10°C has been selected for commercial use. This procedure will kill all developmental stages of codling moth found on apples at harvest and will not damage apples. Following a successful demonstration of this procedure to Japanese quarantine officials, the ban on apple exports to Japan may be lifted.

Dimethoate residue levels in sour and sweet cherries at harvest and after hydrocooling or processing

In 1983, over-tolerance residues were found in commercial sour and sweet cherries, which had been treated with new, but previously untested, formulations of dimethoate applied in two sprays at the recommended rate of active ingredient (a.i.) at 1.0 kg/ha for control of black and western cherry fruit flies. Control efficiency remained the same as with the previously tested formulation. In 1984 sour cherries that were sprayed at the above rate, 14 days prior to harvest, had residues below the allowable tolerance of 2.0 ppm. Sour cherries from orchards that were sprayed twice, 14 days apart, and harvested 21 days after the last application also had residues below this tolerance. In a

few orchards the tolerance level was attained 14 days after the last application. Hydrocooling sour cherries, immediately after harvest, that had received one spray reduced residues by 48.5%. Sour cherry pie filling made from fruit that received one spray and harvested 21 days after treatment, but not hydrocooled, had 51.5% less residue than the unprocessed fruit. Similarly, pie filling made from fruit that received two sprays 14 days apart and harvested 14 and 21 days after the last treatment had residues reduced by 49.4 and 65.9%, respectively.

Sweet cherries from vigorous trees in commercial orchards treated with one or two sprays of dimethoate at rates of 0.8, 1.0, or 1.4 kg/ha had residues under 2.0 ppm when harvested 14 days after the last treatment. In abandoned orchards with poor vigor trees, cherries that received one spray applied at 0.8 or 1.0 kg/ha had residues under 2.0 ppm at 21 days while those treated at 1.4 kg/ha were only under this level 28 days after the treatment.

Disinfestation of Red Delicious apples by San Jose scale using cobalt-60 gamma irradiation

Apples for export to a large number of countries must be certified to be 100% free of San Jose scale. This certification requires intensive packinghouse inspections leading to doubled packing costs. It would therefore be economically advantageous if a postharvest treatment were available to eliminate scale from apples.

Red Delicious apples infested with San Jose scale were irradiated with either 5, 15, or 30 krad of cobalt-60 gamma radiation and then examined for the presence of live scale for a period of 70 days posttreatment. Apples treated with 30 krad of radiation were scale-free 56 days after treatment, whereas untreated apples still had live scale on them 70 days after treatment.

Developmental and eclosional thresholds of the fruittree leafroller

It has been previously determined that methidathion applied at 5.5 L/ha prior to the eclosion of overwintering fruittree leafroller eggs is an effective control method for organophosphate-resistant strains. In order to predict the time of eclosion, and therefore optimum timing of spray, field-collected egg masses were incubated at a range of constant temperatures in the laboratory. The inverse of the time in days to hatch was used to calculate the eclosional threshold. Subsamples of the incubated egg masses were fixed, embedded, and sectioned at various times in order to follow embryological development. While an embryo developmental threshold of less than 2°C was observed, a threshold for eclosion of 6.5°C was established. It is anticipated that it will be possible to predict the first 10% of hatching larvae in the field.

Mass production and release of genetically enhanced predacious mites for phytophagous mite control

Various orchard practices can result in the demise of the indigenous mite predator responsible for the biological control of apple orchard phytophagous mites. Natural replacement of those predators by immigration and population growth is normally a slow process and is retarded by the application of miticides for phytophagous mite control in the absence of predators. A mass-rearing method has been developed that is capable of producing approximately 100 000 predators every 2 weeks. The predator is the same species normally found in commercial apple orchards in this region, but it has undergone intensive laboratory selection (at the University of California, Berkeley) for resistance to organophosphates, carbamates, and sulfur. Release of over one million of these predators into a number of commercial and experimental orchards in the Okanagan Valley, rendered free of indigenous predators, has demonstrated that they can multiply and persist, even through the winter; that they can spread throughout the orchard; and that under appropriate conditions they can control phytophagous mites during the year of release. In all release orchards, they have been able to control phytophagous mites in the season following release.

Control of apple crown rot with *Enterobacter aerogenes*

A strain of *Enterobacter aerogenes* (Kruse) Hornaeche and Edwards isolated from a local soil produced diffusible antibiotics antagonistic to the growth of *Phytophthora cactorum*, causal agent of apple crown rot. The antibiotics produced were fungistatic and fungicidal. The growth and antagonistic ability of the *E. aerogenes* are not significantly affected when grown on CMA containing 50 and 100 μg/ml of metalaxyl, fosetyl-Al, or mancozeb for 4 weeks. This antagonist was evaluated alone and alternately with metalaxyl applied as soil drenches for control of crown rot of artificially inoculated field-grown apple trees on MM106 rootstock. *Enterobacter aerogenes* (1.0×10^{10} colony-forming units per tree) applied alone significantly reduced the percentage infection. Metalaxyl (with a.i. at 1.0 g per tree) and fosetyl Al (with a.i. at 5.0 g per tree) completely controlled the disease. When metalaxyl and *E. aerogenes* were applied alternately at half rate, control was comparable to the

metalaxyl treatment alone. In another field test, where all of the trees were naturally infected with *P. cactorum*, trees treated with *E. aerogenes* as a soil drench remained alive and produced normal fruit but untreated control trees became terminally diseased and produced only a few small fruits. The level of protection provided by *E. aerogenes* suggests practical potential for the field control of crown rot of apple trees.

Effect of bacterial antagonists of fungi on apple replant disease

Apple replant disease (ARD) is characterized by poor growth of new trees planted in old apple or pear orchards. The causes of these disorders are complex and diverse. The growth of young apple seedlings can be increased significantly by soil disinfection or phosphate fertilizer, or both. Seventy-seven fungi and 26 bacteria were isolated from ARD soils. Six fungi and four bacteria caused stunting of apple seedlings in greenhouse tests. Forty-eight bacterial isolates were tested on potato dextrose agar for antagonism against 76 of the fungi. Four of the bacterial isolates were highly antagonistic to most of the fungi. Twenty-one isolates of *Bacillus subtilis* (Ehrenberg) Cohn and one isolate of *Enterobacter aerogenes* (Kruse) Hornaeche & Edwards were tested for their effect on apple seedling growth in ARD soil. Soil sterilization and P fertilizer increased the growth of apple seedlings about 300% compared with the control, and the addition of four of the *B. subtilis* isolates to sterilized and fertilized soil increased growth a further 200%. In another experiment, the effect of *B. subtilis* and *E. aerogenes* on apple seedlings grown in different proportions of sterilized and nonsterilized ARD soil was studied. *E. aerogenes* significantly increased the growth of apple seedlings in different proportions of sterilized and nonsterilized soil mixtures. These results indicate the potential of using bacterial antagonists in combination with soil sterilization or phosphate fertilization, or both, for the control of ARD.

Effect of fenoxycarb on pear psylla

In laboratory experiments fenoxycarb, a new insect growth regulator, was active against pear psylla. The hatchability of eggs produced by gravid female pear psylla, which were sprayed in a Potter tower with fenoxycarb containing a.i. at 0.5, 0.25, and 0.13 g/L of water and then placed on untreated pear seedlings, was 99.3, 95.7, and 88.5%, respectively. When untreated, gravid females were placed on pear seedlings that had been sprayed to run-off with the above concentrations, none of the eggs they produced hatched. Mortality of the female pear psylla in the above treatments was nil. Eggs on pear seedlings sprayed to run-off with the above concentrations 24 and 72 h after oviposition failed to hatch, but eggs treated 120 h postoviposition hatched. Mortality of second- and third-instar nymphs on pear seedling sprayed to run-off with the above concentrations averaged 66%, with no apparent difference in mortality between concentrations. Similarly, mortality of fourth- and fifth-instar nymphs averaged 51% for all concentrations.

In an orchard spray trial on Bartlett pears, one spray of fenoxycarb with a.i. applied on June 12 at 0.56 kg/ha provided control of pear psylla equivalent to that for one spray of amitraz with a.i. at 1.68 kg/ha or SN72129 with a.i. at 0.84 kg/ha. Two treatments, on 12 June and 19 July, of the above chemicals provided control of pear psylla far superior to that possible with pesticides currently recommended for pear psylla control.

FOOD PROCESSING

Centrifugation of apple mashes

By conventional industrial practice, apple juice extraction is commonly performed in screw presses capable of providing yields of 70–75% from good-quality apples. Screw presses are attractive because of high efficiency and low labor costs, but a procedure that combined high yields with these advantages would be very attractive.

A solid bowl decanter centrifuge was used in place of the traditional press to extract juice from apples. Apples were hammer-milled to pass through 9-mm holes and then pumped through a scraped surface heat exchanger. The apple mash was heated to at least 90°C for 20–30 s and then quickly cooled to 30°C. The thermized mash was treated with 0.05% (w/w) Pectinex Ultra SP (Swiss Ferment Co.) for 2–3 h and then pumped through a Mercobowl decanter centrifuge at 3–4 L/min. Recovery of crude juice was 85.9% (w/w) for McIntosh and 84.8% (w/w) for Spartan apples. These data suggest that enzyme treatments in combination with centrifugation may provide improved yields over those obtained by conventional pressing procedures.

A method for detection and quantitation of aspartame in calorie-reduced fruit spreads

Aspartame is the name given to the chemical compound 1-methyl-*N*-L-aspartyl-L-phenylalanine. Having a perceived sweetness of 150–200 times that of sucrose, aspartame has become a very popular low-calorie sweetener. A procedure for aspartame extraction from a fruit spread and quantitation by high-performance liquid chro-

matography HPLC was developed. To confirm the utility of the method, it was applied to a 6-month storage trial of an apricot spread. In such a spread a coeluting peak was discovered at the same point as aspartame, thus preventing the use of water-based solutions of aspartame for development of the standard curves. Instead, spiked apricot spread was used to develop the necessary standard curves. Correlations for these curves were found to be very good in the method development phase. Subsequently, the method was applied to a storage trial on the apricot spread. It was determined that storage losses of this sweetener could be modeled as a first-order reaction with a half-life of 168 days.

Literature values for aspartame degradation at 25°C for a range of pH values predicted a half-life of 170 days at the pH (3.2) of apricot spread. The method has been published.

POMOLOGY AND VITICULTURE

Effect of root temperature on apple seedlings growth and cation uptake

Soil temperatures in the orchard have been shown to be strongly influenced by the orchard floor covering, with differences as great as 4°C at a depth of 20 cm under a black plastic mulch compared with under a grassed surface. The influence of soil temperature, however, could not be determined because of the many interacting factors. As a first step in defining the role of soil temperatures in nutrient uptake by fruit trees, a trial was prepared.

Apple seedlings (*Malus domestica* Borkh.) were grown at high (256 mg L^{-1}) and low (32 mg L^{-1}) Ca concentrations in Long Ashton nutrient solutions at 8, 12, 16, and 20°C root temperature. Dry weight of seedlings at the top and at the root increased as temperature increased. Ca, K, and Mn concentration in the leaves increased with root temperature from 12 to 20°C. Cu concentration in the leaves decreased over the same temperature range at a low-solution concentration of Ca; there was least concentration of Mg in the leaves at 16°C, whereas Fe in the leaves was unaffected by temperature. In further experiments, seedlings were grown at 12 and 16°C root temperatures at five concentration ratios of Ca:K (4:1, 2:1, 1:1, 1:2, and 1:4) and five concentration ratios of K:Mg (17:1, 10:1, 4:1, 2:1, and 2:3) in nutrient solution. Seedling growth was higher at 16°C and varied inversely with K:Mg ratio but was unaffected by Ca:K ratio. Ca concentration in the leaves increased with temperature, regardless of the composition of the nutrient solution. K concentration in the leaves increased with temperature over the range of Ca:K ratios but not over the range of K:Mg ratios. Mg concentration in the leaves was unaffected by temperature. These data show that Ca, Mg, and K concentration in the leaves increases in response to respective availability in solution, being most pronounced for Mg and least for Ca.

Promotion of apple tree flowering with selected gibberellins

More than 20 natural growth substances known chemically as gibberellins (GAs) occur in apples. These chemicals play a number of roles in plant growth and development, but most were believed to inhibit or antagonize flower initiation in this species. However, recent results indicate that some GAs are inactive in this regard, and certain others actually promote apple flower initiation in some situations. When isolated and applied to fruit trees as a spray, the GAs most inhibitory to flowering appear to be those that are more persistent in vegetative tissues, whereas those that promoted floral initiation in our tests are rapidly metabolized gibberellins. In two recent experiments, off-year flowering of severely biennial Golden Delicious trees was promoted by on-year treatments with GA_4 and C-3 epi-GA_4. The treatments were applied between 4.5 and 7 weeks after bloom, and treatment rates ranged from 3 to 300 μg per spur. These findings are significant because they offer a new approach to the chemical regulation of flowering in apple and because we can now suggest that certain GAs be avoided when formulating products that regulate plant growth, for use in commercial fruit production.

Relationship of starch to supercooling and freezing injury in the xylem of fruit crop species

Freezing injury to the xylem is common in tree fruits and grapes grown in northern regions and is associated with the homogeneous nucleation (nucleation in absence of eternal nucleators) of a supercooled water fraction in the ray parenchyma. It has been observed that starch is prevalent in the cells of dormant shoots, but absent in cells of other tissues in which this freezing phenomenon does not occur, such as bark cortical cells. Starch is also absent from xylem ray parenchyma of several other woody species that do not exhibit supercooling, including poplar, willow, and alder. Hydrated starch samples exhibit homogeneous nucleation if suspended in oil. The supercooling phenomenon in these cells may be associated with the amyloplast (starch granual and membrane), or the starch, which has a high capacity to absorb water, may be responsi-

ble for maintaining hydration levels in other parts of the cell that nucleate at the homogeneous nucleation point.

Increasing calcium concentration of Golden Delicious apples

A field study was undertaken to compare the effectiveness of foliar sprays of $CaCl_2$, Ca-chelate sprays, and trunk injection of $CaCl_2$ as methods of increasing Ca concentration in the flesh of Golden Delicious apples. All foliar sprays were applied to runoff, with spray volumes dependent upon tree size. An apparatus was constructed and used to inject 1.5 L of 1% $CaCl_2$ directly into tree trunks. During 1981–1983, four sprays of 0.75 and 1% $CaCl_2$ (w/v), applied weekly during the month prior to harvest, significantly increased Ca concentration in fruit flesh without the leaf phytotoxicity that occurred with two sprays of 2% $CaCl_2$ or a single preharvest spray of 4% $CaCl_2$. Concentration of Ca in fruit flesh was not increased significantly by Ca chelate sprays, 1:100 v/v in 1981 and 1:25 v/v in 1982, applied twice, nor 1:50 v/v applied four times in 1983. Since chelated Ca is about 10 times more expensive per unit of Ca in British Columbia than $CaCl_2$, chelated Ca sprays are unlikely to be cost-effective. Direct trunk injections of $CaCl_2$ also failed to increase the Ca concentration of the fruit.

SOIL SCIENCE AND AGRICULTURAL ENGINEERING

Factors affecting concentration of Zn in the leaves of apple seedlings grown in nutrient solution

Zn deficiency can be a problem in apple orchards in British Columbia. Concentrations of Zn in the leaves usually average less than 20 μg Zn/g dry weight (dw) and often less than the 14 μg Zn/g dw, which is considered deficient in the world literature. Thus, a series of laboratory experiments were completed to investigate Zn concentration in the leaves of apple seedlings grown in nutrient solutions of various Zn and P concentrations. Zn deficiency symptoms and relatively low mid-terminal Zn concentrations in the leaves were observed in seedlings grown in a minus-Zn Long Ashton solution consisting of reagent grade but unpurified chemicals. However, Zn concentration in the leaves of the seedlings increased as the initial concentration of added Zn increased through the range of 0–4 μ*M* and was highest at 27.2 μg Zn/g dw for seedlings growing in solutions with both high Zn and high P concentrations. Furthermore, very high P concentrations in the leaves were associated with inadequate Zn nutrition. Thus, the response of apples in the field to soil Zn levels and to a possible P-Zn interaction seem to be two areas of profitable future research, especially since P fertilization at planting time has been gaining popularity with orchardists.

Plastic mulch, herbicide, or grass effects on Foch grapes and on soil temperatures

Total yields of Foch grapes summed over 4 years was 53, 42, and 20 t/ha under plastic mulch, glyphosate soil treatment, and permanent grass sod, respectively. The difference between the plastic mulch and herbicide treatments was large in the first 2–3 years but declined to a small value in the fourth year. The difference between plastic mulch and grass sod remained consistently large from year to year such that yield under plastic mulch was more than double that under grass. Grass sod is not a suitable cultural technique in vineyards but it provided a basis for comparison of other soil surface treatments.

In none of the 4 years of production did the soil surface treatments affect the sugar content of grapes. Therefore, the yield differences can be translated directly into differences of total yield of sugar per hectare, the most important statistic for wine-grape growers.

Differences in soil temperature created by the treatments appear to be too small to explain the yield differences. From March through December 1985, mean monthly soil temperatures at 20 cm differed by less than 2°C between all three treatments. The greatest mean difference for any month was 1.3°C between the glyphosate and grass treatments in July, with the higher temperature under the herbicide. However, in late November the daily soil temperature under the herbicide fell to –7.7°C at 20 cm and remained some 6°C below temperatures under both the plastic and grass treatments for several days. The soil temperature under herbicide rebounded to within 2°C of the other treatments by the end of December. Soil temperatures under the herbicide treatment tended to fluctuate more widely than under other treatments, but the consequences on vine performance are not yet evident.

Soil chemical and mineralogical changes resulting from acidification in apple orchards

Five Okanagan Valley soil series that had been in orchards for 12–40 years were studied to determine the effect of orchard practices on chemical and mineralogical soil properties. Acidification produced by fertilization, irrigation, and herbicide use had lowered pH values from 5.0–6.0 in the alleys between the trees to about 3.0–3.5 near the trees and had greatly decreased permanent-

charge cation exchange capacities, base saturation percentages, and ratios of exchangeable Ca:Mg, Ca:K, and Mg:K. The pH-dependent or variable charge increased with organic C content and thus originated mainly from organic matter of these coarse-textured soils. The proportional losses of exchangeable bases during acidification followed the order Ca >Mg >K. Acidification had also released large quantities of plant-available Al and Mn. The soil clays from both the higher and lower pH sites were relatively poorly crystalline, with X-ray amorphous constituents and mica as major components. Acidification appeared to have decreased mineral crystallinity as well, as indicated by consistently higher levels of extractable oxides of Si, Al, and Fe in the clays from the acidified soils. These effects of orchard practices on chemical and mineralogical properties developed rapidly and were evident in one soil within 12 years.

The harm done thus far to the soils can be corrected; however, the cation exchange capacity (CEC) results obtained by extraction with a buffered neutral salt solution indicate that liming would completely restore the CEC. Also, the Ca:Mg:K ratios could be properly restored by judicious choice of calcitic and dolomitic limestone.

Fertilizer injection

Two fertilizer injectors were designed and tested with either granular phosphate fertilizer or with a suspension of this fertilizer. Both injectors were forced into the ground by foot, and the fertilizer was deposited 15–20 cm deep at several locations around apple trees. The liquid was forced into the soil by pressure from a sprayer pump, and the solid was deposited by gravity through a release mechanism. Preliminary results indicated a 35% increase in P in the leaves for either solid or liquid injections of 1 kg of ammonium phosphate, whereas surface applications of 5 kg showed no appreciable increase. More tests will be done in 1986.

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Plant Pathology

R. Stace-Smith, B.S.A., Ph.D., F.A.P.S.	Head of Section; Raspberry viruses, virus characterization
H.A. Daubeny, B.S.A., M.S.A., Ph.D.	Plant breeding, small fruits
S.H. De Boer,[4] B.Sc., M.Sc., Ph.D.	Bacterial diseases
P.J. Ellis,[5] B.Sc., B.Sc. (Hons), M.P.M.	Potato viruses
R.R. Martin, B.S., Ph.D.	Strawberry viruses
H.S. Pepin, B.S.A., M.A., Ph.D.	Root rots, red stele of strawberry
T.C. Vrain, D.E.A., Ph.D.	Nematology

Virus Chemistry and Physiology

H.W.J. Ragetli, Ir., Ph.D.	Head of Section; Chemistry and ultrastructural cytopathology of viruses
R.I. Hamilton, B.Sc., M.Sc., Ph.D., F.A.P.S.	Virology, virus interaction and seed transmission
D. Rochon, B.A., M.Sc., Ph.D.	Plant viruses, molecular biology
J.H. Tremaine, B.Sc., M.Sc., Ph.D.	Biophysical virology
M. Weintraub, B.A., Ph.D., F.N.Y.A.S.	Cytopathology, electron microscopy

Departures

G.G. Jacoli, B.A., Ph.D. Retired 9 October 1985.	Biochemical virology
A.T.S. Wilkinson, B.S.A. Retired 30 September 1985.	Soil insects, biological control of weeds
N.S. Wright, B.S.A., M.S.A., Ph.D. Retired 1 November 1985.	Potato diseases, serology

VISITING SCIENTISTS

L. Beczner, Ph.D. Plant Protection Institute, Budapest, Hungary	Virus characterization
R. Credi, Ph.D. University of Bologna, Italy	Plant virology, grape viruses
D.J. Donnelly, B.Sc. (Agr.), M.Sc., Ph.D. Postdoctorate fellow, 1 July 1984 to 30 July 1985	Plant tissue culture
R.E. Ford, Ph.D. University of Illinois, Urbana, Ill.	Virus characterization
A. Kurppa, B.Sc., Ph.D. Agricultural Research Centre, Jokioinen, Finland	Plant virology, molecular virology
S. Kurppa, B.Sc., M.Sc. Agricultural Research Centre, Jokioinen, Finland	Nematology
R. Nestby, Dr. Scient. Kvithamar Agricultural Research Station St. Jordal, Norway	Small fruit breeding
B.C.S. Sutton, B.Sc., Ph.D. Postdoctorate fellow, 1 October 1984 to 30 September 1985	Molecular plant pathology

Honorary Research Associate and Editor

F.C. Mellor, B.S.A.	Virus eradication

Graduate students

T. Baumann, B.Sc.	Plant breeding
H. Contant, M.Sc.	Entomology
R.C. Johnson, B.S.A.	Plant pathology
G. Kalmar, B.Sc.	Virus chemistry and physiology
B. Lyons, M.Sc.	Entomology
R.B. Smith, M.Sc.	Entomology
P. Therrien, M.Sc.	Entomology
J. Walker, B.Sc.	Nematology

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[1]Effective 1 November 1985.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]Educational leave, Texas A and M University.
[4]Transfer of work, 1 June 1984 to 31 May 1985, at Research Institute for Plant Protection, Wageningen, The Netherlands.
[5]Educational leave, University of British Columbia.

INTRODUCTION

This is the 23rd annual report of the Vancouver Research Station in which some of the highlights of the research program are outlined. We continue to be the national center for plant virus research, with a natural extension of this program into biotechnology. A second important function is development of the integrated pest management program, which assists producers to increase the efficiency and decrease the cost of controlling pests and diseases of small fruits and vegetables. The station lost three senior scientists in 1985 by retirement: Dr. G.G. Jacoli, a molecular biochemist; A.T.S. Wilkinson, an entomologist in biological control of noxious weeds; and Dr. N.S. Wright, the eminent specialist in potato diseases. On the positive side, we congratulate Dr. R.I. Hamilton on his election as a fellow of the American Phytopathological Society.

Further details of research or reprints of this report or the publications listed can be obtained from the scientists or the Research Station, Research Branch, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Biotechnology

One of our seven cDNA clones (pC2) to potato spindle tuber viroid (PSTV) was labeled with ^{32}P by nick translation or by oligo-labeling, which was simpler and more efficient. Optimum conditions of hybridization and autoradiography were determined for detection of PSTV in plant extracts. The minimum amount reliably detected in crude sap was 10 pg. Clone pC4 was subcloned on M13mp 18 vector and sequenced; clones pC7 and pC2 were sequenced directly by the dideoxy method. Preliminary results indicated a length of 350 nucleotides for clones pC2 and pC4 and 270 nucleotides for pC7.

Seven monoclonal antibodies (MCAs) against southern bean mosaic virus bean-type strain, B4 to B10, and two MCAs, against the cowpea type strain, C1 and C3, were tested against virus, swollen virus, and virus protein antigens from five bean strains and four cowpea strains in three liquid phase serological tests—gel diffusion, immunoelectron microscopy, and antigen competition enzyme-linked immunosorbent assay (ELISA) and in three solid phase tests—indirect ELISA, double antibody sandwich (DAS)-ELISA, and latex agglutination. B5, B6, and B10 reacted strongly only with the virus of the bean strains; and the binding sites of these MCAs on the virion were not blocked by trinitrobenzene sulfonic acid. B4, B7, B8, B9, C1, and C3 reacted strongly with the swollen virus and protein antigens of the bean and cowpea strains in solid phase tests. They did not react with either virus in liquid phase tests. Apparently the virus is denatured by attachment to plastic ELISA plates or latex beads or by reaction with the coating antibody in DAS-ELISA. This is probably one of the factors involved in the high sensitivity of DAS-ELISA in routine virus indexing.

Physical, chemical, and serological properties of viruses in vitro

Carnation ringspot virus, R strain (CRSV-R) aggregates and disaggregates in a temperature reversible manner. The effect of increasing concentrations of chemicals on the aggregation temperature was studied at pH 5.0 and 7.0 with CRSV-R at 0.8 mg/mL. The greatest reduction without denaturation occurred with EDTA and EGTA. Small decreases occurred with increasing concentration of NaCl, acetamide, urea and Triton X 100, Tween 20, and alginic acid. Sucrose was very effective in raising the aggregation temperature and may be useful in preventing aggregation of viruses during purification and in characterization.

Two isolates of a tobamovirus from *Lychnis alba*, collected in the Okanagan Valley in British Columbia, were closely related to tobacco mosaic virus (TMV) Holmes' ribgrass (HR) isolate on the basis of their amino acid composition. They differed from TMV-HR in their symptomatology on Samsun tobacco and in their sensitivity to in vitro decapsidation conditions. Analysis of viral RNAs with fingerprint techniques showed a complexity similar to other well-known strains of TMV, with no difference between the two isolates. The coat protein of both isolates behaved like a 16 000 polypeptide as characterized by gradient polyacrylamide gel electrophoresis. Several immunological cross-reactions were obtained with different TMV isolates. This is the second report of HR-related tobamovirus isolates from wild *Lychnis alba* (Caryophyllaceae).

Ultrastructural responses to virus infections

The movement of turnip yellow mosaic virus (TuYMV), tobacco mosaic virus (TMV), and potato spindle tuber viroid (PSTV) in leaves with functioning hydathodes was investigated by transmission-electron microscopy (TEM) and scanning-electron microscopy (SEM) and by bioassay of exudates. TuYMV and TMV were detected by TEM extracellularly in situ in *Brassica chinensis* and *Lycopersicum esculentum*, respectively, as well as in negatively stained exudates. In addition, TuYMV and TMV, but not PSTV, were detected in the exudates by bioassay.

Virus infection

Four new species in the order *Centrospermae* were found to contain virus inhibitors of the class for which the inhibitor from carnation is the prototype. They included the first representative of the *Nyctaginaceae*.

Little cherry disease (LCD)

Virus like particles associated with LCD were purified from cherry leaves collected outside the two areas known to harbor the disease. The new isolates were serologically identical to the authentic isolates when tested by serology-specific electron microscopy against polyclonal antiserum homologous to the latter.

An improved method of isolating LCD-associated dsRNAs was devised using cellulase and pectinase digestion of cherry leaf or bark tissues; phenol extraction of nucleic acids; removal of polysaccharides from the nucleic acids by precipitation in 0.5 *M* sodium perchlorate; isolation of dsRNAs by adsorption to Cellex N-1 in 16–17% ETOH/STE and desorption in STE; and removal of traces of host DNA by digestion with RNase-free DNase. Five dsRNAs (molecular weight $3.2–10.8 \times 10^6$) were observed following agarose gel electrophoresis of extracts from infected trees, two of which were similar in molecular weight to those found in the virus-free bean cultivar Black Turtle Soup. These findings suggest that LCD-associated dsRNAs may be a mixture of host and viral dsRNAs.

PLANT PATHOLOGY

Small fruit breeding

Raspberry. Advanced selections 74-10-81 and 74-12-42 continued to perform well in test plots. Both will be given cultivar status in 1986. At that time there should be enough certified plants for distribution to growers thoughout the Pacific Northwest. 74-12-42 is the higher yielder of the two and produces large, firm fruit. Yields of 74-10-81 are similar to Willamette and it produces fruit of high quality with a prolonged shelf life for the fresh market. Both selections should be adapted to machine harvesting. Both are resistant to the aphid vector of raspberry mosaic virus and thus will escape the virus. Selection 84-10-81 may be resistant to pollen transmitted by the raspberry bushy dwarf virus.

Strawberry. Advanced selection 69-5-34 has performed consistently well over a number of years in trial plantings throughout the Pacific Northwest. It shows virus tolerance, winterhardiness, and produces high yields of reasonably firm fruit suitable for processing. If its performance in growers' trials is satisfactory in 1986, it will be given cultivar status.

Fungal pathology

Raspberry. To determine the effect of spur blight (*Didymella applanata*) on raspberry yield components, natural infections on the red raspberry cultivars Haida, Willamette, Meeker, Chilcotin, Malling Leo, Malling Jewel, Glen Clova, and Glen Prosen were labeled in the fall of 1984, and symptom expression was followed through the summer of 1985. Length of infected buds of all cultivars and bud emergence in the spring were significantly less than on noninfected controls. Infected spurs were significantly less vigorous for all cultivars except Malling Leo and Meeker. All cultivars except Willamette and Malling Jewel produced significantly fewer laterals per infected spur.

Strawberry. Plants of the strawberry cultivar Totem were artificially altered to change the microclimate surrounding fruiting scapes. Plant structure significantly affected fruit rot susceptibility. Fruit on upright scapes above the leaf canopy had significantly less pre- and postharvest fruit rot than scapes artificially held on an angle within the canopy, and the latter had significantly less fruit rot than scapes held horizontally on the soil surface. Breeding for a suitable plant structure should reduce fruit rot susceptibility.

Bacteriology

Corynebacterium sepedonicum, the cause of bacterial ring rot of potatoes, was detected in symptomless potato stems and tubers by immunofluorescence using monoclonal antibodies specific for this pathogen. The concentration of bacterial cells in potato tissue preparations ranged from >500 to <1 cells per microscope field. When symptomless tubers containing ring rot bacteria were planted in field plots, they yielded plants with ring rot symptoms, plants with latent ring rot infections, or plants with no detectable

levels of ring rot bacteria, depending on the number of bacterial cells in the parent tuber.

Cellular fatty acid analysis was studied as a new rapid procedure for identifying *Erwinia carotovora* subsp. *atroseptica* by gas–liquid chromatography with a fused-silica capillary column. All *E. carotovora* strains contained, in decreasing order of amount present, 9-hexadecenoic acid, hexadecanoic acid (16:0), 9-octadecenoic acid (18:1), dodecanoic acid (12:0), 3-hydroxytetradecanoic acid (3-OH.14:0), and tetradecanoic acid (14:0). In addition, some strains contained a small amount of 13, 15, 17, and 18 carbon saturated fatty acids. *E. carotovora* subsp. *atrospectica* could be differentiated from *E. carotovora* subsp. *carotovora* on the basis of fatty acid ratios of dodecanoic-to-tetradecanoic acid, hexadecanoic-to-dodecanoic acid, and 9-hexadecenoic-to-9-octodecenoic acid, which were <3.71, >4.87, and >2.70, respectively.

Nematology

The root-lesion nematode, *Pratylenchus penetrans*, is the most damaging pest of the growing raspberry industry. The resistance and tolerance of 21 raspberry cultivars, breeding lines, and *Rubus* species to the root-lesion nematode was determined in three greenhouse experiments and in field microplots. The growth parameters measured showed no detectable differences between plants inoculated with nematodes and those that were not, indicating a considerable tolerance of the plants when they are not water-stressed. The cultivar Nootka supported fewer nematodes than Willamette or Sumner. A clone of *Rubus crataegifolius*, an Asiatic species used in breeding for superior fruit traits, and a clone of *Rubus idaeus strigosus* supported the lowest nematode densities in their roots.

The population dynamics of root-lesion nematodes in raspberry were followed after low dosages of fenamiphos were applied over the root zone through a drip irrigation system. One application containing active ingredient (a.i.) at 4 kg/ha, followed by four drenches with a.i. at 1 kg/ha over a period of 2 years, lowered the nematode density in the roots by 71% (averaged over 6 sampling dates). Yields were increased by 45%. Carbofuran applied in the same manner did not depress the nematode density as much, but nevertheless increased yields by 38%.

Virology

The double-stranded RNA technique was used to identify raspberry leaf spot virus (RLSV) in commercial cultivars and advanced selections of raspberry. Under field conditions in British Columbia and Washington, only aphid-susceptible cultivars were found infected with RLSV. In breeding plots, all aphid-susceptible selections were infected with RLSV, seven in British Columbia and three in Washington. Of 47 aphid-resistant plants tested, only one was infected with RLSV. The resistant plants were adjacent to susceptible plants and had been in the field for at least 6 years. The aphid-resistant character is also a very useful means of preventing the transmission of raspberry mosaic complex.

A sequence homology between cauliflower mosaic virus and strawberry veinbanding virus has been demonstrated. ^{32}P-labeled CaMV DNA hybridized to total nucleic acid of SVBV-infected, but not to healthy, strawberry blotted onto Genescreen. The level of homology is relatively small since the hybridization occurs at 50°C but not at 65°C. This level of homology will not be useful for a SVBV detection program, but should be useful for monitoring the purification of SVBV or SVBV DNA.

Three hybridoma clones (510h, 412g, and 112e) that secrete monoclonal antibodies (MCAs) specific for beet western yellows virus (BWYV) were produced by cell fusion between mouse spleen cells (Rb. 812) with Fox-NY myeloma cells. A fourth clone (411b) appears to be specific for potato leaf roll virus strains 1 and 2. Clones 412g and 112e produced antibodies of the subclass IgG1; clone 510h of subclass IgG2a; and clone 411b of subclass IgM. Subclasses were determined with sets of rabbit anti-mouse antisera for hybridoma subisotyping, using double diffusion in gel and ELISA. The objective of this research is to produce hybridomas that secrete BWYV-specific MCAs that will be useful in the detection of BWYV to determine if this virus is an important component of potato leaf roll disease.

ENTOMOLOGY

Vectors

Little cherry disease (LCD). The apple mealybug, *Phenacoccus aceris* (Signoret), and the dodder, *Cuscuta lupuliformis* Krocher, were confirmed as vectors of LCD when they induced redleaf symptoms, fruit symptoms, and electron microscopic inclusions diagnostic of LCD in test trees. Control of the apple mealybug, coupled with a rigorous program of removal of diseased trees, appears to have already significantly reduced the incidence of LCD in Okanagan orchards.

Aphid survey. New records brought the number of known aphid species in British Columbia to 368. Aphids have now been collected

from 810 different host plants, and the total number of aphid-host associations is 1529.

Pest control

Potato aphid monitoring. *Myzus persicae* was monitored at 14 locations throughout the Fraser Valley from May to September. Top-kill dates were set when monitoring data showed an increase in numbers of flying aphids. Top-kill dates were thus delayed several weeks.

Blackheaded fireworm. Two pheromone components, (*Z*)-11-tetradecenyl acetate and (*Z*)-11-tetradecenyl alcohol, in a 3:1 combination, provided an effective attractant for monitoring population levels of the blackheaded fireworm *Rhopobota unipunctana* (Haworth). The addition of (*Z*)-9-dodecenyl acetate, a previously reported attractant, did not significantly improve field trapping results.

Ermine moth (*Yponomeuta mallinellus*). This recently introduced European pest of apples is widely distributed in the lower mainland of British Columbia and poses a potential threat to the Okanagan apple industry. Research is being conducted, in cooperation with the British Columbia Ministry of Agriculture and Food, Summerland Research Station, and Food Production and Inspection Branch, to develop a treatment for dormant nursery stocks to ensure that exports from the lower mainland are free from ermine moths.

Wireworms. A seed treatment and a furrow treatment with the new synthetic pyrethroid PP993 were compared with the two registered controls, terbufos granules in the furrow and the diazinon–lindane seed treatment, for the control of the wireworm *Agriotes obscurus* L. in corn in heavily infested silt loam. A treatment combining the terbufos furrow treatment and the diazinon–lindane seed treatment was also tested. All treatments gave two to three times greater yield than the untreated check, but there was no significant difference in yield between treatments. Residue analyses of corn grown in plots with the combined treatment of terbufos and diazinon–lindane showed no detectable residues of these chemicals or of their breakdown products.

Twospotted spider mite. A simple sampling scheme and an economic threshold function have been developed as part of an IPM program for the twospotted spider mite, *Tetranychus urticae* Koch, on strawberry. The sampling scheme is based on the proportion of mite-free leaflets, as observed in the field with the naked eye. Using a simple table, the grower can determine the precision of the estimate of mean density and the number of samples required to obtain a desired precision. The scheme makes no assumptions about distribution and requires much less time than is needed to count mites using a stereomicroscope. The economic threshold function will allow the grower to make pest control decisions based on *T. urticae* density, sample precision, number of weeks before harvest, differences in environmental conditions relative to the experimental studies, control measure to be used, and market price of the crop. Field experiments suggested that introductions of the predator *Phytoseiulus persimilis* Athias-Henriot, at rates of 27 000, 13 000, or 400 females per hectare were unable to regulate *T. urticae* populations. The native predator *Amblyseius fallacis* (Garman) showed a rapid numerical response to *T. urticae* introductions and may be a good candidate as a biological control agent.

Cabbage maggot. Cardboard traps painted with 94 chromatic or achromatic hues were used in fields of cole crops to study the color preferences of the cabbage fly, *Delia radicum* (L.). Yellow, white, blue, and violet were the most attractive colors tested, in that order. Colors reflecting a large number of ultraviolet wavelengths were not attractive. Cabbage flies appear to be attracted to traps reflecting wavelengths at 400–480 nm (blues) and 550–570 nm (yellows) and repelled by ultraviolet wavelengths at 300–360 nm. Yellow sticky traps were effective for monitoring cabbage fly populations in three rutabaga fields. The use of these traps will facilitate more accurate timing of sprays in cole crops.

A minor use registration was obtained for Lorsban 4E on cabbage, cauliflower, and broccoli, and the chemical was widely used by growers this year. Additional research was completed to support the registration of granular Lorsban 15G and for the new liquid formulation Lorsban 4E-HF. These formulations will provide growers with excellent maggot control in the major cole crops without the phytotoxicity associated with the alternative chemicals.

Lettuce aphid. A sequential procedure for monitoring lettuce aphids was developed and implemented this year in all lower mainland commercial lettuce fields. The procedure is also effective for assessing levels of the alfalfa looper, *Autographa californica* (Speyer). The monitoring progam allowed growers to determine the need for and the effectiveness of insecticide sprays against loopers and aphids. In insecticide efficacy trials, the unregistered systemic organophosphates Di-Syston 8EC and Metasystox-R 2.4SC were found to be superior to currently registered insecticides for controlling lettuce aphids. A minor use registration for Di-Syston 8EC is being sought for 1986–1987.

Tuber flea beetle. The procedures for monitoring the tuber flea beetle, *Epitrix tuberis* Gentner, developed up to 1984, were implemented on 20 commercial potato fields this year. The program successfully reduced insecticide sprays in all fields while maintaining crop quality. Methods for improving the efficiency of the monitoring program continue to be developed.

Residue chemistry

Cabbage maggot. Two chlorpyrifos formulations, Lorsban 15G and Lorsban 4E-HF, were evaluated for control of cabbage maggots in cole crops. Band treatments with Lorsban 15G containing a.i. at 2.2 g/10 m of row were applied at seeding. To reduce mid- and late-season maggot damage, a maximum of two drenches with Lorsban 4E-HF at 1.0 g/10 m of row were applied during the season to cabbage, Brussels sprouts, and broccoli; a maximum of four drenches were applied to rutabagas. At harvest the marketable produce was analyzed for residues, including the breakdown products 3,5,6-trichloro-2-pyridinol and 3,5,6-trichloro-2-methoxypyridine. No residues at the limit of detection of 0.002 ppm fresh weight were present in cabbage, Brussels sprouts, or broccoli. Some residues were detected in marketable rutabagas; their levels depended on the interval between the last drench and harvest. The total residues ranged from negligible (0.1 ppm fresh wt) to 0.16 ppm, which was detected in rutabagas harvested 15 days after the last drench. Application is in progress for minor use registration of Lorsban 15G against cabbage maggot in cole crops.

Lettuce aphid. Di-Syston Liquid Concentrate Systemic (72% disulfoton) and Metasystox-R Spray Concentrate Systemic (24% oxydemeton-methyl) were again found to be effective for lettuce aphid control. Residue levels in the marketable produce were determined. To reflect the highest probable levels of residues, only the three outermost wrapper leaves were collected to form composite samples. After spraying with Di-Syston with a.i. at 1.12 kg/ha, the total residues were less than 0.1 ppm fresh weight in 23 days and about 0.01 ppm in 28 days. Metasystox-R appeared to be more persistent than Di-Syston. At the same application rate, total oxydemeton-methyl residues were 0.14 ppm after 23 days. Application is in progress for minor use registration of Di-Syston against lettuce aphid.

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