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Research Branch Report

1972

CANADA DEPARTMENT OF AGRICULTURE

CONTENTS

Executive of the Research Branch, v	Direction de la recherche, v
Organization Chart, vi	Organigramme, vi
Map of Canada, vii	Carte du Canada, vii
Research Coordinators and Administration, viii	Coordonnateurs des recherches et Administration, viii
Foreword, ix	Avant-propos, x
Research Stations (Eastern)	Stations de recherches (Est)
St. John's West, Nfld., 1	
Charlottetown, P.E.I., 7	
Kentville, N.S. 19	
Fredericton, N.B., 29	
L'Assomption, Que., 41	
Lennoxville, Que., 45	
Sainte-Foy, Que., 51	
St. Jean, Que., 65	
Delhi, Ont., 75	
Harrow, Ont., 81	
Ottawa, Ont., 93	
Vineland Station, Ont., 109	
Research Institutes and Services	Instituts et Services de recherches
Animal Research Institute, 117	
Chemistry and Biology Research Institute, 131	
Entomology Research Institute, 143	
Food Research Institute, 155	
Plant Research Institute, 163	
Soil Research Institute, 175	
Research Institute, London, 189	
Engineering Research Service, 197	
Statistical Research Service, 205	
Research Stations (Western)	Stations de recherches (Ouest)
Brandon, Man., 211	
Morden, Man., 219	
Winnipeg, Man., 225	
Indian Head, Sask., 239	
Melfort, Sask., 243	
Regina, Sask., 251	
Saskatoon, Sask., 259	
Swift Current, Sask., 271	
Beaverlodge, Alta., 283	
Lacombe, Alta., 289	
Lethbridge, Alta., 299	
Agassiz, B.C., 315	
Kamloops, B.C., 323	
Sidney, B.C., 327	
Summerland, B.C., 331	
Vancouver, B.C., 343	
Index of Professional Staff and Visiting Scientists, 353	Cadres professionnels et chercheurs invités, 353
Subject Index, 363	Table des matières, 363



Dr. B. B. Migicovsky



Dr. E. J. LeRoux



Dr. D. G. Hamilton



Dr. T. H. Anstey



Dr. R. A. Ludwig



Mr. D. G. Peterson

**EXECUTIVE OF THE RESEARCH BRANCH
DIRECTION DE LA RECHERCHE**

Director general

Directeur général

B. B. MIGICOVSKY, B.S.A., M.S., Ph.D., D.Sc., F.C.I.C., F.A.I.C.

Assistant Director General (Planning and Coordination)

Directeur général adjoint (Planification et coordination)

E. J. LEROUX, B.A., M.Sc., Ph.D.

Assistant Director General (Eastern)

Directeur général adjoint (Est)

D. G. HAMILTON, B.Sc., M.Sc., Ph.D., F.A.A.A.S.

Assistant Director General (Western)

Directeur général adjoint (Ouest)

T. H. ANSTEY, B.S.A., M.S.A., Ph.D.

Assistant Director General (Administration)

Directeur général adjoint (Administration)

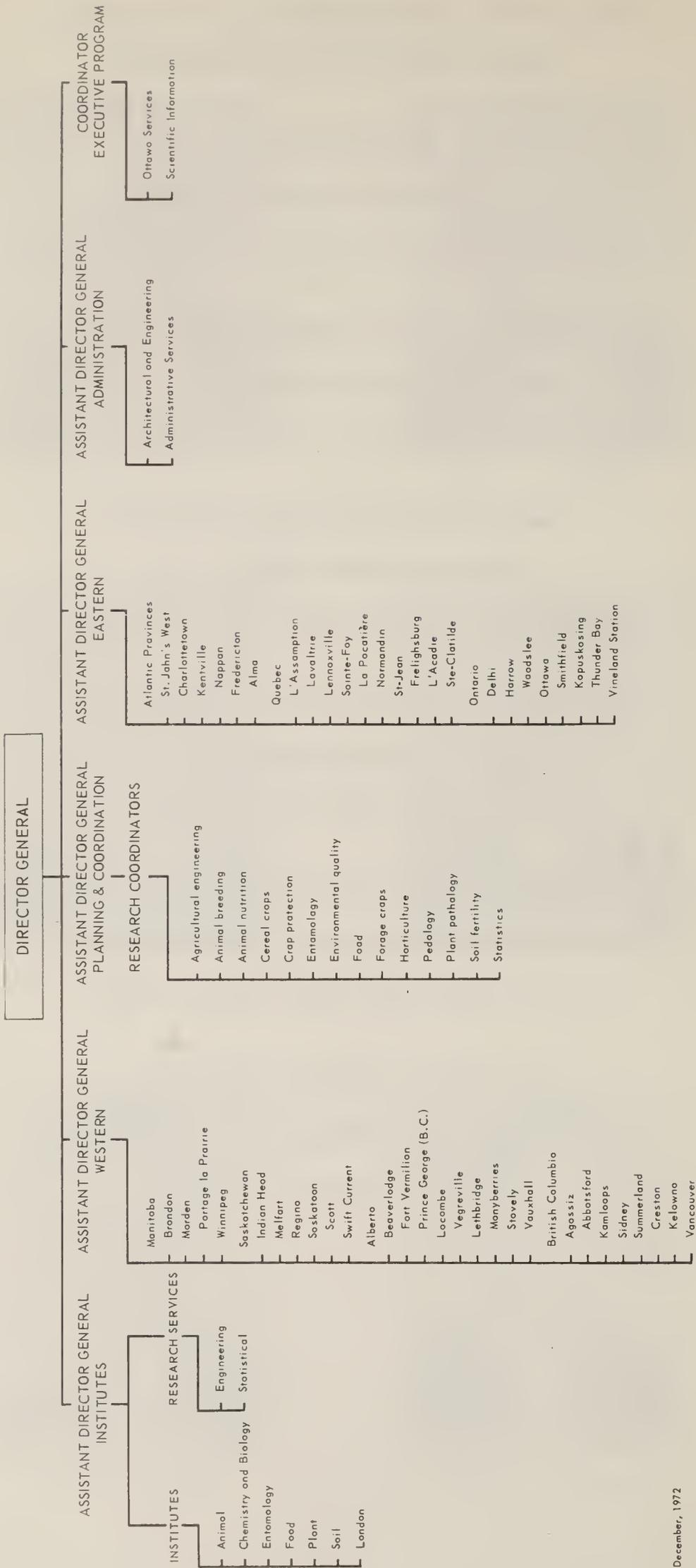
R. A. LUDWIG, B.Sc., M.Sc., Ph.D., F.A.P.S.

Coordinator (Executive Program)

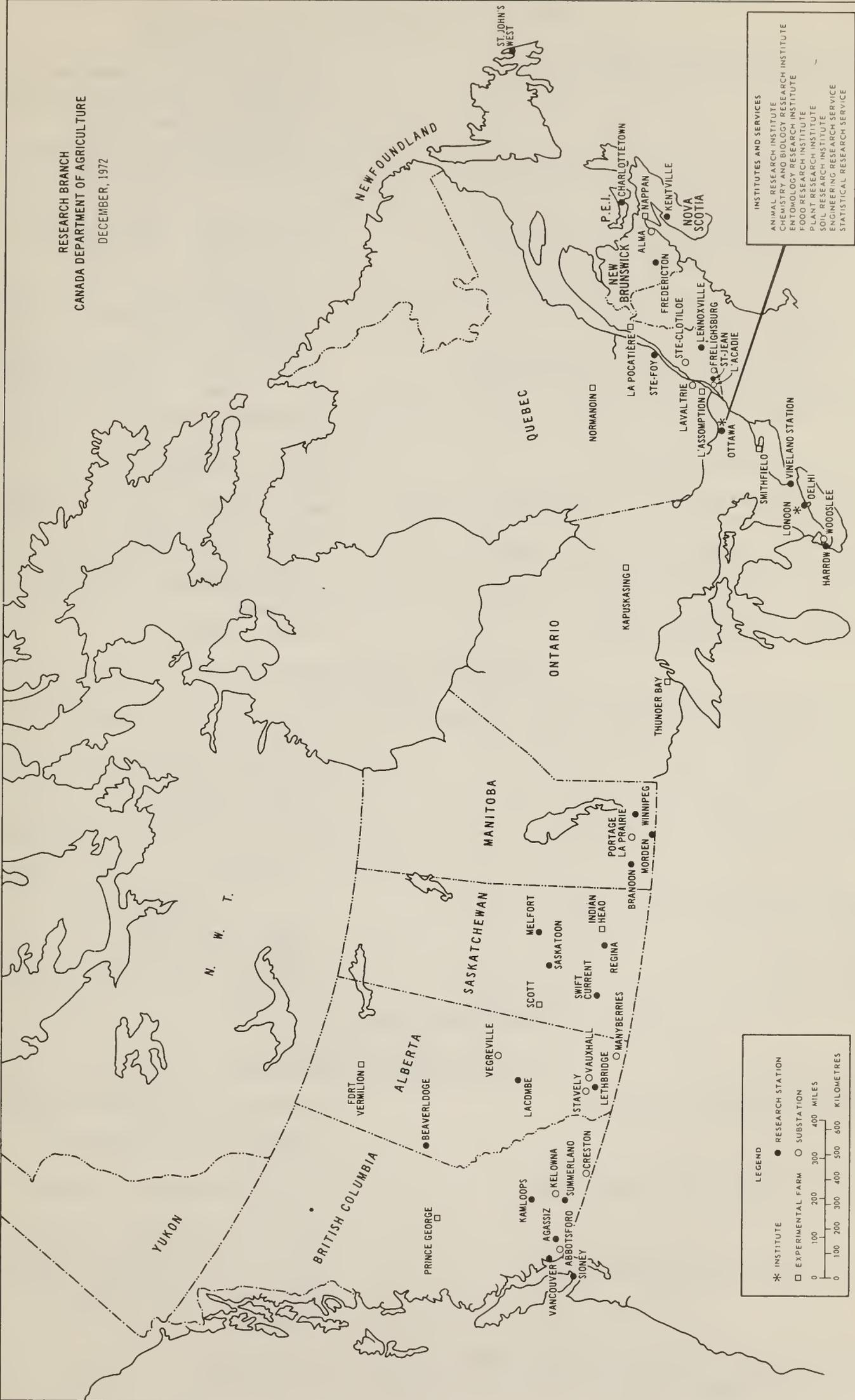
Coordonnateur (Programmes, exécutif)

D. G. PETERSON, B.A., M.Sc.

CANADA DEPARTMENT OF AGRICULTURE
RESEARCH BRANCH



RESEARCH BRANCH
 CANADA DEPARTMENT OF AGRICULTURE
 DECEMBER, 1972



LEGEND

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- RESEARCH STATION
- EXPERIMENTAL FARM
- SUBSTATION

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 MILES
 KILOMETRES

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- ANIMAL RESEARCH INSTITUTE
- CHEMISTRY AND BIOLOGY RESEARCH INSTITUTE
- ENTOMOLOGY RESEARCH INSTITUTE
- FOOD RESEARCH INSTITUTE
- PLANT RESEARCH INSTITUTE
- SOIL RESEARCH INSTITUTE
- ENGINEERING RESEARCH SERVICE
- STATISTICAL RESEARCH SERVICE

RESEARCH COORDINATORS

COORDONNATEURS DES RECHERCHES

E. J. LEROUX, B.A., M.Sc., Ph.D.	Assistant Director General (Planning and Coordination) Directeur général adjoint (Planification et coordination) Horticulture Horticulture
C. J. BISHOP, B.Sc., M.A., Ph.D., F.R.S.C., F.A.S.H.S.	
J. J. CARTIER, B.A., B.Sc., M.Sc., Ph.D.	Entomology Entomologie
M. F. CLARKE, B.S.A., M.S.A., Ph.D.	Forage Crops Plantes fourragères
C. G. E. DOWNING, B.E., M.Sc., F.A.S.A.E., F.E.I.C.	Agricultural Engineering Génie agricole
W. S. FERGUSON, ¹ B.S.A., M.Sc., Ph.D.	Soil Fertility Fertilité des sols
R. L. HALSTEAD, B.S.A., Ph.D. (Acting) (Intérim)	Soil Fertility Fertilité des sols
H. HURTIG, ² B.Sc., Ph.D.	Environmental Quality Qualité de l'environnement
L. P. LEFKOVITCH, B.Sc.	Statistics Statistique
H. V. MORLEY, B.Sc., Ph.D. (Acting) (Intérim)	Environmental Quality Qualité de l'environnement
J. W. MORRISON, B.Sc., M.Sc., Ph.D.	Cereal Crops Céréales
W. J. PIGDEN, B.S.A., M.Sc., Ph.D.	Animal Nutrition Nutrition animale
N. W. TAPE, B.S.A., Ph.D.	Food Aliments

ADMINISTRATION

R. A. LUDWIG, B.Sc., M.Sc., Ph.D., F.A.P.S.	Assistant Director General (Administration) Directeur général adjoint (Administration)
J. E. RYAN, A.C.B.A., R.I.A.	Chief of Administrative Services Section Chef des services administratifs
D. R. KINSMAN, B.Sc.	Chief of Architectural and Engineering Section Chef de l'architecture et du génie technique

EXECUTIVE PROGRAM

PROGRAMMES, EXECUTIF

D. G. PETERSON, B.S., M.Sc.	Coordinator (Executive Program) Coordonnateur (Programmes, exécutif)
C. E. CHAPLIN, B.Sc., M.Sc., Ph.D.	Chief of Scientific Information Section Chef de l'information scientifique
A. I. MAGEE, B.Sc. (Agr.), M.S.A.	Chief of Ottawa Services Section Chef des services techniques (Ottawa)

¹Acting Assistant Director General (Institutes and Services) for part of the year.

²On French Language Training.

FOREWORD

The Research Branch Report for 1972 is presented in the traditional manner, each director reporting on the activities of the establishment program for which he is responsible. The report does not demonstrate the case that exists, namely, that all programs throughout the Branch are related to produce an overall Branch program in accordance with Branch objectives and goals.

In 1973 we intend to write an additional report that will present the national program in terms of objectives and goals. The new report will supplement the reports of the establishments.

The report this year indicates changes of direction in many of our programs and demonstrates our attempts at program consolidation. The kind of research being conducted indicates that introduction of management by objectives has served the useful purpose of enabling more efficient management of our resources without restricting the activity and research capacities of the scientists.

Several temporary and permanent changes in management personnel took place during the year. Dr. E. J. LeRoux, Assistant Director General (Institutes and Services), was the Director General, in an acting capacity, for several months. Dr. W. S. Ferguson, Research Coordinator (Soil Fertility), acted for Dr. LeRoux, while Dr. R. L. Halstead, Research Scientist, Soil Research Institute, acted for Dr. Ferguson.

Dr. A. E. Hannah, Assistant Director General (Planning and Coordination), was promoted to Assistant Deputy Minister with responsibility for the newly formed Food Systems Branch. Dr. E. J. LeRoux's responsibilities were transferred from Institutes and Services to Planning and Coordination, succeeding Dr. Hannah.

Dr. A. S. Johnson, Research Coordinator (Animal Breeding), was transferred to the Food Systems Branch. Mr. D. G. Peterson, Research Coordinator (Crop Protection), was appointed Coordinator (Executive Program). Dr. H. Hurtig, Research Coordinator (Environmental Quality), who was absent throughout the year on language training, was replaced temporarily by Dr. H. V. Morley, Research Scientist, Chemistry and Biology Research Institute.

Dr. W. A. Ehrlich, Research Coordinator (Pedology), and Dr. A. J. Skolko, Research Coordinator (Plant Pathology), retired.

Dr. M. F. Clarke, Director of the Research Station at Agassiz, was appointed Research Coordinator (Forage Crops).

Mr. L. P. Lefkovitch, Research Scientist, Statistical Research Service, became Director of that Service, succeeding Dr. P. Robinson, who transferred to Communications Canada. Mr. J. J. Jasmin was appointed Director of the Research Station at Saint-Jean, succeeding Mr. A. A. Beaulieu. Mr. J. R. Foster, Director of the Experimental Farm at Indian Head, retired.

The Research Institute at Belleville was closed and the staff and programs were transferred to other Branch establishments.

A conference of directors and coordinators was held in the spring of 1973 and proved to be very successful in providing the necessary input of the directors into the planning process. We are making some progress in attaining better communication among our scientists throughout the Branch and with scientists at universities and provincial establishments. It is our intention to improve this communication, which is necessary to the national research programs.

B. B. Migicovsky
Director General

AVANT-PROPOS

Le rapport de la Direction de la Recherche pour l'année 1972 vous est présenté dans sa forme traditionnelle, chaque directeur décrivant les diverses activités en cours à son établissement. Le rapport ne met pas en évidence le fait que tous les programmes de la Direction sont agencés dans un ensemble d'objectifs et de buts.

Nous nous proposons de présenter en 1973 un rapport supplémentaire comportant tout le programme en termes d'objectifs et buts. Ce nouveau rapport s'ajoutera à ceux des divers établissements.

Le présent rapport souligne certains changements d'orientation et reflète nos efforts de consolidation des programmes. La gestion par objectifs nous a permis d'utiliser à bon escient nos ressources scientifiques sans restreindre pour autant les activités de nos chercheurs.

Plusieurs permutations et changements temporaires dans le personnel des cadres ont eu lieu durant l'année. Le Dr E. J. LeRoux, Directeur général adjoint (Instituts et services), a été Directeur général intérimaire durant plusieurs mois. Le Dr W. S. Ferguson, Coordonnateur de recherches (Fertilité des sols), a remplacé le Dr LeRoux tandis que le Dr R. L. Halstead, chercheur scientifique de l'Institut de recherches sur les Sols, remplaçait le Dr Ferguson.

Le Dr A. E. Hannah, Directeur général adjoint (Planification et coordination), a été promu au rang de Sous-Ministre adjoint avec autorité sur la nouvelle Direction des Circuits Alimentaires. Le Dr E. J. LeRoux a succédé au Dr Hannah.

Le Dr A. S. Johnson, Coordonnateur de recherches (Zootechnie), a été transféré à la Direction des Circuits Alimentaires. M. D. G. Peterson, Coordonnateur de recherches (Protection des cultures) a été nommé Coordonnateur (Programmes, exécutif). Le Dr H.

Hurtig, Coordonnateur de recherches (Qualité de l'environnement), en congé d'études de langue durant l'année, a été remplacé temporairement par le Dr H. V. Morley, chercheur scientifique, Institut de Recherches Chimiques et Biologiques.

Le Dr W. A. Ehrlich, Coordonnateur de recherches (Pédologie), et le Dr A. J. Skolko, Coordonnateur de recherches (Phytopathologie), ont pris leur retraite.

Le Dr M. F. Clarke, Directeur de la Station de recherches d'Agassiz, a été nommé Coordonnateur de recherches (Plantes fourragères).

M. L. P. Lefkovitch, chercheur scientifique, Service de Recherches Statistiques, est devenu Directeur de ce service en remplacement du Dr P. Robinson, qui a été transféré au Ministère des Communications. M. J. R. Foster, Directeur de la Ferme expérimentale d'Indian Head, a pris sa retraite. Enfin, M. J. J. Jasmin a été nommé Directeur de la Station de recherches de Saint-Jean, succédant à M. A. A. Beaulieu.

L'Institut de recherches de Belleville a été fermé et le personnel a été réparti dans d'autres établissements.

Une conférence des directeurs et coordonnateurs tenue au printemps de 1973 a connu un grand succès et permis aux directeurs de faire connaître leurs points de vue sur la planification des programmes. Il y a eu des progrès marqués dans les communications entre nos chercheurs des divers parties de la Direction et avec nos collègues des universités et des établissements provinciaux de recherches. Nous nous proposons de continuer nos efforts dans ce domaine afin de renforcer davantage le programme national de recherches.

B. B. Migicovsky
Directeur général

Research Station St. John's West, Newfoundland

PROFESSIONAL STAFF

H. W. R. CHANCEY, B.S.A., M.S.A. Director

Entomology Section

RAY F. MORRIS, B.S.A., M.Sc. Head of Section: Vegetable insects

Horticulture Section

B. G. PENNEY, B.Sc., M.Sc. Vegetable crops

Plant Breeding and Pathology Section

K. G. PROUDFOOT, B.Agr., M.Agr. Head of Section: Potato breeding
M. C. HAMPSON, B.Sc., M.Sc., Ph.D. Plant diseases

Soils and Agronomy

A. F. RAYMENT, B.Sc., M.Sc. Soil fertility
P. K. HERINGA, B.Sc., M.Sc. Pedology
A. SCHORI, B.Sc., M.S.A. Pedology

INTRODUCTION

The Research Station at St. John's West is responsible for regional research on the reclamation and use of peat soils, resistance to potato wart disease, and golden nematode control. The research program also includes studies on insect control, plant diseases and nutrition, controlled storage, and suitable vegetable varieties. Soil survey work is in progress in both the eastern and western sections of the province.

This report summarizes the results of the research done at the Station in 1972. Copies of the report and reprints of the research publications listed can be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's West, Nfld.

H. W. R. Chancey
Director

SOIL SCIENCE

Soil Survey

A soil survey report and soil and agricultural capability maps at a scale of 1:50,000 were completed for the Avalon Peninsula. Agricultural capability maps at a scale of 1:250,000 were also completed for the St. John's and Trepassay map sheets.

Field investigations were completed for the detailed reconnaissance soil survey and agricultural capability survey of the Codroy Valley. Thirty soil series and two land types were described and first drafts have been made of the soil and agricultural capability maps.

In a study on Mn pans found in coarse-textured soils underlying acid peats a heterotrophic *Cephalosporium* fungus was isolated, which grew at pH 4.5 and produced black crystalline MnO on an agar medium containing only MnSO₄. Work is continuing to determine the role of this fungus in the formation of amorphous Mn deposits commonly found in Mn pans.

Chemical analyses of Newfoundland soils established that the movement of Fe and Al was common in the Avalon Peninsula soils whereas the combined movement of Fe and Al plus clay was typical of soils in western sections of the province. In central Newfoundland, fertilizers applied to sandy loam soils moved rapidly downward and became unavailable to crops.

Peat Soils

Trace elements. Because internal parasitism might have complicated previous investigations of the trace element nutrition of lambs grazing on peatland pastures, two lambs from each of three different pastures

were slaughtered and examined for parasites at three different times during the grazing season. Tapeworms, *Moniezia expansa*, and whipworms, *Trichuris* spp., were the only parasites detected on examination of entire digestive tracts, but neither were present in sufficient numbers to indicate complications. Apparently, two anthelmintic treatments of thiabendazole spaced 1 mo apart had been quite effective in controlling parasitism and there were no differences between previously grazed pastures suspected of parasite buildup and an ungrazed pasture. The continued mediocre performance of animals on ample forage and without parasite problems supports our previous contention that deficiencies exist in forage quality.

Pasture herbage samples taken over a 3-yr experimental period have been analyzed for Fe, Mn, Zn, Cu, Mo, inorganic S, and Se, of which the first five were also components of a special fritted trace element mixture applied with fertilizer. Annual application of the fritted elements caused an increased concentration in the forage over that applied in the seeding year only, and of these Zn, Cu, and Mo were statistically highly significant. Swards containing timothy were lower in Mn, Zn, Cu, and inorganic S and higher in Mo than swards containing reed canarygrass. The levels of Cu, Mo, and inorganic S in the foliage were well within accepted values and did not clarify animal responses to Cu on the different swards. However, the sward containing timothy produced unexpected animal responses to Cu and at the same time contained different levels of trace nutrients, indicating a probable nutrient balance relationship. These results may be of minor importance because Se was the only clearly

deficient element at 0.039 ppm. Many investigators consider that a deficiency exists below 0.050 ppm.

Fertility. The effects of N, P, and K fertilizer on yields of transplanted cabbage were determined using the varieties Houston Evergreen, Evergreen Ballhead, Green Winter, Storage Green, and Greenhead.

All varieties responded similarly to increases in fertilizer. There was no significant difference between yields from plots that had received 224 kg/ha of preplant N and 224 kg/ha each of N, P, and K side-dressing and yields from plots that had received 336 kg/ha of preplant N and 112 kg/ha each of N, P, and K side-dressing. Varietal yields in t/ha from plots that had received the former treatment were: Houston Evergreen 67.0, Evergreen Ballhead 65.0, Green Winter 55.1, Storage Green 50.4, and Greenhead 48.4.

Drainage. Preliminary greenhouse experiments to improve permeability of peat soils showed that agricultural limestone at 20 t/ha improved drainage slightly. In similar experiments with gypsum, permeability was approximately 20 times greater than in the control.

Mineral Soils

Fertility. Experiments using direct-seeded and transplanted cabbage were conducted to determine the effects of various preplanting and side-dressing applications of N, P, and K fertilizer on yields of several cabbage varieties.

Both direct-seeded (ds) and transplanted (tp) cabbage responded similarly to like treatments. Preplant N applied at 336 kg/ha as a single or split application produced higher yields than 224 kg/ha of preplant N. Increasing the N level beyond 336 kg/ha did not increase yields. Varietal yields in t/ha were: Pennstate Ballhead (ds 69.2), Danish Ballhead (ds 40.8), Houston Evergreen (ds 35.6, tp 76.4), Evergreen Ballhead (ds 34.3, tp 78.4), Greenhead (ds 27.8, tp 41.2), Green Winter (ds 27.8, tp 56.0), and Storage Green (ds 22.0, tp 35.2).

PLANT SCIENCE

Weed Control on Mineral Soil

Rutabaga (var. York). Preemergence (pre) applications of chlorthal (Niagara Chemicals), postemergence (post) applications of

CNP (Chipman Chemicals) and nitrofen (Rohm and Haas), and preplanting incorporated (ppi) applications of trifluralin (Eli Lilly), prynachlor (BASF), BAS-3921 (BASF), and R-7465 (Stauffer Chemicals) were used in these trials. Other treatments tested included trifluralin (ppi) + CNP (post), prynachlor (ppi + post), and prynachlor + BAS-3921 (ppi). Prynachlor at 4.5 kg active ingredient (ai)/ha and R-7465 at 3.4 kg ai/ha gave excellent weed control without reducing yields.

Direct-seeded cabbage (var. Houston Evergreen). Treatments were preemergence applications of prynachlor and chlorthal, postemergence applications of prynachlor and chlorthal, postemergence applications of CNP and nitrofen, and preplanting incorporated applications of trifluralin, BAS-3921, and R-7465. Other treatments tested included trifluralin (ppi) + CNP (post), prynachlor (pre + post), and prynachlor + BAS-3921 (ppi). Prynachlor at 4.5 kg ai/ha and R-7465 at 3.4 kg ai/ha gave outstanding weed control results without reducing yields.

Direct-seeded lettuce (var. Premier Great Lakes). Treatments included preemergence applications of sulfallate (Monsanto) and prynachlor, and preplanting incorporated applications of BAS-3921, trifluralin, and R-7465. Prynachlor at 4.5 kg ai/ha gave excellent weed control, but none of the lettuce plants emerged. R-7465 at 1.7 kg ai/ha also gave good weed control, but resulted in severe stunting of the crop. Sulfallate at 9.0 kg ai/ha did not cause crop injury, but gave only fair weed control compared with trifluralin and R-7465.

Forage Crops

Forage harvesting and preservation. In a systems approach to harvesting and storage methods, silage and hay produced on a peat soil were evaluated in a feeding trial with pregnant ewes. The forage was a reed canarygrass - timothy mixture that produced a direct-cut high-moisture silage (79% to 72%) with medium acidity (pH 5.2 to 4.4) and protein (9.5% to 9.2%) after 4 to 6 mo in storage. The hay was flue dried and stored at 13% moisture and 9.5% protein. Over a 2-mo period, ewes fed silage alone lost an average of 1.73 kg compared with gains of 0.53 kg for ewes fed equal parts by dry weight of hay and silage.

Formic acid was used as a silage preservative and a preliminary evaluation showed greater acidity (pH 3.8), less spoilage, and equivalent palatability compared with 1971 molasses silage. A tracked forage trailer, especially fabricated for this project and provided by the Division of Agriculture of Newfoundland, greatly increased the efficiency of silage and hay-making operations by allowing simultaneous cutting and hauling with a single tractor.

Alfalfa varieties. Over the 4-yr production period of a variety test seeded in 1968, Apex and Saranac have moved from the top yielding group ($P = 0.05$) to the second group, whereas Rhizoma rose from the lowest group to the top group and Nalfa 2 from the second group to the top group. These changes in relative yield position reflect stand depletion or relative longevity of the varieties. Nalfa 2 is a selection from the Experimental Farm, Nappan, N.S., whereas Rhizoma is an old variety, which is being superceded. If alfalfa production of any consequence is to develop in Newfoundland, it will be necessary to have varieties that are hardy under northern maritime conditions.

ENTOMOLOGY

Cabbage Maggot

Fonofos (Dyfonate 1.8 kg EC; Stauffer Chemicals), carbofuran (Furadan 2.2 kg F; Niagara Chemicals), BAS 2350 (20 EC; BASF Canada Ltd.), thionazin (Zinophos 1.8 kg EC; Cyanamid of Canada Ltd.) and fensulfothion (Dasanit 2.7 kg EC; Chemagro Chemicals) were tested at 1.7 and 3.4 kg ai/ha. Fonofos at the latter rate gave 100% control. Drench-type sprays were more effective than granules when applied at equivalent concentrations. The number of plants in the control plots was reduced by 51% by a heavy infestation of root maggots. Marketable yields ranged from 4.5 kg for the control plots to 53.1 kg for the more effective treatments.

Swede turnip seed pelleted with carbofuran (Furadan 75 WP and SP; Niagara Chemicals) at 240 and 320 g/100 g of seed gave excellent control (82% to 90%) of root maggots but, in some instances, caused up to 24% seedling reduction. Seeds pelleted at 80- and 160-g rates gave good control (60% to

84%) with less phytotoxicity. Activated charcoal applied to the seeds before pelleting reduced phytotoxicity, whereas finely ground peat did not.

Zoecon Sectar I yellow traps and CAB-MAGGOTTRACT II attractant caps (Zoecon Corporation, California) reduced root maggot infestation in swede turnips by 33%. Marketable yields were increased by 10.2%. Traps at 350/ha captured an average of 63.4 root maggot flies from August to November; the ratio of males to females was 1:1.7. Traps also captured a number of white cabbage butterflies, *Pieris rapae* L., diamondback moths, *Plutella xylostella* L., and aster leafhoppers, *Macrosteles fascifrons* (Stål).

Blow Flies

Diazinon (Basudin 50 EC; Ciba-Geigy Canada Ltd.) used as a 0.02% and 0.04% dip solution adequately protected sheep from blow fly, *Phaenicia sericata* (Mg.), attacks for a period of 86 days. In the control group, 30% of the animals were struck in what was considered to be a moderate infestation.

Samples of muscle, kidney, liver, fat, blood, and wool from the experimental animals were analyzed for diazinon residues. All tissue samples were free from diazinon (0.01 ppm in treated or control) except the fat, which contained 0.02 ppm at 6 wk. Blood samples had a maximum value of 0.088 ppm after 20 h and less than 0.02 ppm after 24 h. Wool retained from 48.8 ppm to 93.7 ppm after 3 wk, which decreased to 4.2 ppm to 7.55 ppm after 6 wk.

Golden Nematode

DPX 1410 (10 G and 0.9 kg EC; DuPont of Canada Ltd.), MOCAP (10 G; Pfizer Co. Ltd.), and aldicarb (Temik 10 G; Union Carbide Canada Ltd.) were field tested for golden nematode control. All treatments caused a decline in cyst populations; DPX 1410 10 G at 6.7 and 13.4 kg ai/ha showed a reduction of 25% and 21%. Larval populations of treated plots varied from 16 to 82 per sample, whereas untreated plots averaged 199. No detrimental effect from nematodes or beneficial effect from nematicide treatments was observed.

In crop rotation studies, plots continuously in potatoes since 1964 produced 60.4 kg compared with 82.2 kg for those in 3-yr rotations. There were substantial increases in cysts in the potato monoculture plots.

PLANT BREEDING AND PATHOLOGY

Potato Breeding for Resistance to Wart and Golden Nematode

The wart-resistant selection N48-237 was grown at several centers in demonstration and seed plots. Blackleg infections were observed in all plots and further evaluation of the susceptibility of this selection will be required before it can be named or licensed.

Three wart-resistant selections similar in skin color to Arran Victory were evaluated in a trial at the Station. A selection that was bred from Arran Victory, Ultimus, and an andigena hybrid had a similar yield to Arran Victory, but the dry matter content was lower. Two selections grown from seed produced at the Ontario Agricultural College, Guelph, gave greater yields than Kennebec but with a much lower dry matter content.

The nematode-resistant variety Wauseon was used as the control in a comparison of five nematode-resistant selections. Although two of these selections had a higher dry matter content, yields were substantially lower than that of the control. One promising selection gave yields and dry matter content equal to Wauseon, but tuber growth cracks eliminated its further use. The two remaining selections were both yellow fleshed; one was red skinned and the other white. Because it is wart resistant, trials of the latter will be continued although tuber numbers and small tuber size may be a problem.

Andigena selections resistant to race 8 of the wart organism have been selected for useful horticultural characteristics and will be used in future breeding. A higher susceptibility to tuber blight infection was noted in seedlings bred from Wauseon than in those bred from Ulster Glade and blight susceptibility remains a problem in the production of nematode-resistant seedlings.

Germination and Infectivity of Potato Wart Sporangia

Irrigation effect on wart development.

Increased periods of irrigation from initial planting of sprouted tubers in infested soil decreased the extent of infection; 1, 2, and 3 wk of irrigation produced 46%, 38%, and 26% infection. Frequency and percentage of infection followed each other closely, but soil temperatures governed the success of infections; the highest rate occurred when soil temperatures were lowest. The most interesting feature of this experiment was the low level of consistent infection, which was never more than 48%.

Chemical control. Benlate (50 WP; DuPont of Canada Ltd.) at three concentrations applied as preemergence and two postemergence dips, with repeat dips at 14-day intervals, failed to eliminate wart. Tests were carried out under standard conditions in a growth room where sprouted tubers were planted in an infested potting mix.

Germination of wart sporangia. There was some germination in fresh soil leachates, but none in soil at field capacity or saturated for 3 wk. Some germination took place in leachates of soil plus stems, tubers, roots, and leaves of Arran Victory. Mineral salts (Mg, Zn, Mo, B) and arginine, proline, and alanine failed to induce germination. No germination occurred in sterile distilled water. Galls themselves stimulated germination, but in such situations large numbers of sporangia were present whereas in the experimental assays only 2,000 sporangia/dish were used. Consequently, a comparison is difficult to make. Old sporangia were stimulated more than young sporangia, which reflects previous findings of better rates of infection with older sporangia. There were high levels of germination in water extracts of the flesh and stems of Arran Victory, but none in the tissues of resistant varieties. Germination appeared to increase with higher populations of sporangia, suggesting a mass effect. When germination does occur, it does so within 1–3 days of setting up the culture.

PUBLICATIONS

Research

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Research Station

Charlottetown, Prince Edward Island

PROFESSIONAL STAFF

L. B. MACLEOD, B.Sc. (Agr.), M.Sc., Ph.D.	Director
D. A. HUTCHINSON	Administrative Officer
B. STANFIELD, B.S.A., M.S.A., M.L.S.	Librarian

Cereal, Animal, and Tobacco Section

J. D. E. STERLING, B.S.A., M.Sc.	Head of Section; Breeding (barley)
H. W. JOHNSTON, B.Sc. (Agr.), M.Sc., Ph.D.	Diseases (cereal)
K. E. LELACHEUR, B.Sc. (Agr.)	Tobacco
H. G. NASS, B.S.A., M.Sc., Ph.D.	Physiology (cereal), breeding (wheat)
K. A. WINTER, B.Sc. (Agr.), M.Sc., Ph.D.	Nutrition (cattle)

Forage Section

C. B. WILLIS, B.Sc. (Agr.), Ph.D.	Head of Section; Diseases (forage)
W. N. BLACK, B.Sc. (Agr.)	Nutrition (pasture and corn)
U. C. GUPTA, B.Sc. (Agr.), M.Sc. (Agr.), Ph.D.	Micronutrients (soil and plant)
J. KIMPINSKI, B.S.A., M.Sc.	Nematology
H. T. KUNELIUS, B.Sc., M.Sc., Ph.D.	Physiology and management (forage)
J. H. LOVERING, ¹ B.Sc., M.A., Ph.D.	Economics (production)
J. A. MACLEOD, B.Sc. (Agr.), M.Sc., Ph.D.	Nutrition (forage and cereal)
J. A. MCISAAC, ¹ B.Sc.	Systems engineering
M. SUZUKI, B.Sc., Ph.D.	Biochemistry and physiology (forage)
L. S. THOMPSON, B.Sc. (Agr.), Ph.D.	Insects (forage, cereal, and vegetable)
R. P. WHITE, B.S. (Ed.), M.S., Ph.D.	Nutrition (corn and potato), soil chemistry

¹Seconded from Economics Branch.

Horticulture Section

J. A. CUTCLIFFE, B.Sc. (Agr.), M.Sc.	Head of Section; Nutrition and management (vegetable)
G. W. AYERS, B.Sc. (Agr.), M.Sc.	Diseases (crucifer and potato)
L. C. CALLBECK, B.Sc. (Agr.)	Diseases (potato)
J. A. IVANY, B.Sc. (Agr.), M.S., Ph.D.	Weed control (vegetable, forage, and cereal)
D. C. MUNRO, B.S.A., M.Sc.	Nutrition (potato and vegetable)
D. C. READ, B.Sc. (Agr.), M.Sc., Ph.D.	Pesticide bioactivity, insects (vegetable)

Departure

K. C. SANWAL, B.Sc., M.Sc., Ph.D. Resigned September 2, 1972	Nematology
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INTRODUCTION

The Research Station at Charlottetown has regional responsibility for research into the production of forages, cereals, tobacco, and vegetable crops grown for processing. Research is also conducted on local problems with potatoes, cattle nutrition and breeding, and small fruits. This report summarizes the results from selected research projects; further information on the results presented, or on other aspects of the research program, may be obtained from the Station or individual scientists.

During 1972, Dr. K. C. Sanwal, research scientist in nematology, resigned to return to India and was replaced by Mr. J. Kimpinski. In September 1972, Mr. J. A. McIsaac joined the Economics Branch and was seconded to the Station to work on problems of the choice and use of farm machinery and on systems engineering.

Closer coordination was effected to avoid unnecessary duplication of effort and to delineate regional responsibilities for research on forage and cereal crops at the research stations at Charlottetown and Sainte-Foy, Que.

On June 25, the cornerstone for the new office-laboratory complex at the Station was laid by the Hon. H. A. (Bud) Olson, Minister of Agriculture, during the annual convention of the Agricultural Institute of Canada. The staff of the Research Station of Agriculture Canada and of the Production, Extension, and Veterinary services of the Prince Edward Island Department of Agriculture and Forestry occupied the new complex in November.

Copies of this report and reprints of the scientific papers listed may be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I.

L. B. MacLeod
Director

CEREALS

Breeding and Testing

Barley. Barley selection AB 9-1 was immune to natural infestations of the barley jointworm, *Tetramesa hordei* (Harris). Yields of this selection were satisfactory, whereas all other varieties averaged three galls per culm and failed to produce seed in quantity. The selection was also resistant to *Ustilago nuda* (Jens.) Rostr. It is probable that a license will be applied for in 1973. Studies of the mechanism of resistance indicated that AB 9-1 reacts so strongly to jointworm attack that death occurs in the egg or young larva stage.

Based on results of regional trials, Loyola, a new six-rowed variety developed at Macdonald College, Que., has been added to the list of recommended varieties.

Floret sterility, particularly in two-rowed types, plays an important role in barley yield in the Atlantic Provinces and is given close consideration in the breeding program. The amount of sterility varies from season to season and from variety to variety. In some years, certain varieties have had 60% sterile florets. In 1972, Herta had 15% sterility,

whereas the recently licensed variety Volla had only 4% sterility.

Rye. Although there was considerable winterkilling of the recommended varieties Kustro and Dominant during the winter of 1971-72, two introductions from Finland, Jo 03094 and Ensi, had 70% survival and yielded 4,838 and 4,182 kg/ha respectively. Both varieties are very tall and breeding efforts have been started to reduce plant height but maintain hardiness and yield.

Winter wheat. A severe winter helped to identify winter-hardy germ plasm. The Russian variety Ulianovka had the greatest survival and will be used as a parent in breeding for hardy winter wheat.

Spring wheat. In regional yield tests, Ankra and a Kentville selection from Opal out-yielded Opal by 200 kg/ha. Transgressive segregation in crosses Pitic 62 × Opal and Inia 66 × Opal provided a few lines that have shorter, stronger straw and earlier maturity than the parents. Compared with Opal, the yield potential and kernel type are promising.

Oats. Scott, a yellow oat, has generally

outyielded Garry in several years of testing in Prince Edward Island and is now recommended to producers of the province. Because its recent performance has not been consistent, only small areas should be grown for evaluation in individual circumstances.

Cereal Nutrition and Management

Sources of P for barley. Coating Volla barley seed with P was not as effective as banding the P with the seed. Early growth and data on the uptake of P indicated that P from the coating was not available early in the season. Triple superphosphate banded with the seed gave highest yields and earliest maturity. Diammonium phosphate gave the greatest P uptake, but stand reduction resulted in lower yields.

Nitrogen for whole crop cereals. Applications of N up to 100 kg/ha increased dry-matter yields of Rosner triticale, Dorval oats, and Herta barley when they were harvested as whole crop cereals. The percentage of crude protein (CP) in whole crop cereals increased up to the highest rates of N (300 kg/ha); split applications (at seeding and at stem extension) increased CP more than a single application at seeding. Crude protein ranged from 5.1% to 6.2% for no N checks and from 10.6% to 13.6% for N at 300 kg/ha. Barley yielded the most CP. Nitrate concentrations in whole crop cereals remained below 0.16%, even at the highest rates of N. Lodging, however, was quite severe at the highest N rates of 200 and 300 kg/ha.

Mn decreases micronutrient uptake by barley. A concentration of 142 ppm Mn or less in barley tissue was associated with maximum yield and lack of toxicity. Concentrations of 190–600 ppm Mn in tissue were considered toxic and were associated with reduced yield and necrosis of leaves. Increasing the rates of Mn added to the soil decreased the tissue concentrations of Fe, Mo, and Cu but not B. Tissue of barley at the boot stage collected from various fields on Prince Edward Island contained 15–83 ppm Mn and were not in either the Mn toxicity or deficiency range.

Split application of N increases protein content of wheat. Increasing the rate of application of N from 45 to 90 kg/ha increased the protein content of Opal wheat from 12.4% to 13.3% when the additional N

was applied at seeding and to 14.3% when the additional N was applied 4 wk after seeding. Similarly, increasing the rate at seeding from 45 to 90 kg/ha increased the protein content of Ankra from 12.5% to 13.7%, whereas the application of 45 kg/ha 4 wk after seeding, in addition to the 45 kg/ha at seeding, increased the protein content to 14.9%.

Nutrient source influences damage from fertilizer drilled with the seed. In a greenhouse study, nutrient sources were compared for their effects on emergence of cereals when applied with the seed at rates equivalent to 56, 49, and 47 kg/ha of N, P, and K. Percentages of the seeds of barley, wheat, and oats that emerged 18 days after planting in a sandy soil were reduced from 82, 65, and 74 to 40, 38, and 25 when ammonium nitrate and triple superphosphate were replaced by urea and diammonium phosphate. The effects from using either urea or diammonium phosphate were intermediate.

Cultural practices. A rate of seeding study at 17.8 and 22.9 cm row spacing indicated that the recommended seeding rates for Opal wheat (134.5 kg/ha), Keystone barley (125.6 kg/ha), and Garry oats (100.9 kg/ha) are quite adequate.

A 2-wk delay in seeding beyond the first possible seeding date (May 27) in 1972 resulted in yield reductions of 1,388, 1,727, and 1,894 kg/ha for wheat, barley, and oats. Delayed seeding also decreased bushel weight and kernel weight; crop maturity was delayed by 7–10 days.

Physiology. An analysis of the grain filling period of 10 spring wheat varieties showed that the highest yielding varieties, Ankra and Opal, had a rapid rate of grain filling coupled with a long filling period.

Winter injury to winter wheat. Only 24% of the winter wheat plants on Prince Edward Island survived the winter of 1972. The plants lost vitality gradually throughout the winter. Of the cultivars tested, WW 1001-1 maintained the highest vitality followed by Yorkstar, Talbot, and Genesee.

Diseases of Cereals

Surveys of oat fields in the Charlottetown area revealed an average of less than 2% barley yellow dwarf infection in 1972; severe damage was restricted to a few late-seeded

fields. Yields from plots treated with granular disulfoton were 10% higher than those from check plots.

Early seeding was found to be an effective means of reducing pathogenic leaf lesioning on barley, oats, and wheat and of increasing yield. Severity of leaf lesioning on the May 18 seeding was 50% lower than on the June 8 seeding. Seeding with conventional equipment when soil conditions were ideal gave better yields than seeding earlier with an all-terrain vehicle on wet soil.

Seed treatment with ethirimol (Milstem; Chipman Chemicals Ltd.) gave the best control of powdery mildew on wheat. The severity of mildew was greatly reduced because winter wheat did not survive sufficiently well to permit a good carry-over of mildew spores.

Barley varieties that are intermediate in their reaction to *Cochliobolus sativus* (Ito & Kurib.) Dreschl. ex Dastur. responded to Vitaflo (UniRoyal Chemical) seed treatment with increased yields. Varieties that are highly susceptible or have resistance did not respond.

FORAGES

Nematology

Nematodes associated with forage legumes. Nine genera of potentially plant-parasitic nematodes are associated with alfalfa, red clover, and birdsfoot trefoil in Prince Edward Island. All the samples collected contained the root-lesion nematode; 87% the pin nematode; 81% the root-knot nematode; 73% the stunt nematode; 73% the ring nematode; 71% the cyst nematode; 65% the spiral nematode; 5% the dagger nematode; and 3% the needle nematode. The high frequency of occurrence and population densities in both soil and root samples indicated that root-lesion and root-knot nematodes may be the most economically important in forage production.

Nematode control. Soil drenches with DuPont 1410 at 3.36 and 6.72 kg/ha at seeding and foliar sprays at 1.9 and 3.8 g/litre at 4 wk after seeding gave significant control of *Pratylenchus penetrans* (Cobb) Filip. & Stek. and increased foliage and root yields of Leo birdsfoot trefoil in the greenhouse. A soil drench of 3.36 kg/ha at seeding plus foliar sprays of 1.9 g/litre at 4 and 8 wk after

seeding reduced nematode numbers by more than 99% at 16 wk after seeding and increased foliage and root yields by 74% and 73%. Significant negative correlations were observed between nematode numbers and plant yield.

Preplant, broadcast applications of granular Namacur (Chemagro Corp.) in the field reduced root-lesion nematode numbers substantially in soil and in Leo birdsfoot trefoil roots, and resulted in forage yield increases of 20% in the seeding year. A supplementary application in the spring of the year after seeding resulted in no further yield increases when compared with plots that had not received the supplementary treatment. DuPont 1410 applied three times as a foliar spray in the seeding year resulted in a slight reduction in nematode numbers and a slight yield increase. When applied as a foliar spray every 3 wk the next year, yields were increased 10% over untreated plots.

Nematode reproduction on forage legumes. A mixed population of *Pratylenchus* spp., *Paratylenchus* spp., and *Meloidogyne hapla* Chitwood reproduced at different rates on Leo birdsfoot trefoil in the greenhouse, but reproduction was not influenced by applications of N at 0, 20, 40, and 80 ppm to the soil at seeding. Over a 6-mo period, *M. hapla* increased by 25 \times , *Pratylenchus* spp. by 34 \times , and *Paratylenchus* spp. by 185 \times .

Reproduction of *Pratylenchus* spp. on alfalfa in the greenhouse was not affected by applications of P at 0, 50, 100, and 200 ppm mixed with all soil prior to seeding. Nematode reproduction was not affected by banding 100 ppm P 4 cm below the seed, nor by coating the alfalfa seed with lime or lime + P.

Nematodes and fungi on birdsfoot trefoil. Air drying, steam sterilization, methaphenamiphos applications, and methyl bromide fumigation of a soil significantly reduced *P. penetrans* numbers and increased birdsfoot trefoil forage and root yields in the greenhouse. Air drying and Namacur did not reduce *Fusarium* spp. infections of rootlets; however, yield increases were as great as with steam sterilization and methyl bromide fumigation, which completely controlled both nematodes and fungi. These results indicated that *Fusarium* spp. infections did not affect plant yields under greenhouse

conditions over the observed period of 26 wk.

Effect of nematicides on fungi in vitro. The nematicides Nematicur, fensulfothion, and DuPont 1410 at concentrations that controlled nematodes in the greenhouse and field did not inhibit in vitro growth of fungi normally associated with the forage legume root rot complex. Inhibition of 22 fungus isolates was not evident at 10 ppm and was slight to moderate at 100 ppm. Isolates of *Rhizoctonia solani* Kühn were inhibited at lower nematicide concentrations than were isolates of the other five fungus genera.

Nutrition

Phosphorus placement for forage establishment. Increases in yields of alfalfa in the seeding year were 300–400 kg/ha greater from band than from broadcast applications of P at rates of 25–100 kg/ha. With brome-grass, increased yields from banded over broadcast P were 215–580 kg/ha. With both crops, the advantage of banding was greatest when P was applied at 50 kg/ha. Banding of P may also be important in minimizing competition from weeds because of the rapid establishment of the crop canopy.

Boron requirement of forage crops. Maximum yields of red clover, alfalfa, and birdsfoot trefoil were obtained in the greenhouse when B at 0.25–1.0 ppm was added to the soil. There was a B × lime interaction on birdsfoot trefoil and red clover, so that much higher yields occurred with high rates of lime and B. Levels of 4–9 ppm B in the leaf tissue of the three legumes were in the deficiency range. Boron concentrations of 21–45, 39–52, and 30–45 ppm in red clover, alfalfa, and birdsfoot trefoil, respectively, were indicative of sufficiency and were associated with maximum yields. Sufficiency levels of soil B for legumes appeared to be related to pH because B deficiency was more severe when the pH was high.

Evaluation of magnesium sources. In a greenhouse experiment various Mg sources, in addition to adequate N, P, K, and S, were mixed with an acid soil to supply 50 ppm Mg. The mean uptake of Mg in mg/pot for three cuts of ryegrass were: check, 1.27; coarse dolomitic grits, 1.32; commercial MgO source, 1.40; finely ground dolomitic limestone, 2.07; $K_2Mg(SO_4)_2$, 2.12; and $MgSO_4$, 2.43. Neither the grits nor the

commercial MgO source supplied any significant amount of Mg to the plants.

Susceptibility of forages to NH_4^+ -N. Growth of alfalfa, birdsfoot trefoil, red clover, orchardgrass, timothy, and wheat was less when high concentrations of N in nutrient solutions were supplied as NH_4^+ rather than NO_3^- . The effect of NH_4^+ -N on decreasing growth was greater on legume than on grass species except timothy. Although the decrease in growth was least with orchardgrass and wheat, the highest concentration of NH_4^+ -N was obtained in the vegetative tissue of wheat (0.12%). The highest concentration of NH_4^+ -N in other species was 0.03–0.06%. The maximum NO_3^- -N concentration was highest in orchardgrass (0.76%) followed by timothy (0.42%) and wheat (0.29%). Concentrations of NO_3^- -N in other crops were below 0.2%.

Corn nutrition. Removal of K over a 3-yr period by silage corn ranged from 278 kg/ha on plots that received no K to 363 kg/ha on plots that received 744 kg/ha at the beginning of the 3-yr period. No further K was supplied during this experiment. The amount of K determined in the check plots decreased from 176 to 121 kg/ha, whereas in the plots fertilized with 744 kg/ha it decreased from 650 to 167 kg/ha in the 3 yr. No yield responses occurred from the application of K, but yields of the check plots appeared to decline in the third year. Maintenance applications of K seem to be required on corn, in spite of the lack of yield responses, to prevent serious depletion of K in the soil.

Physiology and Management

Winterkill of forage legumes and grasses. Surveys conducted during the winter and spring of 1971–72 in Prince Edward Island showed that 80% or more of the red clover, alsike clover, alfalfa, and orchardgrass plants were killed or injured in most areas. Birdsfoot trefoil and brome-grass sustained less damage. Timothy was the hardiest crop, but it did not escape. Lethal damage to individual species occurred at different times; clovers were killed in February or earlier, alfalfa in April, and birdsfoot trefoil in May. Grass species lost vitality gradually throughout the winter and were dead by June. In spite of extensive damage, there was

little injury from frost heaving, a major cause of winterkill in the past.

Time-lapse photography for unattended, continuous observation. Time-lapse photography was used to record growth, development, and dormancy patterns of Champ timothy and Tardus orchardgrass grown in a growth chamber under controlled environmental conditions simulating day and night temperatures and day lengths for Prince Edward Island. An 8-min film was produced that showed plant growth for 15 continuous months including the seeding year, overwintering, and part of the second year. Time-lapse photography proved to be a useful method for exhibiting physiological characteristics of the two species that had hardly been recognized by conventional, intermittent observations.

Pure forage species vs. a mixture for grazing. The productivity and persistence of three grasses, and a mixture of Climax timothy, early red clover, alsike clover, and alfalfa, seeded in 1967, were measured for 4 yr (1969–72) under careful grazing management. Each type of sward was subjected to seven different fertilizer treatments annually. P at 79 kg/ha and K at 149 kg/ha were applied in early spring, and N at 0–280 kg/ha in two to four split applications during the growing season. On the basis of all fertility treatments, Frontier reed canarygrass outyielded Saratoga brome grass, Champ timothy, and the mixed sward. Reed canarygrass and brome grass, both deep-rooted species, proved to be more productive than the shallower-rooted species from mid-September to the end of the grazing season. Annual split applications of N at 224–280 kg/ha maintained seasonal production at satisfactory levels; persistence in the grasses was best where N at 56 kg/ha was applied in early spring. Even with economic rates of fertilization and careful grazing management, Kentucky and Canada bluegrass, brown top, and weeds infiltrated all swards.

Formic acid improves quality of direct-cut silages. An application of formic acid at 6 litres/t to direct-cut orchardgrass and alfalfa–timothy forages resulted in an improved quality as compared with untreated silages. The pH, percentage of NH_4^+ -N, and butyric acid of treated silages were lower than those of untreated silages. The treated silages were also more readily consumed by

growing heifers and had a more acceptable odor than the untreated silages.

Weed control for alfalfa establishment. Fourteen herbicide treatments were evaluated for the control of broadleaf weeds and quack grass in Saranac and Iroquois alfalfa. Fair control of broadleaf weeds with no alfalfa injury was obtained with preplant incorporation applications of EPTC at 3.36 kg active ingredient (ai)/ha and trifluralin at 1.12 kg ai/ha. Dalapon applied postemergence at 3.36 kg ai/ha gave excellent control of quack grass. A postemergence application of carbetamide at 4.48 kg ai/ha gave excellent broadleaf weed control. A postemergence application of 2,4-DB at 0.57 litre ai/ha also gave excellent control of broadleaf weeds but caused some early, short-lived alfalfa injury. A postemergence application of 2,4-DB at 0.45 litre ai/ha plus dalapon at 3.36 kg ai/ha gave excellent control of broadleaf weeds and quack grass. This treatment caused more injury than either chemical alone and yields were reduced, but plant recovery was good. Severe alfalfa injury and poor weed control were obtained with postemergence applications of bromoxynil at 0.19 litre ai/ha, MCPB at 0.19 litre ai/ha, and paraquat at 0.056 litre ai/ha; and with a preemergence application of asulam at 2.24 kg ai/ha.

Corn seeding dates and plant populations. Reductions of 11%, 12%, and 33% in silage yield and 11%, 19%, and 34% in percentage of dry matter content at harvest were recorded for corn planted at 10-day intervals after the first planting on May 27. Temperatures of the upper 5 cm of soil had not reached 10°C before May 27. The dry matter in the grain component also was decreased by 16%, 25%, and 65% with the later plantings.

Silage yields were not significantly different at plant populations of 54,500, 69,000, and 79,000 plants/ha, but the dry matter content decreased slightly at the higher populations. A lower yield was recorded at 39,500 plants/ha than at 54,500 plants/ha.

Sources of nitrogen for corn. Plant growth after 42 days, silk emergence, and final yield data indicated that diammonium and monoammonium phosphate applied in a band 5 cm to the side and 5 cm below corn seed to provide N at 56 or 112 kg/ha were better sources than ammonium nitrate, which was

better than urea. Urea retarded growth in the early sampling. Both rates of N gave similar results.

Minimum tillage for corn. Corn farmers can save both time and money in spring land preparation by reducing tillage operations. Silage production on corn-stubble land with minimum tillage practices was equal to, or better than, that obtained by current farmer practices. Planting immediately after spring plowing with a revolving blade tiller towed directly behind the plow gave yields as good as did fall plowing followed by one discing plus two harrowings in the spring. Fall plowing plus one pass in the spring with a power harrow, which was very effective in removing quack grass, yielded better than the same operation followed by three passes with a disc.

Quack grass control and rate of various oils in field corn. Postemergence applications of atrazine in combination with oil gave better control of quack grass in field corn (Pride 109) than atrazine alone. Control with atrazine alone at 2.8 kg/ha was 25%, whereas this rate plus Atroil (Fisons Canada Ltd.) at 9.35 litres/ha gave 42% control. Atrazine alone at 5.6 kg ai/ha gave 60% control, whereas two applications of atrazine at 2.8 kg ai/ha plus Atroil at 9.35 litres/ha applied 2 wk apart gave 80% control.

Oils at 1.17, 2.34, and 9.35 litres/ha were evaluated for phytotoxicity to field corn (Haapala 175 and Stewarts 2300) when used in combination with atrazine at 2.24 kg ai/ha. In general, it was found that the greater the content of surfactant in the oil the greater the chance for corn injury as the oil rate was increased. Tronic (Fisons Canada Ltd., 100% surfactant) was safe only at 1.17 litres/ha and gave phytotoxicity at the two higher rates. Corn Oil Concentrate (Chipman Chemicals Ltd.) and Booster Plus (Green Cross Products, 16% to 17% surfactant) showed little or no phytotoxicity at 2.34 litres/ha, but noticeable injury at 9.35 litres/ha. The corn recovered rapidly and appeared normal 3 wk later. Co-op Oil (Inter-provincial Co-operatives Ltd.) and Korn Oil (Shell Canada Ltd., 1% to 2% surfactant) showed only slight phytotoxicity at 9.35 litres/ha, but recovery was rapid and the corn appeared normal 2 wk later.

Herbicide residues. Only minor reductions were observed in the germination and growth

of alfalfa, timothy, brome grass, red clover, and rutabagas planted on plots that had received atrazine at 2.2 kg ai/ha sprayed on corn the previous year. Potatoes, field peas, wheat, barley, and oats showed no apparent effects. At a 5.6 kg/ha rate, stand and yield reductions on all crops were observed, and reductions were severe at the 7.8 kg/ha rate. At the 5.6 kg rate, potato yields were reduced by 10% compared with the control.

HORTICULTURAL CROPS

Potato Nutrition and Management

Potato nutrition. Netted Gem and Sebago potatoes gave maximum yields with N at 135 to 157 kg/ha. Nitrogen had no significant effect on specific gravity of tubers but did increase the percentage of A-size tubers. Applications of P at 30–60 kg/ha were adequate for both varieties. The specific gravity and the percentage of A-size tubers were not affected by the rate of applied P. Acid-soluble plus adsorbed P (Bray method) in the soil was 190 ppm. Exchangeable K in the soil was 155 ppm and there was no yield response to applied K. However, increasing fertilizer K from 0 to 225 kg/ha decreased tuber specific gravities from 1.087 to 1.080 for Netted Gem potatoes and from 1.082 to 1.072 for Sebago.

Paraquat timing on potatoes. Paraquat was applied at 1.12 kg ai/ha at ground crack, when 10–30% of potato shoots had emerged, and when 100% of shoots had emerged on Sebago and Netted Gem potatoes. There was little difference in yield between the first two timings on either variety. When the application was delayed until 100% of potato shoots had emerged, yields of Sebago table stock were reduced 15% below hand-weeded controls and 15% below the plots treated at ground crack. With Netted Gem, the table stock yield from application when 100% of the shoots had emerged was 30% below hand-weeded controls and 24% below the plots treated at ground crack. Early application of paraquat is obviously necessary for maximum yields.

Potato top killers. Potato top killers whose active ingredient is dinoseb are now being formulated so that the addition of a petroleum oil to the mixture is not necessary. This is a distinct advantage, because the adding of

oil involved the risk of tubers being off-flavor. Diquat has given good kills and is particularly useful for application by aircraft.

Potato Disease Control

Promising potato varieties and seedlings were assessed for resistance to *Fusarium sambucinum* Fckl. f. 6 Wr., *F. coeruleum* (Lib.) Sacc., *Phoma tuberosa* Melhus, Rosenb. & Schultz, and *Verticillium albo-atrum* Reinke & Berth. The variety Dorita proved to be immune to decay caused by *F. coeruleum* and highly resistant to decays caused by *F. sambucinum* f. 6 and *P. tuberosa*. Dorita also showed moderate resistance to wilt caused by *V. albo-atrum*. The variety Wauseon showed high resistance to wilt and fusarium (*F. coeruleum*) decay, whereas the seedlings F59045 and F65089 proved highly resistant to wilt. The systemic compounds benomyl 10% dust and thiophanate-methyl 5% dust, when applied to cut seed at 10 g dust/kg seed, were highly effective in the control of seed-borne verticillium wilt and fusarium decay of seed pieces. Similar control was achieved with these chemicals in 1971 and there was no evidence of phytotoxicity in either year of testing.

The screening of fungicides for the control of late blight caused by *Phytophthora infestans* (Mont.) de Bary indicated that Bravo 6F (Diamond Shamrock Corporation), a captafol (Difolatan 4.8F; Chevron Chemical Co.), maneb, mancozeb, and metiram (Polyram) will continue to be recommended. Cupric hydroxide (Kocide 101) and fentin hydroxide (Du-Ter) showed marked phytotoxicity.

A prediction method has been developed for estimating tuber yield losses caused by late blight disease. The percentage yield loss can be calculated for any given foliage blight progress curve.

In 2 yr of testing, potato seedling F66077 has shown very high resistance to infection by the late blight fungus, even when subjected to a complex of races 1 to 9.

Vegetable Nutrition and Management

Effect of N, P, and K on cauliflower yields. In experiments conducted at three locations in 1972, broadcast applications of N and P increased the yields of cauliflower, whereas applications of K had much less effect. Optimum yields were obtained where N was applied at 112 kg/ha, P at 49–98 kg/ha, and

K at 93 kg/ha. These results are in keeping with those of earlier experiments with Brussels sprouts and broccoli.

Effect of spacing and N on incidence of hollow stem in broccoli. Both plant spacing and applications of N affected the incidence of hollow stem in trials conducted over a 3-yr period. Plants grown at 22 × 22 cm and closer had very little hollow stem at any level of N. However, as plant spacing increased beyond 22 × 22 cm, hollow stem progressively increased to a high of 90–100% at 46 × 46 cm. At plant spacings greater than 22 × 22 cm, N applications of 90, 180, and 270 kg/ha resulted in 34%, 48%, and 52% hollow stem.

Liming affects B requirement of rutabagas. Field and greenhouse studies indicated that brown heart was more severe at a high soil pH than at a low pH under B deficiency conditions. Application of lime did not decrease the hot-water-soluble B content of the soil, but generally decreased the concentrations of B in leaf tissue. No brown heart was noted in roots grown on soil containing more than 1.3 ppm available B at a soil pH of 5.8–6.8 or at 1.0 ppm available B at soil pH of 5.3.

New clubroot-resistant turnip-rutabaga hybrid. In 1971, the Station reported the development of a purple-topped rutabaga strain with greater clubroot resistance than the variety York. This strain was obtained by selection for top color and clubroot resistance from a cross between the varieties Wilhelmsburger and York. In 1972, this strain was crossed with plant progeny from a cross between Gelria R turnip and York rutabaga. The Gelria R turnip was known to be resistant to clubroot races 1, 2, and 3, whereas York rutabaga had known resistance to races 2 and 3. Progeny from the 1972 cross was planted at Nappan, N.S., in an area highly infested with race 1 of the clubroot pathogen and 67% of the roots showed no evidence of clubbing in stock grown to full maturity. Control plantings of Wilhelmsburger, York, and the 1971 Wilhelmsburger × York hybrid became completely clubbed. The turnip-rutabaga hybrid proved homozygous for yellow flesh and most roots were purple topped. This is the only known rutabaga-like crucifer that has been developed with resistance to race 1.

Further work is required to develop quality and homozygosity for resistance.

Factors affecting germination of shepherd's-purse and corn spurry. Greenhouse experiments showed that shepherd's-purse germinated best when seeded on the soil surface and germination decreased to nearly zero as seeding depth was increased to 2.5 cm. Corn spurry was affected little by depth of seeding and showed only a slight decrease in germination when seeded at 2.5 cm. Germination of both species was increased two or three times by the addition of 0.2% or 0.5% KNO_3 , indicating that infestation with these weeds would be more severe in soils heavily fertilized such as for vegetable production. With K_2HPO_4 , corn spurry germination was inhibited at concentrations of 0.2% and 0.5%, whereas shepherd's-purse was little affected. Scarification of shepherd's-purse seed with sandpaper doubled the germination rate and increased the total germination by 50%.

Effect of lime on white bean yields. Bean yields were substantially increased by applications of lime to an acid soil (pH 5.0). Both Seaway and Sanilac produced about 2.1 t/ha in 1972 where dolomitic limestone had been applied at 2.24 t/ha as early spring applications in 1971 and 1972. Where the limestone was applied at 4.48 t/ha each spring, the yields of both cultivars were about 2.4 t/ha. Where no lime was applied, the yields of Seaway and Sanilac were 1.0 and 0.8 t/ha.

Control of Soil Insects

Biotoxicity and detoxification of insecticides. Placement of insecticides on the soil surface, mixing commercial formulations into the upper layers of soil, or banding applications below the soil surface may greatly influence the rate of release of toxic metabolites into the microenvironment as well as the subsequent degradation. For compounds such as parathion and chlorpyrifos, the bioactivity period lasted from about a week for surface applications to several months for subsurface band treatments. Residual organophosphorus insecticides, such as fonofos or trichloronat, were bioactivated and degraded to nontoxic compounds within 2 or 3 wk when applied to foliage or to the soil surface and in about 5 to 7 wk when mixed into the upper 2 or 3 cm of

surface soil. However, when these compounds were banded 3 to 4 cm below the soil surface, the bioactivation was so slow that toxicants did not destroy insects in the soil during the year of application and residues persisted for at least 2 yr. Also, toxic compounds were slowly absorbed by plants during the growing season and very slowly degraded by the crops in storage. Toxicants of a new insecticide, AC 92100 (Cyanamid of Canada Ltd.), were readily absorbed by cruciferous crops.

TOBACCO

Boron levels in flue-cured tobacco. A survey of tobacco produced after varying applications of P and K showed tissue levels of B that are considered normal in other tobacco-producing areas. Applications of P were varied from 0 to 896 kg/ha and of K were varied from 0 to 448 kg/ha without affecting B concentrations significantly. The amount of B in the tissue increased slightly with higher stalk positions of leaves. Sand leaves contained 23–30 ppm B, cutter leaves 21–33 ppm, body leaves 23–40 ppm, and tip leaves 26–54 ppm. There was no evidence of B toxicity to the plant at the highest recorded tissue levels.

Tobacco cutworms. Tobacco that follows sod, plowed the previous summer, has been most susceptible to attack by the redbacked cutworm. Moderate to severe infestations were controlled with a spray treatment of a compound such as chlorpyrifos applied about June 20. The black cutworm has caused the most severe damage to tobacco in Prince Edward Island. Areas with protective snow cover and low to moderate soil moisture permitted a high winter survival of this insect. Further studies are required on the ecology of the black cutworm before adequate control measures can be recommended.

CATTLE NUTRITION

Cull potatoes for steers. Crude protein provided at 101%, 111%, or 135% of NRC requirements for growing steers on a diet of potatoes fed free choice plus 1 kg of hay per day and 1 kg of supplement did not affect animal performance. The average intake of potatoes during the 16-wk feeding period

was 11.1% of body weight. The average daily gain was 1.2 kg and the feed conversion efficiency averaged 5.4 kg of dry matter per 100 kg of gain. It was concluded that dietary crude protein fed to meet NRC requirements is adequate for growing steers on a potato ration.

Selenium content of feedstuffs. Timothy, red clover, barley, and oat samples from a

number of locations in Prince Edward Island were analyzed for Se content and the average values in ppm of dry matter were: timothy, 0.008; red clover, 0.012; barley, 0.016; and oats, 0.021. All the samples contained less than 0.10 ppm, which is the amount required in a ration to prevent deficiency problems. These data indicate a high risk of selenium deficiency in livestock fed on home-grown feeds in all parts of Prince Edward Island.

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Research Station Kentville, Nova Scotia

PROFESSIONAL STAFF

Administration

J. R. WRIGHT, B.Sc. (Agr.), M.S., Ph.D., F.C.I.C.	Director
J. S. LEEFE, B.S.A.	Assistant Director
K. M. CARTER, B.Com.	Administrative Officer

Chemistry

R. F. BISHOP, B.Sc., M.Sc., Ph.D.	Head of Section: Soil fertility
C. R. BLATT, B.Sc., M.S., Ph.D.	Plant nutrition
D. CHISHOLM, B.Sc.	Insecticide chemistry
C. R. MACEachern, B.Sc.	Soil chemistry
M. T. H. RAGAB, B.S., M.S., Ph.D.	Herbicide chemistry
D. K. R. STEWART, B.Sc., B.A., M.Sc., Ph.D.	Fungicide chemistry
L. R. TOWNSEND, B.A., B.Sc.	Plant chemistry

Entomology

A. W. MACPHEE, B.Sc. (Agr.), M.Sc., Ph.D.	Head of Section: Insect ecology
K. P. BUTLER, B.A.	Insect ecology
H. J. HERBERT (Miss), B.Sc. (Agr.)	Mite investigations
C. R. MACLELLAN, M.C., B.Sc. (Agr.), M.A.	Ecology of the codling moth
W. T. A. NEILSON, B.Sc., M.Sc.	Apple maggot investigations
D. J. PREE, B.S.A., M.Sc., Ph.D.	Toxicology
K. H. SANFORD, B.Sc. (Agr.), M.Sc.	Integrated control
H. B. SPECHT, B.Sc. (Agr.), M.S., Ph.D.	Vegetable insects

Food Technology

R. STARK, B.Sc., Ph.D.	Head of Section: Food processing
W. G. SIMPSON, B.S.A., M.S.	Food processing

Plant Pathology

R. G. ROSS, D.F.C., B.Sc. (Agr.), M.Sc., Ph.D.	Head of Section: Tree fruit diseases
C. O. GOURLEY, B.Sc. (Agr.)	Vegetable and small fruit diseases
C. L. LOCKHART, B.Sc. (Agr.), M.Sc.	Fruit and vegetable storage diseases

Plant Physiology

F. R. FORSYTH, B.A., Ph.D.	Head of Section: Postharvest physiology
P. A. POAPST, B.Sc., B.Sc. (Agr.)	Postharvest physiology
D. H. WEBSTER, B.Sc., M.Sc., Ph.D.	Tree fruit physiology

Poultry

F. G. PROUDFOOT, B.Sc. (Agr.), M.S.	Head of Section: Genetics
A. C. COX, B.S.A., M.Sc., Ph.D.	Physiology

Small Fruit and Ornamentals

D. L. CRAIG, B.Sc. (Agr.), M.S., Ph.D.	Head of Section: Plant breeding
L. E. AALDERS, B.Sc., M.Sc., Ph.D.	Cytology and genetics
I. V. HALL, B.Sc. M.Sc., Ph.D.	Ecology and physiology

Tree Fruit

A. D. CROWE, B.Sc. (Agr.), M.Sc., Ph.D.	Head of Section: Tree fruit breeding
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Weeds, Vegetables, and Project Farms

J. S. LEEFE, B.S.A.	Head of Section: Weed control
E. W. CHIPMAN, B.Sc. (Agr.)	Vegetable crops
G. G. SMELTZER, B.Sc. (Agr.)	Forage and pasture crops

Experimental Farm, Nappan

T. M. MACINTYRE, B.Sc. (Agr.), M.Sc.	Superintendent: Livestock management and nutrition
F. W. CALDER, B.Sc. (Agr.), M.S.	Pastures and forage physiology
L. P. JACKSON, B.Sc. (Agr.), M.S.	Soil fertility and crop management—blueberries
J. E. LANGILLE, B.Sc. (Agr.)	Cereal and forage crops

Departures

C. A. EAVES, B.S.A., M.Sc., F.A.I.C.
Retired Feb. 29, 1972

Head of Plant Physiology Section

P. R. DEAN, B.Sc.
Resigned Feb. 1, 1972

Food processing

INTRODUCTION

This publication is a summary of the main research results for 1972 of the Research Station at Kentville and the associated Experimental Farm at Nappan. Mr. C. A. Eaves retired after 35 years of leading the fruit and vegetable storage research at the Station.

Copies of this chapter of the Research Branch Report, 1972 and reprints of the listed scientific papers are available on request from Research Station, Research Branch, Canada Department of Agriculture, Kentville, Nova Scotia.

J. R. Wright
Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Lowbush Blueberries and Cranberries

Blueberry plants that were started as seedlings produced more and longer shoots of smaller diameter than plants started as cuttings. The two types produced about the same quantity of fruit. Twenty-five plants, propagated in each way in 1966, were set in the field in 1967 to compare the growth habits of the two kinds of plants.

Injury to plants and to fruit development of lowbush blueberries in 1971 was found to be due to subfreezing temperatures, which occurred several times during the sensitive growth period immediately after flowering and pollination. The number of plump seeds per berry was negatively correlated with subfreezing temperatures and positively correlated with fruit yield.

Experiments were carried out to determine the optimum time to harvest lowbush blueberries. The yield of ripe fruit was not reduced appreciably in years of above normal heat by picking 5 days earlier than the normal date in the industry. Early picking increased the proportion of green fruit slightly, but the tougher skin of the earlier picked ripe berries resulted in a higher proportion of whole fruit in processed products.

Anthocyanin formation in cultivated cranberries at a low light intensity of 2.58×10^4 lm/m^2 was enhanced by decreasing temperatures. Plants of the cultivar Stevens that received 12.8°C in the light and 7.2°C in the dark had darker red leaves than those receiving 18.3°C (light) and 12.8°C (dark). Plants subjected to 23.9°C (light) and 18.3°C (dark) had green leaves. Detached berries of this cultivar also had the greatest color

development (as measured by a color meter) and the greatest anthocyanin concentration under the coolest conditions. Both of these decreased as the temperatures increased.

Cranberry plants injured by frost had fewer later developing primordia than the normal ones. The flower primordia in Stevens developed earlier and were more vigorous than those in the native selection. The development of flower primordia in a native selection was similar to that reported for the cultivated cranberry, *Vaccinium macrocarpon* Ait., in Wisconsin.

Highbush Blueberries

Ammonium sulfate had more effect on plant characteristics than superphosphate, KCl, or $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ in a 6-yr experiment. The application of $(\text{NH}_4)_2\text{SO}_4$ was associated with decreased yields and bush size in each of 4 yr, with decreased fruit size in 2 of 3 yr, and with increased winter injury in 2 of 4 yr. This treatment increased leaf N in each of 6 yr but decreased leaf Ca in 3 of 6 yr. Regression equations showed leaf Ca, bush size, and winter injury to be the most important variables that affect yield. Fruit size is influenced most by leaf N and bush size.

Strawberries

Bounty, a new strawberry cultivar, was released. It is high yielding, tolerant of many of the common strawberry diseases, attractive in appearance, and suitable for both the fresh-fruit and processing markets. The fruit reaches maturity 8–10 days later than Red-coat, which is the principal strawberry cultivar grown in the Atlantic region. The Station distributed limited quantities of plants in

1972 to local nurserymen and selected growers. Nurserymen will have plants for sale in 1973.

Apples

The "scaffold renewal" system of pruning apple trees has given promising results. A high density planting of 1,480 trees/ha produced 50% more apples than a planting of 370 trees/ha. The tree density experiments indicated that biennial bearing may be more of a problem in a high density planting.

A combination of triiodobenzoic acid (TIBA) and succinic acid 2,2-dimethyl hydrazide (Alar; UniRoyal Chemicals) on apples at half strength increased the yield per tree by 50% to 11 kg per tree with McIntosh and 100% to 9 kg per tree with Lobo. There was no critical concentration below which a response to Alar was absent.

Pears

Fourteen new cultivars were added to the Station's collection and 1,045 seedlings from the pear breeding program were field planted.

Vegetable Crops

Greenhouse experiments were conducted to determine the direct and interaction effects of pH on the growth and Mn and Fe content of carrots grown on an acid sphagnum peat soil.

The highest content of Mn in carrot tops occurred at pH values of 4.4 to 5.0 and the lowest at pH 6.2 and 6.4. The Mn content was lower at pH 4.0 than at pH 5.0. There was a significant interaction of pH and Mn on the Mn content of tissues. At a low pH, high rates of applied Mn increased the Mn content of tissue several times more than it did at a high pH. Bronze-colored symptoms on carrot leaves appeared when the Mn content of tops was more than 2,600 ppm. Such symptoms were associated with lower yields of carrots when the Mn content of tops exceeded 8,000 ppm. This reduction in yield was also associated with low pH and a high water-soluble Mn content of 37 ppm or 5% of total Mn in the peat soil obtained after the harvest of carrots. When no Mn or 100 ppm was added, the water-soluble Mn content was 0.6–3.0 ppm. The Mn content of roots varied from 133 to 236 ppm. The Fe content of tops was lower at pH 4.1 than at higher pH values. The extraction of plant ash by

H₂SO₄ for directly determining Mn from the extracts was rapid and highly satisfactory.

Field Crops

Corn cut for silage in mid-September had the best feeding value. Corn cut earlier had a lower feeding value but a higher value than frozen corn cut in late October. The three cuts of silage were fed to Hereford steers to assess feeding value by weight gains.

Kustro, a new high-yielding variety of winter rye, was introduced in Nova Scotia in 1969. As a result of performance tests carried out at Kentville and Nappan a Canadian license (no. 1337) was granted. The variety has proved to be winter hardy in western Nova Scotia, but more testing is required before it can be recommended for central and northern New Brunswick.

Soils

In 69 samples of surface soil (0–15 cm), representing nine soil series, the total Zn was 14–108 ppm. The amount extractable with 0.1 N HCl was 0.9–10.5 ppm and with EDTA plus (NH₄)₂CO₃ was 0.5–8.0 ppm. Total Zn in leaves of barley (*Hordeum vulgare* L.), carrot (*Daucus carota sativa* L.), corn (*Zea mays* L.), grape (*Vitis* spp.), onion (*Allium cepa* L.), pea (*Pisum sativum* L.), strawberry (*Fragaria* spp.), and wheat (*Triticum* spp.) and in barley and wheat grain was 13.5–80.6 ppm.

The results suggested that, with the possible exception of corn leaf samples from one location, Zn levels in plant tissue are adequate. However, the results also indicated that liming strongly acid sandy soils reduces Zn availability and may induce a deficiency in Zn-sensitive crops.

PROTECTION OF CROPS AGAINST PESTS

Insect Pests

Codling moth numbers in wild apple trees were found to depend on a combination of such factors as the failure of the wild trees to produce a crop, crowding by other species of trees, degree of isolation, and natural enemies. Codling moth populations on wild trees scattered throughout Nova Scotia were compared with those in commercial orchards. Young commercial orchards require artificial control measures within a few years of first

bearing fruit to prevent severe crop losses. In older commercial orchards natural controls require an occasional assist by chemical treatment to contain the codling moth below economically tolerable levels.

The female:male ratios of codling moth winter larvae, adults, and summer larvae varied inversely with codling moth density changes in commercial orchards over a 17-yr period. The sex ratio data was obtained when winter mortality was being assessed in the spring from adults collected in bait pans from June to September and from summer larvae taken from infested apples. Codling moth density was estimated by counting infested apples in late August.

In a study of the relative density within mature apple trees the phytophagous mites, *Panonychus ulmi* (Koch) and its eggs, and *Aculus schlechtendali* (Nal.) mites were found to be more numerous in the lower position of the tree, whereas the reverse was true for the predacious mite *Zetzellia mali* (Ewing) and its eggs.

By early September the foliar concentrations of P, K, and particularly N were significantly depressed by high *P. ulmi* populations. Seasonal trends of the percentages of N, P, and K were measured in apple trees infested with the European red mite, *P. ulmi* (Koch), at four population levels created by the action of predators or chemical treatment.

An artificial medium with formalin as a microbial growth inhibitor was satisfactory for rearing larvae of *Rhagoletis pomonella* Walsh, but yielded adults that seldom mated and laid few eggs. Omitting formalin and autoclaving the media at 107°C for 20 min provided acceptable control of contaminants and the adult progeny from reared larvae laid 76 to 251 eggs.

The insecticides Tamaron (Chemagro Ltd.), Galecron (Ciba-Geigy Canada Ltd.), and azinphos-methyl, and the biological insecticide *Bacillus thuringiensis* (Berliner) gave good control of *Pieris rapae* (L.) and *Trichoplusia ni* (Hübner) infesting cabbage. Combining *B. thuringiensis* spores and the Galecron at reduced rates gave the best control. Combining *B. thuringiensis* spores and a virus or two different viruses resulted in adequate control.

The principal injurious cutworm of tobacco in Nova Scotia was found to be the dark-sided cutworm, *Euxora messoria* (Harris). A trace of the black cutworm, *Agrotis*

ipsilon (Hufnagel), was found in one field. The variegated cutworm, *Peridroma saucia* (Hübner), caused minor damage in September. Other species reared from field-collected larvae and bait and light trap catches included: yellow-headed cutworm, *Apamea amputatrix* Fitch; armyworm, *Pseudaletia unipuncta* (Haworth); *Amphipyra tragopoginis* L.; w-marked cutworm, *Spaelotis clandestina* (Harris); and the glassy cutworm, *Crymodes devastator* (Brace).

Eleven families of spiders comprising 35 genera and 55 species were found in three hayfields in Nova Scotia. The spider fauna was sampled by means of pitfall traps from May to October 1960. Specimens of the genus *Pardosa* were trapped in greatest numbers.

Plant Pathology

The fungus *Apioportha vepris* (de Lacr.) Wehm. was found in April colonizing red raspberry canes that had been subjected to an unusual period of freezing temperatures in the previous September. It was not found on winter-killed canes. The fungus was found only on *Rubus* spp. and is not considered an active parasite. Isolations made from both perithecia and pycnidia yielded colonies that produced pycnidia of the conidial state, *Phomopsis vepris*, on agar media and mature perithecia on autoclaved stems of red raspberry.

Cankers caused by *Godronia cassandrae* Pk. f. *vaccinii* Groves were found on lowbush blueberries in several areas of Nova Scotia and in one location in Prince Edward Island. A lowbush blueberry isolate of this fungus was pathogenic on lowbush blueberry, highbush blueberry, and cranberry plants.

Sclerotinia sclerotiorum (Lib.) de Bary was determined for the first time as the cause of a disease of horse-chestnut, *Aesculus hippocastanum* L. The pathogen was isolated from severely blighted trees in Colchester County, Nova Scotia, in July 1970. This extends the host range of the pathogen.

A 37% solution of formaldehyde dripped at a rate of 176 ml/m³ onto peat on a conveyor belt between drying and sealing in polyethylene bags controlled saprophytic and free-living nematodes. Untreated processed

peat was found to contain up to 160 nematodes/kg and the processor was losing sales because of the infestation.

Carrots washed and graded before being stored for 15-16 wk at 0°C and 95-100% relative humidity (RH) had significantly less decay than carrots stored directly from the field. Spraying carrots in 1970 and flooding them in 1971 with sodium phenylphenate after washing gave a further significant decrease in decay. A postharvest spray rinse of dichloran was effective in one year but not in the other. In 1971-72 thiabendazole gave significantly better control than sodium phenylphenate. Chlorine did not control storage decay. *Botrytis cinerea* Pers. was the predominant rotting organism.

Pesticide Residues

Applications of lead arsenate (PbHAsO_4) to the soil resulted in increases in the levels of Pb and As in the surface soil (0-15 cm) and the crops grown on treated plots. The Pb levels in some crops approached or exceeded the Canadian residue tolerance of 2.0 ppm. The treatments did not affect the Cu absorption by the crops. On areas such as old orchard land contaminated with lead arsenate residues it may be advisable to ascertain the soil lead status before planting certain crops and the lead affinity and arsenic sensitivity of the plants to be grown.

FOOD TECHNOLOGY

Preharvest sprays of CaCl_2 , $\text{Ca}(\text{NO}_3)_2$, or water-soluble wax increased berry size and decreased the rate of softening of raspberries during storage for 48 h at 21°C. In a split plot experiment, with four cultivars and three dates of harvest, preharvest sprays of wax increased firmness but had no effect on total acidity, acid loss, water loss, or fungal decay. There were, however, significant interactions between cultivars and harvest dates in relation to firmness, acidity, and rot development.

Pears packed by the vacuum syrup method were rated better than those packed by the exhaust or the hot fill method. They were uniform in color and had a very high gloss. At the 6-lb pressure test level¹ they were firmer than those packed by the other two methods. At the 4- and 2-lb levels this difference was not detected. Pears packed by the exhaust method were irregular in color at

the 6-lb level. At the 4-lb level their color was more uniform, and at the 2-lb level they were similar in appearance to those given the vacuum syrup treatment. From the standpoint of color, those packed by the hot fill method were the poorest. In these experiments, Clapp Favourite pears were ripened at 18°C and 85% RH and at 24°C with no control over humidity. Pears from each storage temperature were processed when they attained pressure test values of 6, 4, and 2 lb.

ANIMAL SCIENCE

Poultry

No overall detrimental effect on hatchability could be demonstrated by periodic reduction in incubation temperature caused by setting two-sevenths of the incubator capacity weekly, using cold (11°C) eggs vs. pre-warmed (37°C) eggs. The introduction of cold eggs caused a temporary reduction in incubator air temperature of 5°C. In other experiments there was no evidence that either the number of eggs per tray or separation vs. contact between eggs during hatching had any effect on hatchability although egg numbers varied from 30 to 150 eggs per tray.

In a comparison of a full with a "skip-a-day" feeding program and the feeding of a low-protein growing diet, the "skip-a-day" treatment resulted in the most hatching eggs, fewer double-yolked eggs, increased egg size, improved feed conversion, reduced body weight, and higher monetary returns. The experiment, involving four meat-type genotypes with 2,230 adult females and 354 adult males, was conducted to study the separate and combined effects of three rearing feed treatments and two adult feed treatments. After peak egg production, the daily time for eating was restricted for one-half the population to limit feed consumption to approximately 90% of the full-fed controls. The restriction of feed for adults had no important beneficial effect on performance.

Results from a sensory taste panel revealed a statistically significant difference in toughness between birds grown in low and high density environments; birds grown

¹Magness-Taylor pressure tester scale

under high density conditions exhibited more carcass tenderness. The results of the texture measurements provided supporting evidence as the muscle shearing force requirements were higher for birds from the low density pens; this difference approached significance at the 5% level. Moisture content, color, fat extract, and cooking loss were unaffected by the rearing treatments.

Cattle and Sheep

During a first grazing season clinically normal steers shedding low numbers of gastrointestinal worm eggs contaminated the parasite-free pastures sufficiently to give rise to large residual pasture infections and clinical parasitic gastroenteritis in grazing stock during the second grazing season. Worm burdens of 100,000 to 200,000 *Ostertagia ostertagi* and *Cooperia oncophora* were established in several steers showing marked clinical signs. In spite of treatments with high dosages of thiabendazole in attempts to keep worm burdens at a minimum, there was a slow but gradual buildup of pasture infections in the paddocks grazed by the control steers over the 3-yr period. During a second and third grazing season there were significant differences in the daily rate of gain between the parasitized and control animals on both upland and dikeland pastures. The parasitized groups of steers had daily rates of gain ranging from 0.29 to 0.80 lb less than their comparable control groups. These investigations were carried out over three grazing seasons with parasitized and treated (control) steers on irrigated and nonirrigated upland and dikeland pastures. The stocking rate in each paddock was adjusted by either adding or removing animals so as to maintain as uniform a sward and rate of grazing as possible. Animals were weighed on and off the pastures and fortnightly during the grazing seasons. Irrigation did not have a consistent effect on weight gains and development of parasitism.

Comparisons made between reed canarygrass, *Phalaris arundinacea* L., grazed and fed as silage showed that animal gains from pasture were much better than from silage with yearling Hereford steers. Gains from bromegrass were equal when grazed or fed as silage. Increasing N fertilization from 168 kg/ha to 336 kg/ha accentuated the difference between grazing and silage feeding results. Seasonal depression of digestibility

was more rapid for reed canarygrass than bromegrass. Total N content of herbage increased during the first 20 wk of the grazing season with the applied N showing a linear effect. Total production of dry matter of reed canarygrass as harvested with a forage harvester, four times in the season, was 11,468 kg/ha with 336 kg/ha of N applied and 10,733 kg/ha with 168 kg/ha of N.

A 5-yr experiment, concluded in 1972, indicated that pregnant cows can be kept over winter in a wooded area without any other shelter and fed on hay alone. The type of shelter did not have a significant effect on body weight during the winter. The cows remained healthy and dropped healthy calves. There was no particular problem at calving time in the woods, when the snow melted early and the woods dried up before calving. In years when there was a lot of snow during calving, calf losses were heavy. During such conditions some dry shelter is required for the cow and calf. Managing cows in the woods presents some problems not encountered in barns. Rough terrain presents hazards that may lead to loss of cows so that close observation is necessary. There is some indication that the woods environment had an adverse effect on breeding. The selection of cows adaptable to this kind of environment would no doubt result in improved performance. The work demonstrated that cows can be kept outside all winter in the Maritime Provinces and that the cost of wintering cows can be materially reduced by using woods as shelter.

An instrument¹ based on the Doppler principle was used to test sheep for pregnancy. The instrument will detect a fetal heart pulse at about 80 days of gestation in the ewe. A skilled operator can detect pregnancy at an earlier stage. Multiple fetuses can also be detected with considerable accuracy, thus enabling the farmer to feed his sheep accordingly. Over 200 sheep were tested at Nappan by an inexperienced operator with an accuracy of about 85%. This method of detecting pregnancy offers some promise to the sheepman. The cost of the instrument is about \$550.

A simple inexpensive teat bar was developed for feeding cold liquid diets to lambs. The system can be used for research or for artificial rearing of lambs in a commercial

¹Allard Model V601, Allard International Ltd.

operation. Eighty-six crossbred lambs from two different lambings were successfully fed

a commercial and an experimental milk replacer.

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Research Station

Fredericton, New Brunswick

PROFESSIONAL STAFF

G. M. WEAVER, B.Sc., Ph.D.	Director
F. J. WHITTEN	Administrative Officer
D. B. GAMMON, B.A., M.A., B.L.S.	Library Area Coordinator, Quebec and Atlantic Region

Environmental Quality Program

A. A. MACLEAN, B.Sc., M.Sc., Ph.D.	Program Manager; Soil chemistry
C. F. EVERETT, B.Sc., M.Sc., Ph.D.	Herbicides
W. A. HODGSON, B.Sc., M.Sc.	Fungicides
M. LANTAGNE, B.S.A., M.Sc.	Hydrological engineering
D. D. POND, B.Sc.	Insecticides
G. R. SAINI, B.Sc., M.Sc., Ph.D.	Soil physics

Livestock Feeding and Animal Nutrition Program

J. W. G. NICHOLSON, B.Sc., M.Sc., Ph.D.	Program Manager; Meat animal nutrition
P. L. BURGESS, B.Sc., M.Sc., Ph.D.	Dairy cattle nutrition
C. F. EVERETT, B.Sc., M.Sc., Ph.D.	Weed control
A. D. L. GORRILL, ¹ B.S.A., M.Sc., Ph.D.	Calf and lamb nutrition
E. A. GRANT, B.Sc., M.Sc.	Forage and cereal crops
J. G. KEMP, B.E.	Harvesting and storage engineering

Potato Program

D. A. YOUNG, ² B.Sc., M.Sc., Ph.D.	Program Manager; Breeding
J. B. ADAMS (MRS.), B.A., M.Sc.	Aphid physiology
R. H. BAGNALL, B.Sc., M.Sc., Ph.D.	Virus resistance
R. H. E. BRADLEY, B.Sc., Ph.D., D.Sc.	Aphid-borne viruses
M. C. CLARK, B.Sc.	Biochemistry of resistance
W. B. COLLINS, B.Sc., M.Sc., Ph.D.	Potato physiology
H. T. DAVIES, B.S.A.	Quality and breeding
H. DE JONG, B.A., M.Sc., Ph.D.	Diploid breeding and genetics
C. F. EVERETT, B.Sc., M.Sc., Ph.D.	Weed control

W. A. HODGSON, B.Sc., M.Sc.	Late blight
M. LANTAGNE, B.S.A., M.Sc.	Soil erosion
C. H. LAWRENCE, B.Sc., M.Sc.	Soil-borne pathogens
C. R. LEE, B.Sc., M.Sc., Ph.D.	Potato nutrition
M. E. MACGILLIVRAY (Mrs.), B.A., M.Sc., D.Sc.	Insect ecology
J. P. MACKINNON, B.Sc., M.Sc.	Latent viruses
A. R. MCKENZIE, B.Sc., M.Sc., Ph.D.	Soil-borne pathogens
G. C. MISENER, ³ B.Sc., M.Sc.	Harvesting and storage engineering
D. D. POND, B.Sc.	Insect control
G. R. SAINI, B.Sc., M.Sc., Ph.D.	Soil physics
R. P. SINGH, B.Sc., M.Sc., Ph.D.	Virus diseases
G. C. C. TAI, B.Sc., M.S., Ph.D.	Quantitative genetics
T. R. TARN, B.Sc., Ph.D.	Cytogenetics
G. W. WOOD, B.Sc., M.A.	Insect control, small fruits

Departure

T. C. CHIASSON, B.Sc., M.Sc. Retired January 22, 1972	Cereal crops
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VISITING SCIENTISTS

National Research Council postdoctorate fellows

R. E. HANNEMAN, B.Sc., M.Sc., Ph.D. Fellowship terminated July 31, 1972	Diploid breeding and genetics
K. F. HARRIS, B.Sc., M.S., Ph.D. Fellowship terminated July 31, 1972	Aphid-borne viruses

¹On transfer of work at University of Sydney, Sydney, Australia, July 1972 to July 1973.

²On transfer of work at Foundation for Agricultural Plant Breeding, Wageningen, The Netherlands, until July 1972.

³On educational leave, University of Illinois, Urbana, Ill., USA.

INTRODUCTION

The Research Station at Fredericton is the main location in Canada for research on the potato crop. Emphasis is placed on breeding and genetics, pest and disease management, harvesting and storage engineering, and soil and crop management. The Station is also the Atlantic center for harvesting and storage engineering and for utilization and nutritional studies related to the production of cereal and forage crops for livestock feeding. The Station collaborates with other Branch establishments to evaluate the potential of new crop cultivars and selected management practices in New Brunswick.

In collaboration with other agencies, a study relating to environmental quality was started. Our research is emphasizing the impact on water quality of plant nutrients and pesticides applied to the potato crop. Research that was started during the year and for which scientific specialists have been recruited includes soil erosion and hydrological studies and work on diploid breeding – haploid genetics of the potato.

This report represents a brief summary of the major thrusts undertaken during 1972. Additional information can be obtained from reprints of publications and through communication with the Station. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Box 280, Fredericton, N.B.

G. M. Weaver
Director

ENVIRONMENTAL QUALITY

Effects of Agricultural Practices on Water Quality

Investigations were begun in 1971 to assess the effects of agricultural practices, and of potato production in particular, on water quality in the Saint John River Valley. The work has involved a program for monitoring concentration and discharge of a number of chemical parameters including nutrients and pesticides, and of suspended sediment.

Hydrometric stations were established in the drainage basins of two watersheds, Holmesville (3,700 ha) and Ste. Andre (1,630 ha), to measure these parameters under three situations: (i) background level from a non-agricultural forested area, (ii) agriculture of medium intensity, 40% in crop production, and (iii) intensive agriculture, 72% in crop production.

Preliminary data showed higher concentrations of most inorganic cations and anions in the area of intensive agriculture. However, the concentration of those nutrients considered to have greatest influence on water quality was rather low. During the first year, mean concentrations for a number of parameters at sites representing background level and intensive agriculture respectively were: pH, 7.6 vs. 8.0; NO₃-N, 0.5 vs. 3.2 ppm; inorganic P, 3.1 vs. 8.9 ppb (10⁹); K, 0.4 vs.

1.1 ppm; Ca, 16 vs. 60 ppm; Mg, 2.3 vs. 4.5 ppm; Cl, 0.9 vs. 10.7 ppm; SO₄, 4.9 vs. 22.7 ppm; and organic C, 3.4 vs. 8.4 ppm. The presence of pesticides, notably endrin and in a few cases DDT and its derivatives, was occasionally detected. The discharge of total solids was generally low (2–5 t/mo from 1,630 ha) and no higher from the area of intensive agriculture except after heavy rainfall.

This work will be continued in 1973 and other concomitant phases of the program will be started.

LIVESTOCK FEEDING AND ANIMAL NUTRITION

Formaldehyde-treated Rapeseed Meal

Treatment of protein supplements with formaldehyde reduces protein degradation in the rumen and allows more dietary protein to reach the lower digestive tract. A commercial formulation (37% formaldehyde) was diluted 1:5 with water and the mixture applied at the rate of 5% to rapeseed meal. Spraying the solution onto the meal was as effective as sprinkling. The treated meal was held for 24 h in a closed container before being dried. This level of formaldehyde treatment reduced degradation in the rumen without reducing overall digestibility in the animal.

A feeding trial in which potatoes provided

the main source of energy resulted in average daily gains of 0.9 kg/day by beef calves when supplementary protein was supplied by control rapeseed meal, and 1.0 kg/day with formaldehyde-treated rapeseed meal. A second trial with older cattle fed a basal ration of corn silage failed to show any advantage for formaldehyde-treated rapeseed meal.

Choline Chloride Increases Gains

The addition of 4.5 g of choline chloride per day to the ration of beef calves increased gains in two feeding trials. In the first trial, with a basal ration of potatoes and corn silage, the addition of choline chloride resulted in average gains of 1.0 kg/day; the control calves gained 0.9 kg/day. The basal ration in the second trial was corn silage and cracked corn and the addition of choline chloride produced similar gains. These results indicate that further research is warranted to confirm this effect.

Calving-out Beef Heifers Before Slaughter

One way to increase the beef output from the national cattle population is to have each heifer produce a calf before she is sent for slaughter. A preliminary trial with 12 cross-bred heifers, bred at 12 to 15 mo of age, showed that gestation did not result in premature aging and carcasses were graded as heifers eligible for Canada A and B grades. The heifers were dried off after calving and the calves raised on milk replacers. The feed costs for producing a calf from a heifer destined for slaughter were much less than for keeping a cow for a year.

Rapeseed Protein in Milk Replacers

Rapeseed protein prepared at the Food Research Institute, Ottawa, was used as a partial replacement for milk protein in milk replacers for calves and lambs. Flours from a low-thiogluconide variety (Bronowski) were more acceptable to calves than those from high-thiogluconide varieties. Among lambs, the digestibility of dry matter and protein in Bronowski flour, prepared by extraction with both an oil solvent and water, was higher than that of flours prepared by solvent extraction only or from unextracted material. Growth of lambs was similar when fed milk replacers in which 0 or 50% of the milk protein was replaced with protein from solvent- and water-extracted Bronowski rapeseed. The results indicate that properly

processed rapeseed protein is suitable for inclusion in commercial milk replacer formulas.

Fish and Soybean Proteins in Milk Replacers

Lambs and calves have been raised successfully on milk replacers in which up to 65% of the total protein came from fish sources. Herring meal gave lower gains than milk proteins and some fish protein concentrates, and the meal had an objectionable odor. Fish protein concentrates did not give the meal an objectionable odor or taste.

Alkali treatment of soybean protein concentrate improved its dispersibility in liquid milk replacers but nitrogen retention and lamb gains were lower than with soybean not treated with alkali. Full-fat soybean flour prepared by the Food Research Institute, Ottawa, was a satisfactory source of protein for lambs when used to supply 50% of the total protein in combination with either low-heat skim milk powder or a mixture of skim milk and sweet cheddar whey powder. Nitrogen retention was lower when the soybean flour was used in combination with the whey and roller-dried buttermilk powder.

Whole-crop Silage for Dairy Cattle

The yield and nutritive value of whole crops of wheat (Opal), barley (Herta), and forage oats (AO 121-3) ensiled at the early-dough stage were compared as the sole forage for 24 lactating Holstein cows in a 12-wk study. Silage was offered ad lib.; concen-

Yields of wheat, barley, and forage oats averaged 5,802, 3,932, and 3,769 kg/ha, respectively, with an acid detergent fiber content varying between 33% and 39%. Daily silage dry matter intake averaged 1.75, 1.71, and 1.62 kg/100 kg body weight, whereas 4% fat-corrected milk yield was 21.2, 23.3, and 22.1 kg/cow respectively. Intake differences between the wheat and forage oat silages were significant ($P < .05$). Changes in rumen volatile fatty acids, rumen and blood nitrogen fractions, and milk composition were minor for the three silages. Because of low field yields, relatively low intakes, and high fiber levels, the potential use of cereals as forages for dairy cows is limited.

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Forage Oats

The forage yield and digestibility of forage oat lines from breeding programs at Ottawa and Indian Head have been generally inferior to late grain types. The Ottawa line OA 123-1 was similar in performance to Dorval, the late grain type used as a standard in this study. Indian Head lines on the average took 10-15 days longer to mature, had lower digestibility, and were more susceptible to infection by barley yellow dwarf virus.

As OA 123-1 matured, digestibility of dry matter, energy, and protein declined rapidly. Dry matter intake by sheep also declined, and was closely related to increasing fiber content. For maximum yield of dry matter and acceptable voluntary intake levels, forage oats should be harvested at the milk stage.

Horizontal Silos

The cost of filling a horizontal silo with low-density silage was up to 25 cents/t less than that of filling one with high-density silage. The main difference was the cost of tractor operation for packing high-density silage. The loss in capacity due to low density was largely compensated for by heaping the silage in the center.

Surface spoilage of low-density silage was greater, but was largely balanced by the greater amount of wasted frozen material in the high-density silage.

The cost of unloading a horizontal silo with a silo unloader was 10 to 30 cents/t more than the cost of using a tractor with front-end unloader. The increase was due to higher capital cost and additional time required to hook the unit to a tractor and back it into the unloading position. The unloader had an advantage because the physical quality of the silage was better; it was well cut up and fluffy so that frozen or spoiled material was acceptable to animals.

Preharvest Losses of Barley

Three years data on Volla barley showed a highly significant linear relationship between yield losses and delay in harvest. The loss was 32.2 kg/ha per day for yields ranging from 862 to 3,448 kg/ha. Data on yield losses were collected for 4 to 6 wk beginning

when the moisture content of the grain was 15-18%. The work will be extended to a moisture content of 35% to evaluate early harvesting along with drying.

Hay Drying

Total latent evaporation measured by an atmometer from 8:00 a.m. to 8:00 p.m. was used to develop a prediction equation for field-drying of timothy hay. The exponential equation calculated by the method of least squares, which related the initial and terminal moisture contents (dry-weight basis) to total latent evaporation, accounted for 88% of variation in moisture content.

Bronzed Cutworm in Grasses

The first major outbreak of the bronzed cutworm, *Nephelodes minians* Guenée, since the early 1930s occurred in June on a community pasture on the Tantramar Marshes. On June 27, populations varied from 270 to 1,240 larvae/m².

POTATO BREEDING

Evaluation of Potato Seedling Selection Procedures

By convention, approximately 10% of potato seedlings from nonreplicated, single-hill plots are selected and retained. These seedlings are grown in 10- to 25-hill, nonreplicated plots and subjected to further selection procedure. The reliability of these procedures is questioned because, in experiments, the random planting of duplicate seedlings resulted in 14% recovery of duplicates for selected seedlings, and the inclusion of established cultivars provided 16% recovery as selections. Evaluation of the relative importance of different criteria used by selectors revealed that selectors emphasized different characteristics in different seedling populations. Appearance, however, played a dominant role in the decision. Unfortunately, appearance has a low heritability at the single-hill stage. A modified negative selection method is proposed where only highly heritable, undesirable traits are eliminated in single-hill populations and a larger population is retained for identification of less highly heritable traits. We propose to retain about 40% of the seedling population.

An evaluation has been made of a nonreplicated four-hill plot system readily planted

and harvested mechanically and where plant spacings simulate normal field conditions. The four-hill stage of selection would be implemented after the negative selection of single hills and 25% of the progeny retained for advanced evaluation.

Combining Ability Analysis of Quantitative Traits of Potatoes

Two series of experiments were carried out in the field in the past 3 yr. One was a partial diallel experiment involving the progeny from 30 crosses derived from 12 cultivars. The cultivars appeared in the crosses one to seven times. Both experiments were subjected to general least squares analyses. The results indicated that general combining ability was significant for all horticultural traits investigated. Specific combining ability, on the contrary, was statistically significant only in a few cases. The general lack of specific combining ability in the two populations supports the speculation that the gene pool of potato cultivars and breeding stocks (at least for those in the Canada breeding program) may have a narrow genetic base.

Performance of F_1 Andigena-Tuberosum Hybrids

The use of Andigena parents in cultivar breeding is being studied in a series of crosses between Andigena (A) and Tuberosum (T) clones, five parents from each group being used. Four intercross populations have been set up: AA, AT, TA, and TT, representing the two parental and two F_1 combinations. Within each population, five families have been produced by pollinating the five clones used as seed parents with pollen bulked from the five clones used as pollen parents. In the parental combinations the pollen for each cross was bulked separately so that self pollen was not used.

In 1972, the first clonal generation was evaluated in the field from greenhouse-grown tubers. Plants were scored for 10 traits, including top vigor and several yield and tuber traits.

The F_1 populations showed top vigor close to that of the mid-parent mean. There was marked heterosis for total yield and although the F_1 populations showed little difference from the high parent AA population mean, the AT and TA populations were 8.0% and 16.9% higher, respectively, than the mid-parent mean and 22.8% and 33.0% higher

than the TT mean. For tuber number, the AT and TA population means were 9.5% and 3.8% lower, respectively, than the mid-parent mean, 42.6% and 39.0% lower than the AA mean, but 114.1% and 127.7% higher than the TT mean. On the other hand, mean tuber weights followed a different pattern, the AT and TA means being 12.0% and 5.2% lower, respectively, than the mid-parent mean, 39.1% and 34.5% lower than the TT mean, but 58.9% and 71.0% higher than the AA mean. These results confirm the potential value of Andigena germ plasm for cultivar breeding in temperate latitudes, and suggest that selected parental combinations should produce some extremely high yielding progeny.

Estimation of Additive Combining Ability of Potato Parents for Late Blight Resistance

Data from greenhouse tests for late blight resistance of seedlings in 37 crosses were used for estimating the additive combining ability of the 21 parents involved in the crosses. Each parent was used two to nine times in the crosses; the number of seedlings in a cross ranged from 14 to 662. The additive combining ability for each of the 21 parents was estimated by a general least squares analysis. The estimated results were then used to obtain a calculated frequency of resistant seedlings in a cross. A chi-square test between observed and calculated frequencies of resistant seedlings in the 37 crosses gave an excellent fit ($\chi^2 = 1.67, P > .99$). This indicates that the general least squares method is useful for assessing the value of cultivars and seedlings as blight-resistant parents.

Resistance to Potato Viruses S and X

Extreme resistance to potato virus S (PVS) was found in the cultivar Saco and shown to be inherited as a simple recessive gene. Saco was also resistant to PVX (dominant). PVS- and PVX-resistant seedlings were found in the progeny of several crosses between Saco and other parents. Individual seedlings

scored well in one or more yield, bake, boil, chip, and French fry tests.

POTATO PATHOLOGY

Virus-Tested Potato Stocks at Two Elite Seed Farms

Large-scale tuber and foliage testing was continued in the virus "clean-up" programs in New Brunswick and Prince Edward Island. More than 3,300 tubers were tested on indicator plants of *Nicotiana debneyi* Domin., which detects PVS, PVX, and PVY, to ensure that only clean stocks are planted in the preelite plots at the two seed farms.

More than 10,000 plants in these plots were summer-tested for PVS and PVX. At the New Brunswick seed farm, Sebago was the only cultivar out of six planted that was found to be free from both viruses. Kennebec, Red Pontiac, Katahdin, and Keswick were free from PVX, but PVS infections of 6% or less were found. A trace of PVS was found in Netted Gem. In tests of the five cultivars maintained on the Prince Edward Island farm, all the preelite plantings were free from both PVS and PVX. In other tests (6.5 ha) of E I and E II stocks, no PVS was found in Kennebec, Irish Cobbler, or Green Mountain but trace infections were found in Sebago and Netted Gem.

Field Spread of PVS in Three Potato Cultivars

In a replicated field trial with virus-free Green Mountain, Kennebec, and Sebago at Fredericton, much less spread of PVS occurred in 1972 than in a similar trial in the same field in 1971. Virus spread in 1972 in Green Mountain, Kennebec, and Sebago was 14%, 0%, and 0% respectively, compared with 57%, 19%, and 9% in the same cultivars in 1971. Four double tests (serological and plant indicator) were made on the foliage during the summer and one postharvest test was made on *Nicotiana debneyi* with tubers from every plant. The earliest PVS infection in 1972 was found during the third foliage test, August 14 (87 days after planting),

whereas the remaining infections were detected in either or both of the foliage tests on September 7 or tuber tests in late fall.

Attempts to Transmit PVS with Aphids

Because spread of PVS in our Fredericton potato trials for 3 consecutive years could not be explained by sap transmission alone, and because German workers recently reported PVS spread by *Myzus persicae* (Sulzer), the green peach aphid (5 isolates of 18 tried were transmitted), greenhouse experiments were undertaken to determine if Fredericton isolates could be transmitted by this aphid.

Four studies were conducted in which three isolates were used, one each from Sebago, Green Mountain, and *Nicotiana debneyi*. Attempts to transmit the virus to potato seedlings grown from true seed, virus-free Green Mountain, and healthy young *N. debneyi* produced low levels of transmission in two experiments and none in two. Results showed PVS transmissions to one of 40 potato seedlings from the Sebago isolate, to two of 47 Green Mountain plants from the Green Mountain isolate, and to one of 30 *N. debneyi* from the *N. debneyi* isolate. Simultaneous transmissions of PVY from tobacco to tobacco and *N. debneyi* resulted in 87% infection.

Aphid Transmission of Tobacco Mosaic Virus

Aphids have been shown to transmit tobacco mosaic virus by clawing. This is a novel manner for vector transmission of a plant virus. In nature such transmission probably occurs rarely. An exhaustive study failed to reveal any evidence that aphids can transmit this virus by their mouthparts as reported several times by others. Transmission by the claws could account for all previously reported transmissions of this virus by aphids.

Purification and Characterization of Potato Spindle Tuber Metavirus

Potato spindle tuber metavirus (PSTM) was extracted from the leaves of *Scopolia sinensis* Hemsl., and the low-molecular-weight RNA fraction obtained after precipitation with cetyltrimethylammonium bromide and lithium chloride was treated with isopropanol to remove traces of contaminating DNA. The reaction mixture was chromatographed on DEAE-cellulose to remove

DNase and any high-molecular-weight contaminants.

Preliminary attempts based on chromatography with a DEAE-sephadex column failed to provide satisfactory yield or resolution of PSTM. In marked contrast, purification by preparative polyacrylamide gel electrophoresis gave a single isolated peak essentially free from other low-molecular-weight RNA. The yield of PSTM at this stage was 100 μ g/200 g and the estimated purification about 2,000-fold.

As with formaldehyde treatment of earlier, less purified preparations, diethylpyrocarbonate (DEP) inactivated the PSTM. Attempts to characterize the 3' terminus and to determine molecular weight by periodate oxidation and with tritiated sodium borohydride showed that this severe treatment had no effect on biological activity of PSTM. The amine-catalyzed removal of the oxidized 3' terminal nucleoside failed to alter activity, indicating probable involvement in the host plant of pyrophosphorylase, which adds -C-C-A sequence to t-RNA. Analysis of the hydrolysis products of tritiated metavirus indicated that the 3' terminal nucleoside was adenosine. Comparison of the terminally labeled metavirus to tritiated t-RNA from *E. coli* yielded an estimate of molecular weight of PSTM. The value of 71,000 Daltons compared favorably with that obtained by gel electrophoresis.

Comparison of Host Response by Citrus Exocortis and Potato Spindle Tuber Metavirus

A comparative study of host range was made with citrus exocortis and potato spindle tuber metaviruses. Potato plants inoculated with each of these two pathogens produced identical symptoms. The potato plants infected with citrus exocortis were severely stunted. The leaves that developed after infection were small and were grouped close to the stem, giving the plant an upright appearance. The tubers from these plants were elongated, spindle shaped, and marked with longitudinal growth cracks. In addition, symptom response in *S. sinensis*, *Gynura* sp., and tomato was very similar. On the basis of symptoms, it appears that the two pathogens

are either the same or closely related strains of one metavirus.

Seed Production and Use of *S. sinensis* as Indicator Plant for Potato Spindle Tuber Metavirus

The need for a reliable means of seed production was made evident by the demands for this plant as an indicator for the potato spindle tuber metavirus. A simple and effective technique was developed. Pollinations made the day before or the day of flower opening resulted in good fruit and seed set, but pollinations made at the time of anthesis resulted in poor fruit set and almost no seed set. Fertilized flowers produced mature seed in 6-8 wk and freshly harvested seed germinated without any dormancy period.

Field-grown *S. sinensis* plants survived the winter and developed new shoots in late May. Pollinations were made and 50-60% of the flowers yielded fruits.

Seeds were germinated by placing them on moist filter paper for 4-6 days and transferring the sprouted seeds to peat-moss pots containing a fertilized greenhouse soil mix. Inoculations were made on the top two fully developed leaves. The young growth and bottom leaves were removed before inoculation. Expressed sap from single potato leaflets was rubbed on carborundum-dusted leaves. Local-lesion development was reliable when plants were kept at a temperature of 21-24°C with light intensity of 4,300-6,500 lux (400-600 ft-c) for an 18-h day.

Influence of Mn on the Number of Local Lesions of Potato Spindle Tuber Metavirus in *S. sinensis*

Scopolia sinensis seedlings were grown for 3-4 wk in nutrient sand cultures containing Mn at 0 to 18 μ g/ml before they were inoculated with potato spindle tuber metavirus (PSTM) at 50 μ g/ml. The number of local lesions observed 10 days after inoculation was three to five times greater at Mn levels of 6-12 μ g/ml. At Mn levels of about 12 μ g/ml, the number of local lesions decreased. These results verify earlier data with tomato plants and indicate that PSTM has a definite requirement for Mn. In view of these results, detection tests for PSTM can be

improved under controlled Mn concentrations in the growth media.

Estimating Potato Yield from Aerial Photographs

A computerized method was developed to estimate yield losses due to late blight from optical density readings of sequential infrared aerial photographs. The method is based on regression analyses of the relationships between optical density and late blight incidence and between rate of blight development and tuber yield.

Induction of Phenylalanine Ammonia Lyase Activity in Relation to Resistance to Late Blight of Potatoes

In conjunction with host-parasite studies of late blight of potatoes, the activity of phenylalanine ammonia lyase (PAL) was examined in several potato cultivars. Preliminary experiments concerned the response of leaf tissue to photoinduction and blight infection. In photoinduction, leaf disks were subjected to light (4,500 lux, or 420 ft-c, of fluorescent and incandescent light) and dark regimes for 72 h in a controlled-temperature chamber. Parallel experiments were conducted with infected and uninoculated control disks. Phenylalanine-1-C¹⁴ was used as a substrate for the assays. Typically, a small volume of clarified leaf extract was incubated with the substrate for 2 h at 37°C. After the addition of carrier cinnamic acid, proteins were removed by precipitation with trichloroacetic acid and centrifugation; the clarified reaction mixture was extracted with toluene, and cinnamic acid estimated by scintillation counting.

Because of a small amount of endogenous activity, disks subjected to the dark regime showed a small amount of PAL activity. Controls in the blight experiments were devoid of PAL activity. Hence, PAL activities in the photoinduction studies were calculated on the basis of light-to-dark ratios. Typical values for these ratios in Libertas, Katahdin, and Bintje were 8.98, 6.50, and 5.80 respectively. Field resistance ratings are established as 8, 5, and 3 respectively.

In a more extended study, the activity of PAL was examined in eight cultivars with field resistance ratings ranging from 9 to 3.

Generally, the results of assays on photoinduced and blight-infected leaf tissue were highly correlated.

Nematode Culture Technique

A technique for in vitro culturing of aseptic potato tubers, used previously in a study of common scab, is being tested as a means of monoxenic culture of plant nematodes. To date, this technique has been effective in obtaining sterile *Meloidogyne* spp., and may have much wider application. The technique is now being used in a study of the interaction between root-knot nematodes and individual fungal species. None of the nematodes or fungi in this study are known to occur in Canada.

POTATO ENTOMOLOGY

Polymorphism in *Aulacorthum solani* (Kltb.)

When a wingless clone of this aphid was reared under controlled temperatures (15.5 and 21°C) and photoperiods (11–18 h of light in 24 h), sexuales and parthenogenetic morphs were produced. The production of sexual females was controlled by a photoperiod of less than 14.5 h of light per day; the production of males was a product of photoperiod (15 h of light or less) and temperature. As temperature increased from 15.5 to 21°C, the number of males produced decreased.

Wireworm Control

Plots treated at planting time with single applications (3.4 kg/ha) of disulfoton (15% granules), carbofuran (10% granules), and AC92100 (Cyanamid of Canada Ltd.) (10% granules) produced 15.3, 13.4, and 13.6 t/ha respectively of marketable potatoes with no wireworm damage. Untreated plots produced 7.6 t/ha.

No significant differences were noted in sampling populations of wireworms, mainly *Agriotes mancus* (Say), in sod ground from May to September by using a 7.6-cm core or 10.2-cm square. The 7.6-cm depth accounted for 78% of the total population, the 7.6–15.2 cm depth for 20%, and the 15.2–30.5 cm depth for 2%.

POTATO PHYSIOLOGY, NUTRITION, AND SOIL MANAGEMENT

Greensprouting

Light quality and orientation of seed tuber in relation to light source during greensprouting markedly affected subsequent field performance of Netted Gem and Kennebec potatoes.

Plants from seed exposed to fluorescent and mercury light sources produced more tubers than those from seed exposed to natural and incandescent light, but yield was not affected significantly. Plants from seed that had been oriented with the stem end to the light sources produced higher yields than plants from seed oriented oppositely. A trend to rougher and larger tubers was noted from seed oriented stem-end-up.

Soil Acidity and Potato Production

The influence of soil acidity on growth, mineral nutrition, tuber yield, and quality of potatoes was studied in nutrient solution, sand, and soil cultures. Initial growth was affected by Al more than by Mn. A differential tolerance for Al existed among potato cultivars and was related to the plant's ability to absorb and utilize Mg and K in Al solution cultures. In greenhouse soil cultures, Netted Gem and Sebago tuber yields were lower at pH 4.6 than at 5.2 or 5.7. Yield of Sebago was increased at pH 4.6 by applying cow manure, Mg, or superphosphate separately or in combination. Tuber yield from Mg plus superphosphate at a soil pH of 4.6 equaled that at 4.9 or 5.2 without these amendments. These experiments emphasize the importance of maintaining adequate soil levels of Mg, Ca, and P in potato production. Aluminum may be more of a factor than Mn in suppressing yield of Netted Gem and Sebago potatoes in Eastern Canadian Podzols.

Control of Barnyard Grass in Potatoes

In a cooperative study with Plant Industry Branch, New Brunswick Department of Agriculture and Rural Development, herbicides gave excellent control of barnyard grass. The following treatments were equally effective: alachlor plus linuron (2.2 + 1.1 kg/ha) or chlorbromuron (3.3 kg/ha) at about 10 days after planting; alachlor plus

metribuzin (2.2 + 0.6 kg/ha), dinoseb plus monolinuron (4.5 + 2.2 kg/ha), alachlor plus dinoseb (2.2 + 3.3 kg/ha), or prometryne plus TCA (2.2 + 5.6 kg/ha) at ground crack, dinoseb (3.3 kg/ha) at ground crack plus metribuzin (0.85 kg/ha) at early postemergence, or metribuzin (0.6 kg/ha) at early postemergence.

Control of Quack Grass in Potatoes

The recommended treatment, dalapon plus dinoseb (11 + 5.3 kg/ha), applied preemergence, along with cultivation a few days after application gave 50% control until the end of August. Control was only 10% without cultivation.

Paraquat (0.7 kg/ha) applied early postemergence followed by cultivation gave 70% control in July and 50% in September. Considerable foliar chlorosis resulted.

EPTC (5.6 kg/ha) incorporated to a 15-cm depth before planting gave 45–60% control and no subsequent crop damage.

Metribuzin (2.2 kg/ha) and glyphosate (1.7 kg/ha) were less effective.

Evaluation of Potato Topkillers

Twenty-six treatments were evaluated with Red Pontiac and Netted Gem. Treatments were applied in late August with additional treatment 1 wk later for split applications.

Ametryne (2.2 kg/ha) gave excellent desiccation and two applications of diquat (0.28 kg/ha) 1 wk apart gave comparable results. The latter treatment was slightly better than a single application of diquat (0.56 kg/ha).

Glyphosate (1.1 kg/ha) gave complete desiccation but caused tuber breakdown in Red Pontiac. This breakdown occurred initially in the seed end of the tuber. No stem-end discoloration resulted from any treatments.

Value of Shredded Tree Bark in Potato Production

Soil applications of tree bark (90 t/ha, wet basis), supplemented with 1% N, were beneficial in alleviating the deleterious effects of machinery traffic on potato yields. In the presence of bark, yield loss due to traffic was only 2% but was 31% in the absence of bark.

The effect of bark on soil bulk density was difficult to assess but increases in moisture-holding capacity and oxygen diffusion rate of Caribou loam were indicated.

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Ferme expérimentale L'Assomption, Québec

CADRES PROFESSIONNELS

P. P. LUKOSEVICIUS, Diplomlandwirt, M.Sc., Ph.D. Directeur

Tabac

M. DUPRÉ, B.A., B.S.A.

Pesticides

V. KOZUMPLIK, Diplomirani inženjer poljoprivrede,
M.Sc.

Génétique et amélioration
du tabac à cigare

M. LAMARRE, B.Sc. (Agr.)

Phytotechnie

INTRODUCTION

En 1972, d'importants travaux de construction et de réparation ont été réalisés à la Ferme expérimentale de L'Assomption. Nous avons aménagé nos nouveaux locaux en vue de la classification et d'autres travaux de recherches sur les tabacs à cigare et à cigarette.

Ce rapport présente un bref résumé des recherches poursuivies durant l'année 1972. En plus de leur travail expérimental, les chercheurs collaborent également avec d'autres agronomes du Québec en ce qui a trait à la formulation des recommandations pour la culture du tabac.

Nous avons recruté un nouveau professionnel, M. V. Kozumplik, afin de nous aider à poursuivre notre travail sur l'amélioration du tabac à cigare.

Pour obtenir de plus amples renseignements, adresser vos demandes à la Ferme expérimentale, ministère de l'Agriculture du Canada, C.P. 1070, L'Assomption, Québec.

P. P. Lukosevicius
Le directeur

TABAC

Tabac à cigare

Les travaux sur l'amélioration des tabacs à cigare comprennent: la sélection de lignées hybrides et leur résistance aux maladies, en particulier celle causée par *Thielaviopsis basicola* (Berk. & Br.) Ferr.; une évaluation préliminaire et avancée; un essai sur différentes dates de plantation; des essais de dégustation et des études sur différents modes de séchage. Les résultats des données morphologiques obtenues en 1972 sont présentés dans ce rapport ainsi que ceux des données agronomiques et chimiques obtenus en 1971, ceux-ci n'ayant pas été transmis antérieurement. Les données des analyses chimiques et agronomiques de 1972 ne sont toutefois pas encore disponibles.

Sélection. Provenant soit de croisements simples ou doubles, soit de croisements de trois géniteurs (three-way cross) ou de rétro-croisements (backcross), un total de 304 lignées hybrides (de F₃ à F₉) furent cultivées au champ en 1972. Dans la majorité des croisements, nous avons utilisé comme parent au moins un des cultivars suivants, Ottawa 705, R.H. 211 ou Penbell 69. Ces cultivars servirent aussi de comparaison en pépinière de sélection.

De ces lignées, nous en avons choisi au champ 84% en vue d'études ultérieures, mais un certain nombre de celles-ci seront probablement enlevées du groupe après analyse des données chimiques et agronomiques.

Résistance aux maladies. Un lot de 225

lignées hybrides et trois cultivars incluant Ottawa 705 furent cultivés en pépinière, laquelle était infectée artificiellement par le champignon de la pourriture noire des racines, *Thielaviopsis basicola* (Berk. & Br.) Ferr. La plupart des lignées (73,2%) étaient des hybrides de sixième génération.

Même si les conditions météorologiques durant la saison de végétation 1972 favorisaient le développement de la maladie, plus de 51% des lignées ont montré autant ou plus de résistance que le cultivar Ottawa 705. Cependant les deux autres cultivars ont semblé être moins résistants qu'Ottawa 705.

Test préliminaire. On évalua en 1972 un groupe de 26 lignées hybrides et 14 cultivars, y compris le cultivar témoin, Ottawa 705.

Le rendement d'une lignée et l'indice de revenu d'une autre furent significativement plus élevés que ceux du cultivar Ottawa 705. De l'ensemble des lignées, 42% eurent un nombre de feuilles significativement plus élevé qu'Ottawa 705, tandis qu'aucune n'eut significativement moins de feuilles. Les cultivars ont montré moins de variation dans les données morphologiques et agronomiques que les lignées hybrides.

Test avancé. Ce test groupait neuf lignées hybrides (huit de F₉ et une de F₇) et trois cultivars. Les lignées F₉ originent de trois croisements: Parfum d'Italie × R.H. 211 (une lignée); Parfum d'Italie × Ottawa 705 (cinq lignées) et Ottawa 705 × Havana L'Assomption (deux lignées), la lignée F₇ étant une sélection du croisement Penbell 69 × Havana L'Assomption. Une des cinq sélections du croisement Parfum d'Italie ×

Ottawa 705 eut un indice de revenu significativement plus élevé que le cultivar témoin, Ottawa 705. Comparées à celui-ci, 50% des lignées eurent un indice de qualité supérieur et conséquemment moins de déchets et 38% eurent plus de filasse totale. Le nombre de feuilles de 77% des lignées était significativement plus élevé, tandis que seulement 11% des lignées avaient un indice de feuilles significativement plus grand que le cultivar témoin. Nous avons noté dans le groupe des cultivars une plus grande variation dans les données morphologiques et agronomiques.

Dates de plantation. Nous avons planté à trois dates différentes le cultivar Ottawa 705 et une lignée hybride obtenue à la Ferme expérimentale de L'Assomption (L64-169). La première plantation s'effectua le 28 mai et les plantations subséquentes deux et quatre semaines plus tard. On utilisa trois taux d'espacement sur le rang, soit 36, 41 et 46 cm (14, 16 et 18 pouces) tandis que la distance entre les rangs restait uniforme à 97 cm (38 pouces).

Nous avons obtenu les plus hauts rendements (kg/ha), indices de revenus (\$/ha) et pourcentages de nicotine chez la plantation faite à la fin de mai avec un taux d'espacement de 41 cm (16 pouces). Le pourcentage de nicotine, l'indice de qualité et de revenu de la lignée hybride ont été significativement supérieurs au cultivar. Il n'y a pas eu de différence significative entre le rendement de la lignée et celui du cultivar.

Test de dégustation. Pour évaluation, nous avons soumis aux 270 membres de notre jury de dégustation les cigares fabriqués avec le tabac provenant des lignées hybrides et des cultivars témoins. Les résultats finals ne sont cependant pas disponibles pour ce rapport.

En 1972, nous avons cultivé au champ 28 lignées hybrides F_1 dans le but de définir si la production du tabac à cigare par lignée hybride F_1 est souhaitable en tenant compte de tous les facteurs d'appréciation incluant les qualités dégustatives des cigares.

Séchage. Dans le but de déterminer les meilleures conditions de séchage applicables aux producteurs de tabac à cigare, les études sur le séchage du tabac du cultivar Ottawa 705 se sont poursuivies en 1972. Celles-ci eurent lieu dans des séchoirs de type conventionnel avec l'aide d'un chauffage au charbon de bois et de ventilation électrique

supplémentaire et dans des chambres de séchage à température et humidité relative contrôlées.

Les résultats obtenus ont montré que le chauffage au charbon de bois améliorait la qualité du tabac. Des valeurs significativement supérieures aux conditions naturelles se sont révélées en faveur des traitements impliquant le chauffage au charbon de bois; ces valeurs comprenaient le pourcentage de filasses totales, l'indice de qualité et, ce qui est le plus intéressant pour les producteurs, l'indice de revenu (\$/ha). La combinaison d'une ventilation électrique supplémentaire avec le chauffage au charbon de bois comme mode de séchage du tabac à cigare semble améliorer la qualité dégustative des cigares. Cependant une application de ce traitement de séchage sur une grande échelle pourrait s'avérer trop coûteuse pour les producteurs de tabac à cigare.

Les résultats obtenus dans les chambres de séchage ont confirmé les effets favorables produits par un supplément de chaleur durant la période de séchage. Le tabac séché sous les températures de 32,2°C (90°F) ou 35°C (95°F) a donné un pourcentage de filasse totale, un indice de qualité, un rendement et un indice de revenu supérieurs au tabac séché sous 18,3°C (65°F) ou 23,8°C (75°F).

Tabac à cigarette

Évaluation des cultivars et des hybrides. En 1972, nous avons comparé la valeur agronomique de 14 cultivars et 40 lignées. Le cultivar Strain 205 s'est révélé le meilleur pour le rendement et le revenu brut à l'hectare, et il a produit un tabac d'excellente qualité. Le cultivar Strain M-32 s'est signalé le meilleur pour la qualité de la feuille et a produit le plus grand nombre de feuilles.

Quant aux hybrides, la lignée E20-2 a donné le meilleur rendement et revenu brut à l'hectare tandis que Coker 319 a produit un tabac de meilleure qualité.

L'effet du pH et de la fertilisation sur la croissance du tabac. En 1972, nous avons comparé entre eux six niveaux de pH différents. A chaque niveau, nous avons combiné trois taux d'engrais 2-12-12 T. Les résultats indiquent qu'un pH inférieur à 5,5 est néfaste à la plante. Seul l'indice de maturité n'a pas répondu aux traitements d'une manière significative. Nous avons

obtenu le meilleur rendement avec un pH de l'ordre de 6,0 et une application de 2 017 kg/ha (1 800 lb/acre), la plus haute qualité avec un pH de l'ordre de 5,5 et une dose d'engrais de 672 kg/ha (600 lb/acre) et le revenu maximum en combinant un pH de l'ordre de 6,0 à une application d'engrais de 2 017 kg/ha (1 800 lb/acre).

Répression des drageons du tabac. En 1972, nous avons comparé six produits différents pour la répression des drageons. L'essai comprenait aussi deux stades et deux méthodes d'application. Tous les produits ont assuré un bon contrôle des drageons. L'application manuelle et avant l'écimage a donné le meilleur rendement et le plus haut revenu à l'hectare. La meilleure qualité a été obtenue avec une application manuelle après l'écimage. Les produits employés étaient les suivants: Delspray T-148, PG-4 et G-8, de Proctor & Gamble Co. of Canada, Royaltac de UniRoyal Chemical, Division of UniRoyal Ltd; Emtrol 1630B, des Emery Industries (Canada) Ltd; Sucker-Plucker T-148, de Fisons (Canada) Ltd.

Répression des mauvaises herbes. Lorsque le sarclage mécanique est le seul moyen de lutte contre les mauvaises herbes, trois sarclages s'avèrent nécessaires pour un contrôle efficace et pour assurer un rendement et un revenu maximums.

Balan et Devrinol avec un seul sarclage mécanique ont donné un rendement et un revenu brut supérieurs aux trois sarclages mécaniques seuls. La population des mauvaises herbes était plus élevée à la fin de la saison de végétation et Balan n'assurait plus aucun contrôle des mauvaises herbes alors qu'avec Devrinol elle n'atteignait que 80% de celle des parcelles nettoyées avec trois sarclages mécaniques.

Lorsque les herbicides sont incorporés à l'aide d'une bêcheuse rotative, leur efficacité

est de beaucoup supérieure à celle que l'on obtient lorsqu'ils sont incorporés avec une herse à disques à directions perpendiculaires. La multiplication des sarclages améliore l'efficacité des herbicides lorsqu'incorporés à la herse, mais elle est de peu d'utilité quand ils sont incorporés à l'aide d'une bêcheuse rotative. Toutefois, l'incorporation à l'aide d'une bêcheuse rotative réduit le rendement et le revenu brut en deçà de ceux obtenus avec une incorporation à la herse.

Répression des nématodes. Nous avons comparé la fumigation d'automne à celle de printemps. Quatre nématocides, D-D, Telone, metam-sodium et Vorlex, ont été appliqués à la volée à l'automne, en rang et à la volée au printemps.

L'application d'automne a porté le rendement en-dessous de celui des parcelles non traitées. Lorsque les nématocides sont appliqués au printemps, le rendement et le revenu brut sont supérieurs à ceux des parcelles non traitées, sauf pour metam-sodium qui n'a apporté ni réduction, ni augmentation.

D-D et Vorlex en rang, plus les deux applications printanières de Telone, augmentent suffisamment le revenu brut pour couvrir les coûts des nématocides.

Répression des vers gris. Lorsqu'appliqués sur le seigle au taux de 0,56 kg d'ingrédient actif (IA)/ha (1/2 lb/acre), chlorpyrifos contrôle *Euxoa ochrogaster* (Guenee) à 89% et leptophos à 74%. Au taux de 2,2 kg IA/ha (2 lb/acre) sur le sol, chlorpyrifos donne 100% de contrôle et leptophos 93%.

Cette recherche sur le contrôle des vers gris entreprise en coopération avec les Stations de recherches de London, Ont. et St-Jean, Qué., ainsi qu'avec la Station de défense des cultures de L'Assomption, a été mise sur pied suite à la non-possibilité de l'application des recommandations faites aux producteurs de tabac de l'Ontario.

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Station de recherches Lennoxville, Québec

CADRES PROFESSIONNELS

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S. A. ROLA-PLESZCZYNSKI B.A., B.S.A., M.Sc.	Chimie analytique
Retraité	

INTRODUCTION

Le programme de recherches de cette Station est axé, en tout premier lieu, sur les productions animales, dont la principale est la production de la viande bovine. Il englobe aussi les productions fourragères, tant au point de vue de l'exploitation des cultures que de l'utilisation des sols.

En 1972, le progrès vers cette orientation générale fut surtout marqué par l'agrandissement des cadres professionnels. En effet, quatre scientifiques additionnels se sont joints au personnel existant, soit trois en zootechnie et un en productions fourragères. Il nous est ainsi possible d'entreprendre des recherches dans un domaine auquel nous n'avions pas encore touché, celui de la nutrition du ruminant.

Les résultats consignés dans ce rapport ne représentent qu'une partie de la recherche en cours, car ils ne se rapportent qu'aux expériences aux stades de recommandation ou de conclusion. On peut obtenir une brochure dans laquelle il est traité de façon plus détaillée de l'ampleur de la Station et de ses activités; adresser les demandes à la Station de recherches, Ministère de l'Agriculture du Canada, Lennoxville, Qué.

C. S. Bernard
Le directeur

ZOOTECHNIE

L'influence de la température du succédané de lait et du mode alimentaire sur la performance des veaux

On a étudié l'influence d'un succédané de lait servi aux températures de 37°C, 18°C et 1,5°C sur la croissance de veaux de lait et sur le rendement de leur carcasse. On a comparé en même temps deux modes alimentaires: l'alimentation contrôlée, où les veaux recevaient deux buvées par jour dans une chaudière, et l'alimentation à volonté qui permettait aux veaux de s'abreuver en tout temps. Soixante-six veaux mâles Holstein étaient assignés aux traitements.

Les gains moyens journaliers étaient de 0,89, 0,87 et 0,74 kg/tête au lait à 37°C, 18°C et 1,5°C respectivement, soit une différence significative ($P < 0,05$) au désavantage du lait servi froid. L'efficacité alimentaire, exprimée en matière sèche consommée par unité de gain en poids vif, était de 1,53 au lait chaud et au lait froid, et de 1,65 au lait à la température de la pièce. Le rendement en viande ne variait guère; cependant les carcasses des veaux nourris au lait à 18°C, dont le poids représentait 63,3% du poids vif, étaient légèrement supérieures à celles des deux autres groupes.

Le mode alimentaire n'a pas modifié significativement les gains moyens journaliers. Ils étaient de 0,81 kg à l'alimentation contrôlée et de 0,85 kg à l'alimentation à

volonté. Toutefois, par rapport à l'alimentation à volonté, l'alimentation contrôlée diminuait le rendement des carcasses d'environ 3% (62,0% contre 63,8%, $P < 0,05$) et augmentait l'efficacité alimentaire de 16% (1,44 contre 1,71, $P < 0,05$).

Les résultats démontrent clairement qu'il y a avantage à servir au jeune veau le lait soit chaud ou à la température de la pièce, et suivant un régime d'alimentation à volonté.

Taux de croissance et efficacité alimentaire de génisses croisées: boucherie × laitières

On a pesé, à intervalles réguliers, de la naissance jusqu'à l'âge d'un an, des génisses Charolais × Holstein (CHo), Charolais × Ayrshire (CA), Hereford × Holstein (HeHo) et Hereford × Ayrshire (HeA). A l'âge de six mois, les poids moyens des quatre groupes étaient de 151, 149, 141 et 139 kg respectivement, tandis qu'à l'âge d'un an, ils étaient, suivant le même ordre, de 305, 290, 290 et 276 kg.

On a mesuré l'efficacité alimentaire de chaque groupe pendant une période de 90 jours, à partir de l'âge de neuf mois. On leur servait, à volonté, une ration composée de 85% de fourrages et de 15% de concentrés. Les taux d'efficacité furent de 13,7, 12,9, 14,0 et 14,2 kg d'unités nutritives totales par kg de gain pour les croisements CHo, CA, HeHo et

HeA respectivement. Les différences n'étaient pas significatives.

L'influence de la race de béliers sur la production des agneaux de marché

Nous avons comparé 396 agneaux de marché issus de béliers Southdown de la Nouvelle-Zélande (SNZ), Southdown American (SA) et Suffolk (SU). Les sujets étaient abattus au poids vif de 20 ou 40 kg.

Les brebis accouplées aux béliers SA ont donné naissance à 7,0% plus d'agneaux. La mortalité des agneaux issus des béliers SNZ était de 3,7% et 11,8% inférieure à celle des progénitures des béliers SA et SU.

Les agneaux des béliers SU étaient plus lourds à la naissance et à l'âge de 28 jours. Ils atteignaient le poids de 20 kg en 83 jours, alors qu'il en fallait 82 et 88 pour ceux des béliers SNZ et SA. Enfin, l'âge à 40 kg était de 166, 172 et 188 jours pour les agneaux issus des béliers SU, SNZ et SA respectivement.

A l'abattage au poids de 20 kg, la classification et le fini des carcasses provenant des béliers SNZ et SA étaient supérieurs à ceux provenant des béliers SU. Toutefois, la différence n'était plus apparente lorsque l'abattage avait lieu à 40 kg.

La race de bélier n'a pas influencé d'une façon significative le rendement à l'abattage. Les agneaux issus des béliers SNZ avaient le pourcentage de maigre le plus élevé, tandis que les agneaux des béliers SU avaient le plus d'ossature, les coupes les plus longues et les organes internes les plus lourds.

Si l'on compare les agneaux légers aux agneaux lourds, ces derniers avaient une meilleure classification de carcasse et un meilleur fini, mais étaient inférieurs de 0,22% dans le rendement à l'abattage.

Performance des porcs de marché issus de truies croisées

On a enregistré l'âge au poids du marché et l'épaisseur du gras dorsal de 2 343 porcs issus de truies de 28 croisements différents et de verrats Poland China. Il était donc possible de comparer les croisements entre eux du point de vue de la production d'un porc de marché. D'après ces deux critères, les porcs issus des truies Hampshire × Landrace, Lacombe × Landrace et Hampshire × Lacombe étaient les plus avantageux. En général, les porcs dont les mères étaient moitié Landrace ou moitié Duroc avaient les

taux de croissance les plus élevés, tandis que ceux dont les mères étaient moitié Hampshire avaient le moins de gras dorsal.

Composition chimique du colostrum et du lait provenant de sept races de truies

On a étudié la composition chimique du colostrum et du lait de truies des races Yorkshire, Landrace, Lacombe, Duroc, Hampshire, Berkshire et Large Black aux quatre stades de lactation de 1, 14, 28 et 35 jours après la mise bas. Les moyennes générales des constituants furent: gravité spécifique, 39°Q/15,6°C; énergie, 1,11 kcal/g; cendre, 1,04%; solides totaux, 19,0%; gras, 6,3%; protéines, 5,4%; Ca, 0,20%; Na 0,04%; K, 0,10%; Mg, 0,02% et P, 0,17%. L'énergie et les pourcentages de cendre, de matières solides totales, de gras, de Na, de K, de Mg et de P variaient significativement entre les races. Les races Yorkshire, Hampshire et Lacombe étaient supérieures aux autres races quant à la composition de leur lait. Au cours de la lactation, on a observé des changements significatifs de teneur en cendre, solides totaux, protéines, Ca et P.

PRODUCTIONS VÉGÉTALES

Régie et fertilisation du maïs

On étudie l'effet des taux de semis et des doses de N, P et K sur les rendements de trois hybrides de maïs de maturité différente.

Le but de cette expérience est de déterminer la catégorie de maturité du maïs, l'engrais et la population susceptible de fournir un maximum de matière sèche digestible par unité de surface. Les divers facteurs de qualité sont déjà évalués; cependant, les résultats d'analyses alimentaires sont encore trop peu nombreux pour les considérer ici. Seuls les rendements de matière sèche appuient notre argumentation.

Tout indique qu'il y a avantage à hausser le taux de semis du maïs ensilage jusqu'à l'obtention de 120 000 plants/ha (48 000 plants/acre). Cela représente le double du taux de semis recommandé actuellement; les 20 kg/ha (18 lb/acre) supplémentaires de semence ont permis un accroissement de production de l'ordre de 2,5 t de matière sèche/ha (1 tonne/acre), soit de 15 à 20%.

Les apports d'azote ont également eu un effet significatif. L'application de 100 kg/ha (90 lb/acre) produit un accroissement de 2 t/ha (1 800 lb/acre) de matière sèche.

Cependant, l'efficacité de l'application de 100 kg/ha supplémentaires diminue rapidement. Il semble qu'il y ait avantage à utiliser 200 kg/ha (180 lb/acre) de N seulement lorsque la densité du semis est élevée.

La productivité des hybrides utilisés varie passablement. Elle semble plutôt liée à leur adaptation spécifique qu'à leur catégorie de maturité. L'hybride hâtif produit un plus fort tonnage d'épis par unité de surface mais fournit généralement moins de matière sèche totale. La qualité de l'ensilage devrait en être sensiblement améliorée.

L'augmentation de la densité du semis ainsi que l'apport de K ont légèrement retardé la maturation des plants.

Il est à noter qu'il s'agit ici d'un essai effectué sur un sol dont la teneur en P et en K est très élevée. Dans ce cas, il paraît peu opportun de recommander l'application de ces éléments fertilisants.

Le chaulage des sols acides en regard des céréales et plantes fourragères

En 1960, la Station de recherches de Lennoxville entreprenait une étude détaillée de l'action du chaulage sur le pH et la teneur en éléments nutritifs des sols et sur le rendement et la composition chimique des céréales et des plantes fourragères.

La chaux a montré une action très marquée sur les sols étudiés. Cependant, on ne peut faire d'énoncé général concernant le pH optimum ou les doses de chaux à utiliser, à cause du comportement différentiel des plantes et des sols en regard du chaulage.

Les rendements des légumineuses par rapport au pH du sol ont varié selon les types de sol. Sur l'argile Sainte-Rosalie, les rendements en matière sèche se sont accrus de façon linéaire avec les pH du sol, et ce jusqu'au pH le plus élevé, soit 7,5. Sur le loam de Greensboro et le loam limoneux de Coaticook, les rendements des légumineuses ont augmenté jusqu'au pH 6,0 à 6,5. Au pH 7,5, le surchaulage a considérablement diminué la production. Sur le sable Saint-Jude, le chaulage n'a produit qu'une légère augmentation de rendements de l'ordre de 10%, même si le pH original du sol était de 5,0.

Les plantes ont réagi différemment au

changement de pH des sols. La luzerne s'est montrée très exigeante en chaux. On y a doublé les rendements sur presque tous les types de sol en maintenant le pH entre 6,5 et 7,0. Les autres légumineuses (trèfle rouge, trèfle ladino et lotier) ont moins bien répondu au chaulage; toutefois, leur production augmentait de 40 à 60% sur sol chaulé entre pH 6,0 et pH 6,5.

L'avoine et l'orge ont peu bénéficié des applications de chaux, excepté sur le loam limoneux de Coaticook, où le fait d'augmenter le pH de 5,0 à 6,0 ou 6,5 a doublé les rendements. L'augmentation obtenue chez le mil à la suite du chaulage a été de 15% seulement.

Les éléments mineurs influent nettement sur le type d'action que la chaux peut avoir sur une plante croissant dans un sol donné. Ainsi, les céréales et les légumineuses, croissant en un loam de Greensboro de pH 4,5 et contenant plus de 1 500 ppm de Mn, ont manifesté des symptômes de toxicité au Mn et le chaulage a énormément augmenté leurs rendements. Par contre, la réponse à la chaux a été presque nulle sur le sable Saint-Jude ne contenant que 140 ppm de Mn échangeable à pH 5,1.

Les effets de surchaulage observés sur le loam limoneux de Coaticook et le loam de Greensboro ont été causés par des carences de B, dont les symptômes se manifestaient très clairement à pH 7,4.

Enfin, le pourcentage d'humidité du sol modifie quelquefois l'action du chaulage. Ainsi, quand le sol était saturé d'eau, les rendements de luzerne s'accroissaient de façon linéaire à mesure qu'on élevait le pH de l'argile Sainte-Rosalie et du sable Saint-Jude de 5,0 à 6,5, puis à 7,5. Mais lorsqu'on ajustait l'humidité à la capacité de rétention d'eau du sol, et même lorsqu'on la laissait diminuer au point de flétrissement, le rendement maximum en luzerne se constatait à pH 6,5, suivi d'une diminution sur sol chaulé à 7,5.

Ces expériences démontrent que les sols du Québec répondent bien au chaulage, mais qu'une seule recommandation générale ne peut convenir à tous les types de sol, ni à toutes les cultures.

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Station de recherches Sainte-Foy, Québec

CADRES PROFESSIONNELS

S. J. BOURGET, B.Sc. (Agr.), M.S., Ph.D.	Directeur
J. R. FRAPPIER, B.A.	Services administratifs

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Départs

C. AUBÉ, B.Sc. (Agr.), M.Sc., Ph.D. Ministère des Sciences et de la Technologie, Ottawa, juillet 1972	Chef de la section de phytoprotection; maladies des légumineuses
G. PELLETIER, B.Sc. (Agr.), M.Sc. Station de recherches, Lennoxville, Québec, septembre 1972	Plantes fourragères

¹Détaché de la Direction de l'économie du ministère de l'Agriculture du Canada.

INTRODUCTION

La Station de Sainte-Foy groupe les programmes de recherches de Sainte-Foy, La Pocatière et Normandin. A ces deux derniers endroits, les activités sont à caractère polyvalent, alors qu'à Sainte-Foy la recherche porte sur les plantes fourragères, les céréales et les sols.

Ce rapport présente un résumé des résultats obtenus en 1972. Il faut dire que le rôle qu'exerce le personnel de la Station par les contacts et la coopération avec d'autres organismes dépasse de beaucoup les cadres de cette recherche. Adressez toute demande de renseignements à: Station de recherches, Ministère de l'Agriculture du Canada, 2560 Chemin Gomin, Sainte-Foy, Québec.

S. J. Bourget
Le directeur

LES PLANTES

Tolérance au froid

Synthèse des protéines. Des études sur l'absorption de substances nutritives par des plantules de blé d'hiver soumises à des conditions d'endurcissement (journées courtes, basse température) ont montré qu'après deux jours d'endurcissement, le taux d'absorption de L-leucine- $U-^{14}C$, $^{33}PO_4^{-3}$ et H_2O a diminué. La résistance des plantules à la gelée est plus grande après deux jours d'endurcissement.

On a administré de la leucine- ^{14}C à des plantes endurcies et tendres. L'absorption de cet acide aminé par les plantes et son incorporation dans les protéines ont été mesurées pour déterminer le taux de synthèse des protéines. Les plantes endurcies synthétisent les protéines plus rapidement que les plantes tendres, aussi bien à basse température qu'à température normale. Au cours de l'endurcissement, le taux de synthèse des protéines a augmenté plus chez une variété très résistante que chez une variété moins résistante.

Changement dans les lipides. L'endurcissement artificiel de la luzerne stimule la synthèse de l'acide linoléique à partir de l'acétate- ^{14}C , à basse température ($1^{\circ}C$), dans la racine. Cette stimulation est beaucoup plus prononcée chez la variété rustique Rambler que chez la variété tendre Caliverde. Le site de cette synthèse augmentée serait les microsomes. Les folioles de la luzerne incorporent la choline- $1,2-^{14}C$ dans au moins six espèces moléculaires de phosphatidylcholine. L'interprétation la plus plausible des résultats, surtout l'activité spécifique des espèces, c'est

que la phosphorylcholine est acceptée par des diglycérides contenant un résidu linoléique qui est ensuite désaturé en linoléique à l'intérieur de la molécule de phosphatidylcholine.

Le chlorméquat. L'étude du mode d'action du chlorméquat (CCC) se poursuit par la radio-autographie de tissus de luzerne marqués au chlorméquat- ^{14}C et à la choline- ^{14}C , ainsi que la mise au point du dosage du chlorméquat et de la choline par chromatographie gazeuse. Le chlorméquat favorise fortement l'endurcissement artificiel (en cabinet de croissance) de la variété rustique de luzerne Rambler. Son seuil de résistance est abaissé de 2,5 degrés (C). Ce composé favorise également, mais légèrement, la résistance à la gelée de plantes non endurcies, surtout de la variété tendre Caliverde.

La luzerne. Des plants de luzerne de la variété rustique Rambler, cultivés dans de la vermiculite avec des solutions hydroponiques et endurcis pendant quatre semaines à $2^{\circ}C$, montrent à $-12^{\circ}C$ un taux de survie de 5%. Ce taux s'élève à 100% à $-16^{\circ}C$ et à 80% à $-18^{\circ}C$ chez des plants de la même variété, endurcis dans les mêmes conditions mais cultivés dans un terreau adéquatement fertilisé. Par contre, le taux de survie d'une variété sensible telle que Caliverde est de 50% à $-11,5^{\circ}C$ et de 5% seulement à $-16^{\circ}C$. Nous avons également observé au cours de l'endurcissement une augmentation de la matière sèche du feuillage et des collets de la variété Rambler. Ces résultats indiquent que

la vigueur des plants est un élément important de l'endurcissement et de la survie à l'hiver.

Métabolisme de la proline. L'endurcissement des plants de luzerne à 2°C pendant deux semaines a augmenté le contenu en proline libre de la partie aérienne de 12 à 21 μ moles/g de matière fraîche, de 13 à 28 μ moles dans les collets et de 6 à 14 μ moles dans les racines. Une prolongation de la période d'endurcissement à quatre semaines n'a pas augmenté ces quantités. Le rapprochement de ces résultats avec ceux de la survie indique que la luzerne serait complètement endurcie après deux semaines à 2°C. Le contenu en proline de la luzerne est beaucoup plus élevé que celui de l'orge, mais augmente beaucoup moins au cours de l'endurcissement. Le traitement de la luzerne avec le chlorméquat, susceptible d'augmenter sa résistance au froid, augmente légèrement son contenu en proline libre.

L'endurcissement de la variété d'orge d'hiver rustique Kearny augmente le contenu en proline libre de la partie aérienne de 1,1 μ mole à 10 μ moles/g de matière fraîche, de 1,3 à 17 μ moles dans les collets et de 1,3 à 4,0 μ moles dans les racines. Chez une variété sensible telle que la Hudson, l'endurcissement diminue le contenu en proline libre pendant les premiers jours et l'augmente par la suite. Ainsi dans les parties aériennes, le contenu en proline passe de 5 à 0,8 μ moles après 10 jours d'endurcissement et remonte à 7,5 μ moles après trois semaines. Dans les collets, il passe de 8,0 à 0,9 μ moles pour remonter à 15 μ moles.

Plantes fourragères

Étude agro-écologique. Trois sites, représentant chacun une zone écologique différente, ont été choisis dans le comté de Rivière-du-Loup. En mai 1972, on y a semé en semis pur et selon une régie uniforme, quatre espèces de légumineuses (luzerne, trèfle rouge, trèfle blanc, lotier), trois espèces de graminées (mil, brome, alpiste roseau), trois espèces de céréales (avoine, orge, blé), du maïs d'ensilage et du chou fourrager. De plus, une station de météo a été installée à chaque site, afin de mesurer les conditions climatiques au cours de la saison de croissance.

Les résultats de la première année semblent justifier l'hypothèse que les trois sites

étudiés soient écologiquement et agronomiquement différents. Les conditions climatiques varient d'un site à l'autre du point de vue de la précipitation, des températures minimum et maximum, du nombre de degrés-jours, et de la température et de l'humidité du sol. La population des mauvaises herbes varie également d'un site à l'autre. Le site 1 (écologiquement nommé zone à pâturin du Canada/renoncule âcre/épervière orangée) est caractérisé par la silène enflée, le pâturin du Canada, la bourse-à-pasteur, le chiendent et la stellaire moyenne. Le site 2 (écologiquement nommé zone à danthonie/épervière piloselle) est caractérisé par la scléranthe annuelle, le chiendent, les renouées persicaire et liseron et l'ortie royale. Le site 3 (écologiquement nommé zone à fétuque rouge/renoncule âcre) est caractérisé par la fétuque rouge, la prêle des champs, la spargoute, le chiendent et l'ortie royale.

Le rendement des espèces semées est également différent d'un site à l'autre. Leur établissement fut excellent sur tous les sites sauf pour la luzerne aux sites 2 et 3 et pour le brome, l'alpiste roseau et le maïs au site 3. Les rendements sont généralement faibles. Sur le site 1, toutes les espèces, sauf le trèfle blanc et le trèfle rouge, ont donné de bons rendements. Sur le site 2, toutes les espèces, sauf la luzerne, l'orge et le blé, ont donné des rendements satisfaisants. Sur le site 3, toutes les espèces ont donné de faibles rendements à cause de la compétition des mauvaises herbes (spécialement la spargoute). Le mil et le chou fourrager ont mieux réagi aux conditions du site 3. L'alpiste roseau, le brome, l'orge et le maïs ont fait piètre figure.

Nématologie. Nous avons continué en 1972 l'enquête entreprise au Québec en 1971, afin d'acquérir une meilleure connaissance des types de nématodes parasites des plantes associés aux principales légumineuses fourragères dans l'est du Canada. Après avoir parcouru cet été 443 ha de champs fourragers, répartis dans 27 comtés, nous avons recueilli 132 échantillons de sol et de racines répartis comme suit: luzerne, 62; trèfle rouge, 70. Ces échantillons ont été analysés à la Station de recherches de Vineland (Ont.). Les types de nématodes rencontrés le plus souvent sont:

SOL:

Pratylenchus (nématode radicicole), 80%,

densité de population par 0,50 kg de sol (poids sec), 854

Paratylenchus (nématode acuminé), 66%, 360

Helicotylenchus (nématode spiral), 51%, 445

Meloidogyne (nématode cécidogène), 26%, 966

Heterodera (nématode formant des kystes), 19%, 266

Criconemoides (nématode-anneau), 13%, 88

Tylenchorhynchus (nématode provoquant le nanisme), 4%, 200

Xiphinema (nématode-stylet), 2%, 53

RACINES:

Pratylenchus (radicicole), 80%, 87

Meloidogyne (cécidogène), 35%, 377

Helicotylenchus (spiral), 23%, 16

Heterodera (formant des kystes), 10%, 25

Paratylenchus (stylet), 9%, 8

A ce jour, 52% de la superficie totale de foin cultivé au Québec ont été inventoriés.

La luzerne

Amélioration. Des 1 300 plantes mises au champ en automne 1971, seulement quelques 360 ont survécu à l'hiver. Il faut dire que la transplantation s'était faite assez tard dans l'automne. Ces plantes ont été regroupées et laissées à elles-mêmes encore tout l'été. Nous avons fait un relevé des couleurs de fleurs afin de séparer les plantes d'un même clone. Des autofécondations des variétés Europe, Saranac et Iroquois ont été obtenues en quantité au cours de l'hiver 1972-73. Les graines S₁ ont été prégermées et transplantées à Ste-Foy et à Normandin. A Normandin, nous avons aussi transplanté 64 croisements Iroquois × WL-303 obtenus d'Ottawa et représentant quelques 6 800 plantes.

Spécificité et efficacité de Rhizobium meliloti. A partir des nodules de plantes de luzerne, de différentes provenances, nous avons isolé en culture pure 21 souches de *Rhizobium meliloti* sur la variété de luzerne Saranac, trois souches sur la variété Dupuis, sept souches sur la variété Vernal, cinq souches sur la variété Alfa, quatre souches sur la variété Iroquois, deux souches sur la variété Europe, et une souche sur la variété Rambler. Tous ces isolats sont considérés comme des souches différentes à cause de leur origine, que varie selon le type de sol ou de lieu, selon la variété de la plante ou selon

une combinaison de ces conditions. Nous avons aussi obtenu cinq souches commerciales de *Rhizobium meliloti* dont une de l'Ouest canadien, deux du North Dakota et une de la Belgique. Des 21 souches isolées sur la variété Saranac, deux ont montré une lysogénie marquée par le bactériophage du *Rhizobium*, et elles furent éliminées pour les essais d'efficacité. Nous sommes à étudier l'efficacité des 52 souches restantes en ce qui regarde la fixation symbiotique de l'azote atmosphérique sur la luzerne; la matière sèche produite et la quantité d'azote totale fixée sont les deux critères de la première évaluation. Dans cette étude, les facteurs climatiques et culturels qui prévalent au Québec sont pris en considération. Des résultats préliminaires nous indiquent qu'il y a interaction souche × variété, et que les souches commerciales ont moins d'adaptabilité que certaines souches isolées de nos sols.

Le trèfle rouge

Longévité. Neuf variétés de trèfle rouge, des diploïdes et des tétraploïdes, des variétés dites à «une coupe» et «deux coupes», ont été transplantées en pot au début novembre 1971. Le terreau avait été stérilisé au préalable, afin d'éviter toute perte due à la maladie. Le travail a été effectué entièrement en chambre de croissance. Nous avons cessé les coupes vers la fin de septembre; à cette date les variétés à deux coupes avaient été récoltées 14 fois tandis que la variété Tammisto, à une coupe, n'avait subi que 10 récoltes.

L'analyse des résultats n'est pas encore terminée, mais celle des six premières coupes nous a révélé que la variété Tammisto a donné le rendement le plus élevé. Ceci est vrai autant pour les six coupes que pour une même date. C'est à dire qu'au 24 avril, la Tammisto donnait plus de rendement après quatre coupes que toutes les autres variétés, dont certaines avaient déjà subi six coupes. Étant donné que les coupes se faisaient autant que possible uniformément au stade bouton, ces résultats sont déjà très significatifs. L'analyse complète de tous les résultats confirmera ou infirmera cette tendance.

Tache zonée. Nous avons continué à évaluer les pertes causées par le *Stemphylium* sur le trèfle rouge dans les parcelles situées à La Pocatière, Normandin et Ste-Foy. Le Dyrène (Chemagro Corp.) s'est avéré très efficace

pour protéger les feuilles. En serre, le *Stemphylium sarcinaeforme* a causé des pertes variant de 32 à 41% du poids sec et de 33 à 43% de protéine suivant les cultivars utilisés. Les pertes du feuillage de la variété Dollard se sont établies à 45,9% et celles de la variété Hungaropoli à 37,0%. Cette dernière variété s'est manifestée définitivement plus résistante à l'infection par le *Stemphylium* que les cultivars Ottawa, Dollard et Lakeland, aussi bien en serre que dans les trois sites de parcelles.

Pathogénécité des champignons du sol. L'indice de pourriture des racines du trèfle rouge dans les parcelles à La Pocatière et Normandin montre un progrès constant depuis l'année du semis en 1970. A La Pocatière, l'indice est passé de 0,51 au 1^{er} juin 1971 à 2,22 au 17 août de la même année. L'hiver subséquent ayant entraîné la mort des plantes les plus faibles, l'indice au 14 juin 1972 s'abaissait à 1,39, mais il devait atteindre 3,03 au 23 août 1972. A Normandin, au cours de la même période l'indice passait de 0,72 à 2,68 en 1971 et de 2,72 à 3,36 au cours de l'été 1972.

Au cours de la période d'observation, les variétés Dollard et Ottawa ont toujours donné un indice de pourriture plus faible que les variétés Lakeland et Hungaropoli, et cela aux deux sites. La variété Hungaropoli est incontestablement plus susceptible que les trois autres, ayant un indice de maladie d'environ 30% supérieur à celui de Dollard ou Ottawa.

La protection du feuillage contre la tache zonée a contribué à réduire l'indice de pourriture des racines d'environ 7%.

Les céréales

Dans le but d'échantillonner les organismes responsables des maladies fongiques au Québec, nous avons parcouru une cinquantaine de fermes au sud-est de Montréal, sur la côte sud du St-Laurent et au Lac St-Jean. Environ 150 isolats de champignons pathogènes ont été récoltés et sont conservés en culture pour des tests ultérieurs, dans la serre ou dans le champ. Les données pathologiques ont été prises en fonction de l'écologie du milieu et de la région. L'incidence et la sévérité des principales maladies ont été déterminées. Malgré les conditions environnantes assez médiocres qui ont prévalu au cours de l'été, les maladies du feuillage des céréales n'étaient pas aussi sévères qu'on le

prévoyait. Cependant, on a noté une incidence plus grande de maladies de la pourriture des grains et des racines. L'ergot des céréales se retrouvait sur toutes les espèces de céréales cultivées et principalement au Lac St-Jean. En somme, les diminutions de rendement observées surtout dans la région de Montréal étaient dues aux mauvaises conditions météorologiques plutôt qu'aux maladies fongiques.

L'avoine

Évaluation. Dans les essais coopératifs de l'est, quatre des 21 lignées, évaluées pour leur potentiel de rendement, résistance à la verse et autres caractères, provenaient du programme d'amélioration de Ste-Foy. Une autre lignée s'était qualifiée, mais n'a pu être évaluée faute d'espace dans l'essai. Une lignée (QO 115.1.2) semble prometteuse, ayant rendu 30% de plus à La Pocatière que la variété Dorval. Sa paille semble aussi bonne que celle de ce même témoin. Les trois autres lignées (QO 126.7, QO 126.13 et QO 130.4) ont aussi un très bon rendement, surpassant le meilleur témoin.

Amélioration. L'amélioration génétique de l'avoine se fait en deux phases bien distinctes: la sélection et l'évaluation. La phase de sélection comprend cinq générations de ségrégation, ce qui permet de choisir les meilleurs plants ou lignées et d'éliminer ceux qui ne répondent pas aux objectifs fixés. Quelques 250 croisements à tous les niveaux de ségrégation ont été sélectionnés pour leur rendement et la résistance à la verse principalement; la hâiveté, la résistance à la septoriose et au BYDV (barley yellow dwarf virus), sont venus se greffer aux objectifs principaux. Parmi ces 250 croisements, 164 ont été retenus, donnant naissance à quelques 5 000 lignées différentes. La phase d'évaluation suit la cinquième génération de ségrégation où les plants ont atteint un homozygoté certaine. Cette évaluation se fait sur six années consécutives, dont les trois premières sont spécifiques au groupe d'amélioration du Québec. Une sélection parallèle est faite pour chacune de ces six années d'évaluation. Un rapport rédigé par le responsable de l'amélioration de l'avoine est préparé chaque année. Des quelques quarante lignées, provenant de dix croisements différents, évaluées, dix seulement ont été retenues sur leur mérite.

Quelque cent croisements différents ont été

réalisés, la majorité pour répondre à l'objectif principal, c'est-à-dire le rendement. Une dizaine ont été faits pour la résistance au BYDV en utilisant les sources de résistance provenant de l'ouest, mais identifiées comme tel avec les virus de l'est par le Dr A. Comeau. De plus, nous avons semé 804 lignées de la collection internationale d'avoine afin de les observer sous nos conditions et évaluer leur résistance au BYDV. Les lignées CI 00838, CI 00908, CI 01070, CI 01676, CI 01837, CI 01962, semblent offrir des possibilités et seront sûrement inclus dans les croisements futurs.

Septoriose. *Septoria avenae*, cause de la tache septorienne et de la tige noire de l'avoine, montre une variation culturelle importante lorsque soumise à différentes conditions de milieu. Un milieu de culture préparé à base de feuilles d'orge s'est avéré le plus propice à une production abondante et rapide de macroconidies. Une incubation en tubes à essais (diamètre 20 mm) placés à l'intérieur de sacs de polyéthylène, à 24°C et à la noirceur, assure une production suffisante de conidies en six jours. Pour assurer un développement rapide de colonies sporulantes, il est important de bien étendre le matériel transféré, qui consiste uniquement de macroconidies. Une méthode d'inoculation a été développée de façon à permettre le dépistage de variétés d'avoine plus tolérantes.

L'orge

Évaluation. La variété d'orge Champlain a été remplacée par QB 46.127 comme variété à rendement supérieur en grain alimentaire dans les essais pour l'est du Canada. Cette nouvelle variété donne des rendements égaux ou supérieurs à ceux de Champlain et, de plus, possède une meilleure résistance à la verse.

Amélioration. Environ 2 000 nouvelles lignées de la collection internationale d'orge ont été semées et sélectionnées selon les critères: date d'épiaison, maturité, verse, largeur et longueur de la feuille étendard et tolérance au BYDV. Les lignées d'orge à six rangs C.I. 04122, 01242, 01612, 10284 et 10226 ont été retenues de la pépinière 1971, et utilisées dans les croisements 1972 comme sources de feuilles étendards larges et longues.

Effet mutagénique des pesticides. Des

plantules d'orge ont été traitées avec les pesticides suivants: picloram, atrazine, Pirmicarb (Chipman Chemicals), Malovan (Ciba Corp.), C-9122 (Ciba Corp.) et trifluralin. Le picloram, l'atrazine et le C-9122 ne semblent pas avoir d'effet mutagénique mais, par contre, l'influence du trifluralin est radicale et consistante. Il en résulte qu'un grand nombre de cellules demeurent endopolyploïdes, c'est-à-dire les chromosomes s'y multiplient et la division cellulaire n'est pas normale.

Le blé

Évaluation. Les variétés de blé de printemps Opal et Pitic 62 continuent à donner des rendements en grains supérieurs à ceux de Selkirk dans l'ensemble du Québec.

Effet de l'Éthrel. L'Éthrel (Amchem Prod.) a été utilisé comme agent inducteur de stérilité mâle sur 14 variétés de blé de printemps en serres et en chambres de croissance. Une double application à 1 500 ppm a produit une stérilité plus complète qu'une seule application à un stage déterminé de croissance. Des variétés de même âge, et qui semblaient être d'un développement morphologique pareil, ont réagi différemment. Sous les conditions des chambres de croissance, l'Éthrel pourrait être utilisé comme inducteur de stérilité mâle chez certaines variétés de blé de printemps.

LES SOLS

Caractérisation

Profils à drainage déficient. Nous avons procédé à la détermination de certaines propriétés physiques, chimiques et minéralogiques des séries Chaloupe et Batiscan, sols développés dans le comté de Portneuf. Ces deux loams sableux, classifiés respectivement comme gleysol humique régosolique et podzol humo-ferrique orthique, sont d'origine post-Champlain (profluviale). La série Chaloupe présentait une discontinuité lithologique bien définie sous l'horizon Cg; les quantités de sable et de limon passaient respectivement de 93 et 6% dans l'horizon Cg à 31 et 58% dans l'horizon IICg. La série Batiscan présentait de minces couches (1 cm environ) plus compactes entre 58 et 68 cm. Ces couches contenaient de 15 à 20% plus de limon et des quantités d'argile supérieures à celles notées dans les horizons adjacents. Les teneurs plus élevées en oxydes

de fer ainsi que la présence de quantités supérieures de matériel plus fin, attribuable aux variations au cours de la période de déposition, seraient responsables de la formation de ces couches indurées.

La minéralogie de la fraction argileuse de ces profils montrait la dominance de vermiculite chloritisée dans les horizons supérieurs et, en profondeur, de vermiculite. Le chlorite et l'illite se retrouvaient en faibles quantités dans tous les horizons, l'illite augmentant avec la profondeur. La séparation des minéraux lourds (densité $> 2,90$) dans les fractions sable fin ($250-100 \mu\text{m}$) et très fin ($100-50 \mu\text{m}$) a montré la dominance de la hornblende dans ces fractions. La magnétite, qui formait de minces lits principalement dans la série Batiscan, se retrouvait dans la fraction très fine des sables de la plupart des horizons. Les minéraux légers (densité $< 2,90$) comprenaient, outre le quartz, des feldspaths plagioclases et potassiques et un mica de couleur verdâtre, partiellement altéré. Ce mica donnait à l'examen aux rayons-X des raies à 1, 0,5 et 0,33 nm ainsi qu'un pic très intense à 1,24 nm, lequel se déplaçait à 1,3 nm sous l'effet du glycérol. Ce minéral, la glauconie, s'altérait en smectite et était également associé à une faible quantité de kaolinite.

Profils à horizons indurés. On a complété les analyses de plusieurs profils des séries St-Onésime, Manic, Mont-Carmel et Ixworth. Ces séries se trouvent sur le versant nord des Appalaches et se sont développées sur les roches du groupe d'Armagh. En général, on y a constaté une expression moins bien marquée des caractères morphologiques typiques du fragipan et, en particulier, du réseau polygonal des fentes de retrait (stries grisâtres). Ceci peut se comprendre si on admet que ce réseau est dû à une alternance de périodes humides et de dessèchement dans les profils. La compilation des résultats va nous permettre de faire une comparaison avec les sols à fragipan développés sur le versant sud.

Dans la région de Robertsonville, nous avons échantillonné et analysé un profil de sol à fragipan. Les caractères morphologiques extrêmes qu'on pouvait observer sur le terrain entre les horizons supérieurs et le fragipan nous ont amenés à en faire un examen micromorphologique. Celui-ci a confirmé les observations faites lors de l'échantillonnage: différence extrême dans la densité

des horizons, qui suggère une très forte dégradation au-dessus du pan, et une grande compacité du limon et des grains de sable dans les horizons inférieurs. Il nous reste à en mesurer la porosité et la répartition des pores suivant le diamètre, ce qui comblera la lacune entre les analyses physiques et l'examen micromorphologique.

Fertilité

Poudre d'amiante vs engrais magnésiens. La plupart des sols podzoliques du Québec sont pauvres en magnésium, ou alors souffrent de la compétition avec d'autres ions (K, Ca). Dans la première étape, on a fait pousser de l'avoine sur deux séries de sol, le loam sableux Leeds et le loam Ste-Marie. On a séparé l'effet de la chaux de celui de l'engrais magnésien (trois formes, plus l'amiante) par un système expérimental du type 3×3 . Il semble que le loam Ste-Marie ait mieux répondu aux traitements que le sol Leeds et, d'autre part, l'effet de la poudre d'amiante n'a pas été inférieur à celui des engrais magnésiens commerciaux. A certains niveaux en Mg, le rendement a été nettement augmenté. Après la récolte de l'avoine, on a mesuré le pH final des sols. En absence de chaux, les formes d'engrais magnésiens ne contribuent pas à relever le pH. On a donc poursuivi, dans les mêmes pots, l'expérience avec une deuxième culture, la luzerne, pour tester l'effet à long terme des engrais magnésiens. On a effectué trois coupes sur la luzerne. Les résultats tendent encore à confirmer ceux obtenus avec l'avoine. Pour compléter ces essais sur les possibilités d'applications de la poudre d'amiante comme amendement magnésien, on a commencé une expérience avec la pomme de terre qui devrait être beaucoup plus sensible à l'ion Mg.

Poudre d'amiante vs population microbienne. Dans la région de Thetford-Black Lake, nous avons étudié quatre profils dont trois avaient reçu des retombées de poussières d'amiante. Il semble que le matériel basique n'a pas affecté la population totale des bactéries telluriques, mais il a réduit celle des champignons. Les groupes de bactéries facultativement autotrophes étaient concentrés dans les horizons du solum où

l'apport des poussières d'amiante a été le plus important.

FERME EXPÉRIMENTALE, LA POCATIÈRE

Les plantes fourragères

Influence des formes d'azote. Les quatre formes d'azote ont donné des réponses positives: NH_4NO_3 jusqu'à 112 kg/ha, et l'urée, NH_4NO_3 -split et l'urée-soufre jusqu'à 300 kg/ha. Le soufre n'a pas donné de réponse positive et l'urée-soufre a réduit les rendements par rapport à NH_4NO_3 et l'urée. Le nitrate a donné des rendements moindres que l'urée. A la deuxième coupe, les réponses étaient les suivantes: NH_4NO_3 jusqu'à 336 kg/ha, soufre sans réponse, l'urée jusqu'à 112 kg/ha et l'urée-soufre jusqu'à 336 kg/ha. Le NO_3 et l'urée étaient favorisés par rapport à l'urée-soufre. Il semble que l'azote dans l'urée-soufre n'est pas libéré assez vite. Aussi, il est avantageux d'appliquer l'azote en une seule dose.

Effet de N, P, K. Le lotier a profité de 45 kg/ha de N et de 93 kg/ha de K sur le sol à Saint-André, à la première coupe. La luzerne a profité de 22 kg/ha de N, de 52 kg/ha de P et de 83 kg/ha de K, en première coupe. La réponse, en deuxième coupe, a été nulle pour N, 52 kg/ha pour P et 166 kg/ha pour K. Sur le sol de Kamouraska, la réponse a été de 22 kg/ha de N, de 52 kg/ha de P et de 93 kg/ha de K.

Influence de la date et du taux de semis de la luzerne. Des semis effectués le 28 avril, le 12 mai et le 28 mai 1971 et le 8 mai, le 18 mai et le 31 mai 1972 montrent que la période la plus favorable à l'ensemencement de la luzerne se situerait aux environs du 10 mai. En effet, l'année d'implantation, ce sont les semis du 12 mai 1971 et du 8 mai 1972 qui ont donné le meilleur rendement. L'année après implantation (semis 71, récolte 72), l'effet de la date de semis se faisait encore sentir. Le taux de semis ne semble pas avoir eu beaucoup d'influence sur le rendement.

Le même semis répété au cours d'août 1971, soit le 2, le 17 et le 27, montre que c'est le semis du 2 août qui a donné le meilleur résultat, suivi du 17 et ensuite du 27. Le taux de semis a eu peu d'influence sur le rendement.

La récolte de 1972, de la meilleure date de

semis du printemps 1971 et de la meilleure du mois d'août 1971, montre un rendement supérieur du semis de printemps d'environ 1 000 kg/ha de matière sèche. Les dommages de l'hiver 71-72 ne semblent pas avoir été plus graves dans le semis du mois d'août que dans celui du printemps.

Mode de semis. La comparaison de différents modes de semis de plantes fourragères révèle, après une année d'exploitation, que le mélange luzerne-mil semé à la volée se classe premier pour la production de matière sèche; il est suivi de la luzerne pure semée à la volée, du semis de deux rangs de luzerne et de deux rangs de mil alternés, de la luzerne pure semée en rangs, du semis de un rang de luzerne et un rang de mil alternés, du mil pur semé à la volée et finalement du mil pur semé en rangs.

Hivernement de la luzerne. On n'a pas effectué de coupe sur ce semis après le gel des plants à l'automne 1971 et l'on a observé au printemps 1972 qu'il n'y avait eu aucune perte au cours de l'hiver. Dans d'autres semis équivalents mais coupés après le gel, on a observé un certain pourcentage de dommages dus à l'hiver.

Variétés. Dans un essai d'élimination semé en 1970, les lignées de luzerne BW-9, OR-24, AT-IP, BW-14 et BW-1 ont donné un rendement supérieur à nos variétés standards. Des 83 variétés de trèfle rouge semées en 1970, la variété Hungaropoli a donné le meilleur rendement. Elle est suivie par ordre décroissant de rendement de Triptétraploid M9-1537, Vesta Dachnfeldt, Otofte Holvsildig et Adenvalder Ratklee.

Les céréales

Mode d'application du phosphore. Le P, appliqué en bandes avec la semence ou à la volée, a mieux réagi en sol graveleux qu'en sol argileux. Appliqué avec les deux premiers semis et plus tard à la volée, le P a produit les meilleurs rendements en sol graveleux. Il a été plus efficace lorsqu'appliqué avec la semence qu'à la volée, en sol argileux.

Relation entre fertilisants et rendement. On a étudié les effets de divers dosages de N, P et K chez l'orge et l'avoine dans quatre types de sols: du Creux, de l'Anse, Saint-André et Kamouraska. Le rendement maximal d'orge-grain a été atteint avec 100 kg/ha de N sur les quatre types de sols; avec 39 kg/ha de P sur du Creux, de l'Anse et Saint-André et 58

kg/ha sur Kamouraska; avec 37 kg/ha de K sur du Creux et de l'Anse et de 0 kg/ha sur Kamouraska et Saint-André. Le rendement maximal de l'avoine-grain a été obtenu avec 100 kg/ha de N sur du Creux et Kamouraska; 32 kg/ha sur de l'Anse et 0 kg/ha sur Saint-André; 39 kg/ha de P sur du Creux et Kamouraska et 19 kg/ha sur de l'Anse et Saint-André; et avec 37 kg/ha de K sur les quatre types de sols.

Mode d'action des herbicides et des fertilisants sur l'orge. Le N a augmenté le rendement de l'orge et a réduit la phytotoxicité du 2,4-D. Appliqué au taux de 45 kg/ha, le N a réduit la phytotoxicité du bromoxynil. Le 2,4-D a augmenté le rendement. Le bromoxynil et le MCPA, appliqués à hautes doses, ont abaissé le rendement tandis que le MCPA, à basse dose, a augmenté le rendement. Le bromoxynil, à haute dose, a réduit la phytotoxicité du 2,4-D.

Façons culturales. Il est nécessaire de préparer le sol à l'automne afin de semer tôt au printemps. Il faut, du moins, herser le sol avant de semer, pour obtenir de forts rendements. Quelle que soit la date du semis, plus le sol est hersé, plus forts sont les rendements. Les relevés de température ont indiqué qu'un sol non hersé au printemps était légèrement plus froid en surface qu'en profondeur, alors qu'on notait l'inverse en sol hersé. Aussi, le sol hersé était plus sec en surface qu'en profondeur. Un hersage avec herse à dents a eu pour effet de retenir l'eau du sol et de réduire le nombre de mauvaises herbes. Les céréales, semées tardivement, ont subi une forte compétition des mauvaises herbes et ont requis plus de hersage avant le semis.

Les pommes de terre

Mode d'application du phosphore. En sol graveleux, le P appliqué au contact des tubercules a eu pour effet de diminuer le nombre de plantes, de retarder la floraison et de diminuer le rendement vendable, comparativement au mode d'application en deux bandes conventionnelles ou à la volée. En sol limoneux, l'application du P au contact de la semence a augmenté le rendement vendable.

Flétrissure bactérienne. Aucune des solanacées, inoculées par racines, ni aucun des 72 cultivars de la série F69 de Frédéricton, inoculés par racines et couteau contaminés, n'ont montré de résistance à la flétrissure

bactérienne. Grâce à des solanacées sensibles, on a décelé l'organisme pathogène sept jours après inoculation de la cime. Une nouvelle méthode d'inoculation des solanacées permet de détecter la maladie rapidement chez les variétés sensibles. Le contrôle de la maladie par la désinfection du couteau n'a été efficace qu'avec une solution de Kem-Germ et Kem-Klean à raison de 10 onces par gallon.

Variétés. Les cultivars tardifs Pungo et F61013 sont prometteurs en sol organique. Chieftain rend bien en sol minéral. Les cultivars hâtifs F57048 et F66095 ont un fort rendement et sont excellents pour la table. F57048, une fois fragmenté, est sensible à la pourriture des plantons.

Les fruits

Fraisiers. En première année de production, toutes les variétés sont atteintes de pétale vert; Earlidawn s'est révélée la plus sensible avec 17,6% d'infection. Tous les cultivars donnent un meilleur rendement en deuxième année de production lorsqu'on n'observe que des traces de la maladie. Les cultivars tardifs Guardsman et Sparkle donnent de forts rendements et la récolte en est plus précoce en deuxième année de production.

Pommiers. Le taux de reprise de la greffe en tête a été de 78% dans le verger sud-est et de 89% dans le verger nord. Quinte est sensible à la rouille. Quatre ans après la plantation, le cultivar McIntosh écussonné sur OH-8 donne en moyenne 25 fruits par arbre.

FERME EXPÉRIMENTALE, NORMANDIN

Le chou fourrager

Composition chimique. La teneur en matière sèche (MS) du chou fourrager du type moellier a été de 11% pour la récolte du 15 septembre et de 14% pour la récolte à la fin d'octobre. La teneur en matière azotée (MA) est passée de 18 à 15% (sur une base de MS) du 15 septembre au 5 octobre. Une diminution beaucoup moins importante a été observée entre la récolte de la mi-octobre et celle de la fin d'octobre. Le chou fourrager fertilisé au taux de 121 kg/ha de N contenait 14% de MA tandis que celui fertilisé au taux de 233 kg/ha de N contenait 17% de MA.

Les teneurs en fibre brute et en cellulose ont été respectivement de 15 et 25%. Les teneurs en hydrates de carbone insolubles dans les détergents ont été peu élevées; les teneurs en parois cellulaires, en ligno-cellulose et en lignine ont été respectivement d'environ 25, 22 et 3%. La teneur en fibres n'a pas augmenté avec la maturité ou à la suite de la déshydratation. La teneur en Ca a été de l'ordre de 2% et celle du P de 0,4%, donnant un rapport Ca/P de 5.

Digestibilité et ingestion volontaire. Les coefficients de digestibilité ont été très élevés, atteignant près de 80% pour la matière sèche et 82, 86 et 71% pour l'énergie brute, la matière azotée et la cellulose et fibre brute, respectivement. Ni les dates de récolte, ni la déshydratation n'ont affecté la digestibilité. L'énergie digestible du chou fourrager récolté à la fin d'octobre a été élevée, atteignant 3,2 kcal/g (sur une base de MS). Ceci s'explique par une teneur de 75% en composants cellulaires solubles et par l'absence de lignification avec la maturité. L'ingestion volontaire de MS par jour et par mouton a été de 60 et 69 g/kg^{0,75} de poids pour le chou frais et déshydraté respectivement. L'ingestion d'énergie digestible a été de 205 et 218 kcal/kg^{0,75} de poids pour le chou frais et déshydraté respectivement, résultant en un indice moyen de la valeur nutritive de 65. La valeur nutritive du chou fourrager a été un peu supérieure à celle de la luzerne récoltée au stade début floraison où l'indice de la valeur nutritive est d'environ 60.

Anémie du chou fourrager. A la quatrième semaine d'alimentation au chou fourrager, des baisses de l'hémoglobine, de l'hématocrite et du nombre de cellules rouges du sang ont été observées chez des moutons. On a également observé la formation de corpuscules de Heinz-Ehrlich dont le nombre le plus élevé a correspondu aux valeurs de l'hémoglobine les plus basses. Des observations similaires ont été faites à la suite d'une période d'alimentation avec du chou frais ou avec du chou déshydraté à basse température. On a conclu que le chou fourrager ne peut être utilisé comme ration entière que pour une période relativement courte.

Contrôle chimique des mauvaises herbes. Deux semis de chou fourrager, l'un sur argile limoneuse Normandin, l'autre sur un sable Péribonka, ont été traités avec six herbicides

différents; chaque essai comportait un témoin sarclé et non sarclé. L'évaluation visuelle sur l'infestation des parcelles par les mauvaises herbes a révélé que, sur le loam argileux, le BAS 2903-H (BASF Canada Ltd.) au taux de 3,4 kg/ha a donné des résultats se rapprochant le plus du témoin sarclé et que sur le sable Péribonka, cette qualité revenait à l'EPTC au taux d'environ 1,5 litres/ha. Le GS-14260 (Ciba Corp.) a été néfaste au chou en post-émergence, et la prométryne en pré- et post-émergence sur le sol sablonneux. Sur l'argile, seule la prométryne en post-émergence a été néfaste; elle a détruit tous les plants. Le rendement moyen de matière sèche du chou fourrager a été, respectivement, de 7 581 kg/ha et 6 371 kg/ha sur argile et sur sable.

Effet phytotoxique. Des doses de GS-14260, en pré- et post-émergence et équivalentes à 0,5; 1,0; 1,5; 2,0; 2,5 et 3,0 kg/ha du produit actif ont été testées en serre sur des pots ensemencés avec du chou fourrager. Les effets de l'herbicide ont été les mêmes en pré- et en post-émergence et c'est vers 2,0 kg/ha du produit actif que les effets phytotoxiques se sont manifestés.

Les plantes fourragères

Pâturage de graminées pour agneaux. On a fait paître, en 1968, 1969 et 1970, des agneaux sur de la fléole, du pâturin du Kentucky et un mélange de fléole, pâturin du Kentucky et brome. La production en MS du mélange, en 1968, a été de 5 759 kg/ha, suivi de la fléole avec 4 840 kg/ha et du pâturin avec 4 120 kg/ha. Une production de 5 799, 6 103 et 6 274 kg/ha en 1969, et de 5 092, 6 123 et 6 584 kg/ha en 1970 a été obtenue de la fléole, du mélange et du pâturin respectivement. La fléole a mieux réussi en terme de performance des agneaux, avec des gains journaliers par sujet de 0,11 kg, suivi du mélange avec 0,09 kg et du pâturin avec 0,08 kg. Les gains saisonniers en poids des groupes d'agneaux ont été de 643, 574 et 647 kg/ha et le nombre de jours de paissance/ha a été de 5 597, 7 324 et 7 232 pour la fléole, le pâturin et le mélange, respectivement.

Les céréales

Dates de semis de l'orge. On a comparé le rendement en grain de dix variétés et lignées d'orge ensemencées le 15 mai et le 5 juin. Les variétés ont réagi différemment aux dates de semis, mais toutes ont accusé une diminution

moyenne de rendement de 23,8% dans le semis tardif. Comme valeurs extrêmes, on a noté une diminution de 13% avec la variété OAC 21, et de 36,2% avec la nouvelle orge Bonanza. Semées le 5 juin, les orges à deux rangs Herta et Betzes ont produit respectivement 36 et 11,5% moins de grain que dans le semis du 15 mai.

Les légumes

Régie du maïs sucré. Dans un essai dont l'objectif était de vérifier l'influence d'un paillis de polyéthylène transparent (4 nm) sur la maturation du maïs, les résultats de deux ans ont démontré que ce procédé permet d'avancer la maturité de 5 jours chez une variété hâtive, et de 8,5 jours chez une variété semi-tardive. L'espacement entre les rangs, soit 61 et 91 cm, n'a pas eu d'effet sur la maturité mais le rendement/ha a été plus élevé avec le plus faible espacement et, encore là, la variété semi-tardive en a mieux profité.

Régie du concombre. La croissance lente du concombre au début de juin serait attribuable à un sol lent à se réchauffer. Pour

pallier cet inconvénient, on a recouvert le sol, ensemencé avec ce légume, avec du polyéthylène clair et on a comparé la différence de maturité et de rendement obtenue de cette méthode avec un semis conventionnel. A la première récolte du 15 août, on a obtenu quatre fois plus de concombre des parcelles sous polyéthylène. La récolte totale sous paillis a donné 78,6% plus d'unités que sur sol nu et les concombres étaient plus gros et plus lourds.

Répression de l'aleurode des serres. Les méthodes et produits suivants n'ont eu aucun effet sur la répression de *Trialeurodes vaporariorum* (Westw.): deux fumigations au tétradifon (Tedion V-18) suivies de deux arrosages au sulfate de nicotine, de trois saupoudrages au roténone D et d'une pulvérisation au chlordane 40%. Par contre, une fumigation à base de phosdrin (mévinphos, Shell Chemicals), à la forte dose de 89,4 cc du produit/litre d'eau a complètement détruit cet insecte, mais a gravement endommagé des plants de tomates dans la serre; une dose réduite d'environ 18,2 cc/litre semble tout aussi efficace.

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Services administratifs

SCIENTIFIQUE EN SÉJOUR D'ÉTUDE

J. FOREST, B.S.A.
Étudiante post-graduée

Entomologie

SERVICE DE VULGARISATION

Ministère de l'Agriculture et de la Colonisation du Québec

M. MAILLOUX, B.S.A., M.Sc.

Arboriculture fruitière

¹En congé d'étude à l'Université Rutgers, New Brunswick, N.J.

²Affectation comme directeur adjoint à la Station de recherches à Harrow, Ont., du 4 avril au 4 septembre 1972 (Programme d'Affectation des Cadres-CAP).

³En congé d'étude à l'Université Cornell, Ithaca, N.Y.

⁴Stage à la Section de Toxicologie de l'Institut de recherches à London, Ont., du 4 janvier au 31 août 1972.

INTRODUCTION

Le programme de la Station de recherches de Saint-Jean est axé tout spécialement sur les cultures fruitières et maraîchères. Le rapport qui suit donne une idée des travaux les plus importants qui ont été accomplis durant l'année 1972.

Nous avons malheureusement perdu durant l'année MM. A. A. Beaulieu (directeur), L. Sabourin (services administratifs) et J. P. Perron (entomologiste économique).

Durant l'année nous avons poursuivi la consolidation de nos trois fermes satellites localisées à Ste-Clotilde, L'Acadie et Frelighsburg. Cependant, plusieurs des membres du personnel étaient en stage d'étude ou de perfectionnement et notre productivité immédiate en a été affectée.

On peut obtenir des exemplaires des publications mentionnées à la fin de ce rapport ou des informations additionnelles en adressant sa demande directement aux chercheurs ou à la Station, comme suit: Station de recherches, Ministère de l'Agriculture du Canada, Casier postal 457, Saint-Jean, Qué.

J. J. Jasmin

Le directeur

POMME

Entomologie

Tétranyque rouge du pommier. Dans une parcelle expérimentale exempte d'insecticides, une cinquantaine de prédateurs (acariens, arachnides, coccinelles, mirides et thrips) ont réussi à maintenir à un niveau très bas la densité de la population du tétranyque rouge du pommier, *Panonychus ulmi* (Koch). Ces ennemis naturels, pour la plupart identifiés à l'espèce, exercent une lutte biologique qui peut s'intégrer à la lutte chimique. Dans les essais d'acaricides, le Fundal (Nor-Am Agricultural Products, Inc.) fut plus efficace que l'hydrochlorure de forméthane. Dans une autre série de parcelles utilisées pour l'évaluation des fongicides, les populations de *P. ulmi* sont demeurées très faibles sur les pommiers traités avec les produits UniRoyal 2013 (UniRoyal Chemical Ltd.), Cela W-524 (Cela Landwirtschaftliche Chemikalien) et Dikar (Rohm & Hass Co.), alors qu'elles ont atteint une densité très élevée sur les pommiers traités avec la dodine et le thiophanate de méthyle.

Cochenille virgule. La cochenille virgule, *Lepidosaphes ulmi* (L.), dans une parcelle exempte d'insecticides, a été partiellement tenue en échec par ses ennemis naturels dont les plus importants étaient les chalcides *Aphytis proclia* (Walker) et *Anabrolepis mayri* Rschk., parasites des oeufs ou des nymphes de la cochenille, ainsi que l'acarien *Hemisarcoptes malus* (Shimer), qui se nourrit

de ses oeufs. Dans les essais d'insecticides, deux applications de leptophos, de methidathion ou de diazinon, effectuées après l'éclosion des oeufs, s'avéraient plus efficaces qu'un seul traitement de mélange huile-éthion ou huile-carbophenothion, appliqué au stade du bouton vert.

Mouche de la pomme. La mortalité hivernale chez les pupes de la mouche de la pomme, *Rhagoletis pomonella* (Walsh), attribuable aux maladies et aux prédateurs, a atteint un taux de 50%; les moisissures se sont particulièrement développées dans les terrains mal égouttés. La profondeur d'enfouissement des pupes a très peu influencé l'action des fourmis et des coléoptères carabiques. Chez ces derniers, au moins six espèces ont été observées en nombre suffisant pour affecter la survie des pupes. En raison de cette mortalité hivernale et des pluies fréquentes en juillet, les infestations naturelles de l'insecte ont été plutôt légères; par conséquent, les 14 produits insecticides mis à l'essai dans trois vergers différents ont tous assuré une protection de l'ordre de 98 à 100%.

Punaise terne. La lutte contre la punaise terne, *Lygus lineolaris* (P. de B.), dans les vergers, s'est poursuivie au moyen des insecticides azinphos-méthyl, DDT, diméthoate, endosulfan, fénitrothion, phosalone et phosmet. Deux applications de ces produits, l'une effectuée au stade du bouton rose et l'autre tôt après la chute des pétales, ont permis de réduire d'au moins 60% les dégâts sur les

fruits. Toutefois, une troisième pulvérisation appliquée une dizaine de jours plus tard semble nécessaire pour assurer une répression adéquate de ce ravageur.

Charançon de la prune. Dans des essais de lutte chimique contre le charançon *Conotrachelus nenuphar* (Hbst.) infestant les pommiers, le Bay 68138 (Chemagro Corp.), le leptophos, le tétrachlorvinphos et le carbofuran ont fourni de 97 à 99% de fruits sains et se sont montrés nettement supérieurs au fenitrothion, au Galecron (Ciba-Geigy Canada Ltd.) et au phosmet dont le taux d'efficacité a été de 91 ou 92%. Dans un verger fortement infesté, on a appliqué ces insecticides les 3 et 13 juin, c'est-à-dire au stade du calice et du premier traitement de couverture.

Attraction sexuelle. Pour la deuxième année, les phéromones sexuelles synthétiques se sont avérées un moyen efficace pour le dépistage et l'étude de la densité des populations de la pyrale de la pomme, *Carpocapsa pomonella* (L.), et de la tordeuse à bandes rouges, *Argyrotaenia velutinana* (Wlk.); ces populations sont demeurées faibles, en 1972, dans les vergers commerciaux. Le piégeage de ces deux insectes a donné lieu à la capture inattendue de spécimens de la tordeuse à bandes obliques, *Choristoneura rosaceana* (Harr.).

Phytopathologie

Tavelure du pommier. Nous avons employé le captafol en une seule application à dose massive (5,7 litres/450 litres ou 45 litres/ha) sur des pommiers McIntosh, à la mi-mai, soit au stade de débourrement avancé. Ce traitement a été suivi de quatre applications de dodine, effectuées à dose normale du 14 juin au 18 juillet dans un premier verger, et de six applications similaires, échelonnées du 4 juillet au 5 août dans un deuxième verger. Dans les deux cas, les traitements ont assuré une répression adéquate de la tavelure du pommier, *Venturia inaequalis* (Cke.) Wint. De plus, ces résultats corroborent ceux des deux années précédentes.

Dans des essais de traitements réguliers contre la tavelure sur des pommiers McIntosh, neuf applications des fongicides dodine, bénomyle, Dikar, thiophanate de méthyle, UniRoyal 2013 et Cela W-524, employés aux doses recommandées par les fabricants, ont montré un taux d'efficacité de 99% et plus.

Physiologie et nutrition

Régulateurs de croissance. Le produit Alar-85 (UniRoyal Chemical Ltd.), appliqué à la mi-juillet sur des pommiers McIntosh, au taux de 700 ppm, a sensiblement retardé la chute des pommes et augmenté la fermeté sans en réduire la grosseur ou les rendements; au taux de 1 400 ppm, les effets de rétention et de fermeté ont été plus marqués mais il y a eu diminution de la grosseur des fruits, même lors d'applications bisannuelles. Sur des pommiers déjà traités à l'Alar-85, trois applications des mélanges d'Éthrel (Amchem Prod.) (250 ppm) et NAA (20 ppm), ou d'Éthrel (250 ppm) et fénoprop (20 ppm), ont fourni des fruits de très bonne qualité tout en hâtant leur maturité de 10 à 20 jours.

Génétique

Cultivars et porte-greffes. Dans les essais visant à créer des cultivars de pommiers résistants à la tavelure, les croisements de 1971 ont fourni 22 000 plantules qu'on a soumises à des inoculations successives des races 0, 2, 3 et 4 de *Fusicladium dendriticum* (Wallr.) Fckl.; environ 6 000 se sont montrées résistantes et sont conservées pour évaluation ultérieure. En 1972, 26 croisements à Frelighsburg et cinq à Ottawa ont fourni la semence de base pour les essais conduits à Purdue University, Lafayette (Ind.) et à Saint-Jean (Qué.). Dans l'évaluation de porte-greffes et de cultivars propres aux conditions du Québec, la ferme de Frelighsburg compte présentement la série complète des porte-greffes hybrides d'Ottawa et 87 cultivars de pommiers.

Régie des pommeraies

Action de la taille des pommiers sur la quantité et la qualité des fruits. Des six méthodes de taille à l'essai sur des pommiers McIntosh adultes, celle comportant la suppression des branches charpentières selon la technique de Crowe continue de fournir les plus forts rendements qui ont été, en moyenne, de 376 kg par arbre, en 1972. Cependant, les arbres se développent en hauteur et les pommes sont de qualité moyenne. La meilleure pigmentation des fruits ainsi que la forme la plus souhaitable des arbres ont résulté d'une taille sévère effectuée en juin.

PETITS FRUITS

Entomologie

Punaise terne. Cet insecte demeure très préjudiciable aux fraisières, du fait qu'il peut infester jusqu'à la moitié des récoltes. Deux applications des insecticides bromophos-éthyl, diméthoate, carbofuran-méthamido-phos, endosulfan, trichlorfon et fenitrothion, appliqués le 26 mai et le 5 juin, ont assuré une protection de 70 à 83% contre les attaques de *Lygus lineolaris* (P. de B.).

Tétranyque à deux points. Des essais de traitements acaricides, effectués en serre sur des plants de fraisiers comportant en moyenne 700 oeufs et formes mobiles de *Tetranychus urticae* Koch par feuille, ont démontré que les produits BAY 80530 (Vero Beach Laboratories), R28627 (Stauffer Chemical Co.), HOE 2973 (Hoechst Chemicals) et le Fundal étaient tous efficaces durant une période de quatre semaines. Cependant, l'action de BAY 80530 a été plus lente que celle des autres acaricides.

Phytopathologie

Blanc du fraisier. Nous avons continué les essais de fongicides visant à enrayer le blanc du fraisier, *Sphaerotheca humuli* (DC.) Burr., et à augmenter les rendements chez les cultivars Earlidawn, Grenadier, Cavalier et Redcoat. Six applications des produits dinocap, thiophanate de méthyle et Kolospray (Niagara Chemicals) ont été effectuées du 6 juillet au 26 août 1971. D'après les résultats obtenus en 1972, il n'y a que le dinocap et le Kolospray qui ont contribué à l'augmentation des rendements et ce seulement chez les cultivars Earlidawn et Redcoat.

Génétique

Évaluation de lignées et de cultivars de fraisiers. Parmi les six lignées et les 30 cultivars de fraisiers provenant de l'Ontario, de la Nouvelle-Écosse et du Maryland, cinq ont fourni de très bons rendements variant de 12,7 à 18,2 t/ha; ils se sont ainsi montrés supérieurs au cultivar Redcoat. Malgré un hiver néfaste aux fraisiers, les lignées K-64-462 et K-64-403 de la Nouvelle-Écosse se sont avérées très rustiques et ont donné, en général, des fruits de bonne qualité.

Régie des cultures

L'action du gel sur les fraisiers. Une enquête, menée dans la région de Montréal au printemps de 1972, a révélé que de 40 à 50% des plants de fraisiers avaient péri par le

froid. Du 23 au 25 janvier 1972, entre autres, il y eut submersion des plantations à la suite des pluies et de la fonte complète de la neige; cette période de dégel a été immédiatement suivie de froids intensifs atteignant -20°C le 26 janvier. Ces dégâts ont démontré la nécessité de l'égouttement de surface et l'importance de la rusticité des cultivars.

OIGNON

Régie des cultures

Évaluation de variétés et cultivars d'oignons. Parmi les 18 cultivars à l'étude en 1972, 11 ont eu un rendement supérieur au témoin Autumn Spice. Dans l'ensemble, le rendement total a varié de 16,3 t/ha chez Muck Master à 30,7 t/ha chez Nugget. Le trait saillant de 1972 fut une baisse générale de 50% du rendement total par rapport à celui de 1971. On a également remarqué que 84% du volume global avaient atteint un poids vendable, dont 18% des bulbes avaient 5,1 à 7,6 cm de diamètre et 66% entre 3,8 et 5,1 cm. Le fort pourcentage de petits bulbes était un effet direct de la mauvaise température. Bien que l'émergence ait été de 20% supérieure à celle de 1971, la population finale (récolte) au mètre linéaire demeurait la même, soit 30,5 plants/m; seulement 45% de la semence mise en terre a donc produit un bulbe vendable. On constate aussi qu'en 1972, le rendement total de la variété Autumn Spice, de 24,1 t/ha, n'a atteint que 78% de celui de Nugget, en tête du classement; la proportion était exactement la même en 1971, malgré les rendements deux fois plus amples de cette année.

Régulateurs de croissance. En septembre 1971, on a appliqué plusieurs régulateurs de croissance à la variété d'oignon Premier, lors de la tombée de la moitié du feuillage, dans le but de hâter la maturité des bulbes et d'en prolonger l'entreposage. On considère que cette variété atteint la maturité environ sept jours plus tard que l'Autumn Spice, variété recommandée pour l'entreposage. Ces traitements furent comparés à un témoin non traité et un traitement d'hydrazine maléique, traitement recommandé pour augmenter la fermeté des bulbes d'oignon et la durée de l'entreposage. Après huit mois dans un entrepôt commercial, les bulbes de plants traités avec 1 000 ppm d'Éthrel étaient de 25% plus fermes que les bulbes des plants

non traités et de 23% plus fermes que les bulbes de plants traités avec l'hydrazine maléique.

Désherbage chimique. Dans un essai employant des herbicides à rémanence moyenne, soit comparable à celle du produit présentement recommandé, l'allidochlore, seulement trois traitements ont donné une répression acceptable des mauvaises herbes. Ces traitements étaient le propachlore, le Basamaize (BASF Canada Ltd.) et le C-7019 (Ciba-Geigy Canada Ltd.) appliqués d'abord en pré-levée à 6,6, 6,6 et 2,2 kg/ha respectivement et ensuite en post-levée, chacun au même taux. Ils ont cependant causé de la brûlure foliaire.

Dans un second essai, on s'est servi d'herbicides ayant très peu de rémanence. Trois traitements, le TOK E-25 (Rohm & Haas Co.), le CNP et le CNP Plus (Chipman Chemicals Ltd.) à dosage faible de 0,66 kg/ha, mais appliqués cinq fois à intervalles d'environ dix jours à partir de la mi-juin, ont donné un excellent contrôle des mauvaises herbes. Les traitements au CNP Plus ont cependant causé un léger enroulement du feuillage.

Phytopathologie

Charbon de l'oignon. Dans un sol sévèrement infesté du charbon de l'oignon, causé par le champignon *Urocystis magica* (Pass.), on a mis à l'essai neuf préparations fongicides dont huit avaient une action endotherapique. Seules les préparations contenant du Pro-Gro 80D (UniRoyal Chemical Ltd.) à 2,5% ont donné une répression efficace (92 à 95%) et un rendement plus élevé en oignons sains, 35 t/ha, par rapport à celui du témoin, 14 t/ha. D'autre part, HOE 6052 50-W (Hoechst Chemicals) a donné la meilleure répression du charbon (97,5%); par contre, il s'est montré phytotoxique, de même que le bénomyle (Benlate 50-W), en réduisant la germination et les rendements.

Une épreuve de résistance au charbon réalisée en plein champ démontra la grande susceptibilité des 13 variétés utilisées. Le pourcentage de maladie variait de 61% (Autumn Spice) à 86% (Storage King).

Entomologie

Mouche de l'oignon. En traitement dans le sillon, les insecticides granulés fonofos, fensulfothion, carbofuran et HOE 2960

(Hoechst Chemicals) ont donné une répression efficace de la mouche de l'oignon, *Hylemya antiqua* (Meig.), dans des parcelles infestées artificiellement.

CAROTTE

Régie des cultures

Essais de semis. A Ste-Clotilde en 1972, on a mis à l'épreuve dix cultivars en semis hâtif (18 mai au 15 août) et en semis tardif (20 juin au 4 octobre) pour en évaluer le rendement, la population au mètre linéaire, la germination, la longueur et le diamètre au collet.

Parmi les variétés hâtives, Hi Pak et Hy 9182 dominant le classement avec 35,5 t/ha de rendement total. Gold Pak (variété témoin), avec 13,7 t/ha de produits vendables, n'atteint que 50% du cultivar Hi Pak. Le pourcentage moyen de n° 2 et de rebus s'élève à 39% (17% en 1971) et la population au mètre linéaire touche à 39,1 comparative-ment à 45,3 en 1971. Hi Pak, Hi Pak Elite et Spartan Sweet sont populaires et donnent un bon produit pour le cello.

Les pluies excessives de l'été 1972 ont causé des dommages considérables aux récoltes de carottes tardives. Le rendement moyen vendable de 30 t/ha représente une baisse de 35% sur celui de 1971, et varie de 15 t/ha chez la variété témoin Gold Pak à 35,9 t/ha chez l'hybride Spartan Fancy. Malgré une germination supérieure à celle de 1971, le sol détrempé en juillet et août a tout à fait détruit un des blocs et a faussé la croissance et le rendement de toutes les variétés.

Phytopathologie

Brûlures foliaires. Les conditions climatiques de 1972 furent très favorables au développement des brûlures foliaires causées par *Cercospora carotae* (Pass.) Solh. ou *Alternaria dauci* (Kühn) Groves & Skolko, ou les deux; des pertes évaluées à 10 t/ha s'avéraient dans les parcelles non traitées. Le fongicide manèbe 80-W, à un taux de 3,4 kg/ha, fut appliqué selon un rythme prédéterminé où variaient l'époque et le nombre d'applications. Les résultats indiquent clairement l'importance de commencer les pulvérisations de fongicides lorsque les carottes ont une longueur de 10 à 15 cm. Trois applications de fongicides faites à intervalles de sept à dix jours ont assuré une bonne protection du feuillage contre les infections tardives et

ont permis ainsi de réaliser des économies d'environ \$500/ha.

Entomologie

Charançon de la carotte. Une méthode d'élevage de masse a permis de maintenir en laboratoire un élevage permanent du charançon de la carotte, *Listronotus oregonensis* (Lec.), et d'obtenir les milliers d'adultes nécessaires aux études toxicologiques et à l'infestation artificielle des parcelles de répression chimique. Les résultats de la répression chimique obtenus en 1972 ont démontré l'efficacité des produits tétrachlorvinphos, thionazin, Abate (Cyanamid of Canada Ltd.) et parathion. L'analyse des échantillons de sol a démontré que les adultes hivernent hors du champ cultivé.

CHOU

Génétique

Une épreuve de résistance à la hernie des crucifères comprenant 124 lignées et croisements de choux fut réalisée en sol organique à Ste-Clotilde. Seules les lignées F₅ (24-127 × 7-40) et F₆ (24-127 × 8-41) développées à cette station ont montré de la résistance à la race 2 de *Plasmodiophora brassicae* Wor.

Un chou hybride F₁, nommé Châteauguay, a été créé à cette station. Ce chou, de couleur bleu vert, est de dimension moyenne et uniforme; il possède une tige courte. A maturité, la pomme est ronde et très compacte et elle résiste bien au fendillement. C'est un chou mi-hâtif destiné au marché frais.

Les tissus des feuilles et des racines de la lignée 8-41 et du cultivar Badger Shipper, résistants à la hernie, et des cultivars susceptibles Pennstate Ballhead et Golden Acre furent analysés quant à leur contenu en acides aminés. Des 29 acides aminés identifiés, seule la tyrosine fut observée en plus forte concentration dans les racines des plants résistants à la hernie.

MAÏS

Lutte chimique

Pyrale du maïs. Dans le but de remplacer le DDT, les essais de lutte chimique en plein champ contre la pyrale du maïs, *Ostrinia nubilalis* (Hbn.), ont comporté l'insecticide bactérien Dipel (*Bacillus thuringiensis*) et les insecticides chimiques Torak (Hercules Inc.),

méthomyl, carbofuran, tétrachlorvinphos, carbaryl, leptophos, trichlorfon (Dylox) et bromophos-éthyl. Tous ces produits ont réduit d'une façon significative, par rapport aux parcelles témoins, les populations de pyrales. Cependant, à cause de l'infestation naturelle très élevée et de la fréquence des précipitations, toutes les parcelles traitées ont compté plus de 22% d'épis infestés, ce qui dépasse de beaucoup le seuil de tolérance de 5% généralement accepté pour la vente du maïs sucré à l'état frais au Québec. Le Torak et le méthomyl ont assuré la meilleure protection en réduisant de plus de 70% les populations larvaires. Une seule application de carbaryl ou de trichlorfon effectuée sur cinq hybrides commerciaux de maïs-grain en présence d'une infestation moyenne de pyrales n'a pas, en général, augmenté les rendements, sauf chez l'hybride Pride R116 qui a donné, par rapport aux parcelles témoins, 14,5 q/ha.

Génétique

Résistance à la pyrale du maïs. Sous des conditions d'infestations naturelles et artificielles de la pyrale, deux variétés hybrides et 28 lignées de maïs-grain ont fait l'objet d'études suivies quant à leur maturité, leur sensibilité aux pontes de l'insecte, leur tolérance ou résistance à la pyrale, ainsi qu'à leur rendement.

Les deux hybrides et 18 lignées (7 Ottawa, 9 Québec, 2 États-Unis) ont eu très peu de criblure du feuillage, critère important de résistance; cependant, toutes se sont classées intermédiaires ou sensibles quant aux dégâts sur l'ensemble de la plante. Seul l'hybride OX402 s'est montré très résistant pour les deux critères. Deux lignées, Ottawa 625-14-2 et NCG 208, ont démontré une certaine sensibilité à la pyrale. En général, il n'y a eu aucune corrélation chez les lignées entre, d'une part, la criblure du feuillage et, d'autre part, les dégâts sur l'ensemble de la plante (galeries, entre-noeuds attaqués) et les populations larvaires. Cependant, la corrélation était très évidente entre les populations larvaires et les galeries dans la tige ou les entre-noeuds attaqués. Plusieurs lignées canadiennes (Québec 195, Ottawa 202, 6124-44-1) ont semblé aussi résistantes aux attaques des feuilles par la pyrale que certaines lignées américaines (Oh 45, Oh 545) reconnues pour leur résistance. Il semble y avoir

une corrélation très étroite entre les populations larvaires et les galeries creusées dans les plantes mais non avec les dégâts sur l'ensemble de la plante (brisure de la tige en haut ou en bas de l'épi). Cela a déjà été constaté dans d'autres tests avec des lignées provenant de pays européens.

Selon l'infestation naturelle et artificielle, les deux hybrides ont donné un rendement moyen de 75 et 55 q/ha tandis que pour les lignées, le rendement sous infestation artificielle a varié de 4 à 28 q/ha et, sous infestation naturelle, de 8 à 57 q/ha. Chez les lignées, il semble y avoir une corrélation assez étroite entre les données provenant de l'infestation naturelle et de l'infestation artificielle quant aux critères «larves ou galeries/plante» et «entre-noeuds attaqués/no. total d'entre-noeuds». En général, les lignées précoces semblent donner des rendements plus élevés. Les pertes dues aux infestations artificielles ont varié de 2 à 75%.

L'hérédité de la résistance aux attaques sur feuilles par la pyrale sur maïs-grain a été étudiée par un essai de croisements en diallèles 8 × 8. Les résultats indiquent que l'action additive des gènes fut la plus importante et qu'un seul groupe de gènes a montré une certaine dominance. L'hérédité de ce caractère est estimée à 40%.

Fertilité des sols

Réponse du maïs sucré au phosphore rémanent dans le sol. Des essais sur la rémanence du P dans une argile du type St-Blaise se poursuivent depuis 1970. Des taux de N et de K adéquats, pour une récolte normale, étaient appliqués chaque année tandis que le taux de P appliqué à la volée était varié de 0 à 55, 110, 220 et 440 kg/ha. Un accroissement appréciable du rendement d'épis vendables fut, la première année, en relation avec l'accroissement de P ajouté au sol. De même, on notait une interaction entre le taux de P et l'année de l'application. Il semble que les rendements élevés aux bas taux d'application, les années suivant l'application de P, seraient dus à l'augmentation des réserves de N et de la disponibilité de P assimilables. Aux plus hauts taux d'applications de P, les rendements plus faibles des années suivantes résulteraient de l'incapacité du N ajouté ou retenu au niveau des racines de compenser le

manque de P, déjà assimilé par la récolte de première année.

Besoins de N, P et K du maïs sucré. Dans des parcelles recevant des taux de 220 kg/ha de N et de K, des applications de 220 kg/ha de P ont accéléré appréciablement la maturité des épis. Les taux au-delà de 220 kg/ha n'ont pas avancé la maturité de façon appréciable. Aux taux maximums de deux des trois éléments étudiés (440 kg/ha de N, P ou K), le rendement en épis vendables s'est accru seulement lorsque les taux de P étaient augmentés. Les apports de N et de K n'ont occasionné aucune augmentation mesurable parce que la teneur du sol en ces éléments était suffisante pour cette récolte. Le N provenait, semble-t-il, de la minéralisation de l'azote organique du sol.

DIVERS

Sols

Rotations des cultures en sol organique. Pendant une période de cinq années, on a produit diverses cultures maraîchères sans application de fertilisants afin d'étudier l'influence d'une culture précédente sur le rendement des cultures. L'oignon, la laitue, le céleri et la carotte se sont révélés affectés par une culture de carottes immédiatement avant. L'examen des sols où se situaient les essais en 1971 avait démontré la présence de nématodes. En 1972, les champs d'expérimentation furent fumigés et, malgré cela, l'effet d'une récolte précédente de carottes fut de diminuer jusqu'à 40% les rendements des récoltes de cultures suivantes.

Pommes de terre

Les pluies abondantes de l'été 1972 ont endommagé sévèrement les légumes et, en particulier, les pommes de terre. Le semis hâtif F-57048, à l'essai depuis neuf ans et proposé pour homologation en 1973, a donné une performance médiocre: germination de 59%, coeur creux sévère, faible incidence de mosaïque et d'enroulement et un rendement de 10% au-dessous de la normale. Par ailleurs, le semis tardif F-61013, proposé pour homologation en 1973, a été cultivé en parcelle de 1/50 ha pour la deuxième année consécutive. Son rendement total de 26,4 tonnes/ha fut de 8% inférieur à celui de Kennebec et de 50% inférieur à celui de 1971.

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Research Station Delhi, Ontario

PROFESSIONAL STAFF

L. S. VICKERY, B.S.A., M.S. Director

Tobacco

H. H. CHENG, B.Sc., M.Sc., Ph.D.	Entomology
J. M. ELLIOT, B.S.A., M.S.A.	Soil science
S. K. GAYED, B.Sc., M.Sc., Ph.D.	Plant pathology
N. ROSA, B.Sc., Ph.D.	Plant physiology
E. K. WALKER, B.S.A., M.S.	Plant science
F. H. WHITE, B.Sc., M.Sc.	Genetics and plant breeding
B. F. ZILKEY, B.S.A., M.Sc., Ph.D.	Plant physiology

Departure

B. POVILAITIS, B.S.A., M.Sc., Ph.D. Genetics and plant breeding

EXTENSION SERVICES¹

M. C. WATSON, B.S.A.	Tobacco
N. W. SHEIDOW, B.Sc.	Tobacco

¹Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Research Station at Delhi has specialized in the production of flue-cured tobacco for 40 years. Emphasis is now being placed on tobacco and health. This program was expanded in 1972 in cooperation with Health and Welfare Canada and additional facilities are to be completed in 1973.

In 1972, a research program was initiated in cooperation with the Canadian Tobacco Manufacturers Council to study various methods of producing, harvesting, and curing tobacco for the manufacture of homogenized tobacco sheets. Objectives of the project are to reduce the biological activity of tobacco when smoked, to reduce the cost of production, and to improve mechanization. This project is expected to be continued in 1973.

Published results may be found in the scientific papers listed under Publications. For further information, correspondence should be directed to the Research Station, Research Branch, Agriculture Canada, Delhi, Ont. N4B 2W9.

L. S. Vickery
Director

SOIL SCIENCE

Soil Fertility

Phosphorus. A comparison of six rates of P, 0, 17.4, 34.8, 52.2, 69.6, and 87.0 kg/ha, showed no increase in grade index or yield beyond the first increment. Analysis of cured leaves revealed no differences among treatments in P, total alkaloids, reducing sugars, or total N. In a depletion experiment in which five consecutive crops of tobacco had been grown with no P in the fertilizer, the levels of P in the cured leaves from the lower stalk positions were lower than where a complete fertilizer including 70 kg/ha P was applied. Omitting P increased the lamina weight of the lowest leaves and tended to decrease the yield in the fifth year. Soil samples taken in the spring following the fifth crop showed a 12% decrease in levels of P where none had been applied.

In a survey of 32 Ontario farms, levels of P in the tenth leaf of flue-cured tobacco, at topping time, ranged from 0.18% to 0.29% in 1971 and 0.13% to 0.56% in 1972. On these same farms, soil samples taken before planting showed that levels of NaHCO₃-soluble P varied from 37 to 120 ppm in 1971 and 31 to 85 ppm in 1972.

An application of 2-8-6 fertilizer resulted in lower soluble salts in the muck soil than did the regular 2-16-6 tobacco seedbed fertilizer, but tended to decrease the weight of tops and roots of seedlings.

Mineral analysis. The levels of exchangeable Ca, K, and Mg, EDTA-extracted Cu, Fe,

and Zn, and easily reducible Mn in the soil of 32 farms were similar in 1971 and 1972, but the levels of EDTA-extracted Mn were much higher in 1972. Analysis of the tenth leaf taken at topping time showed lower levels of Fe and Mn in 1972, higher levels of K, and similar levels of Ca, Mg, Cu, and Zn in both years.

PLANT SCIENCE

Transplants

The size of transplants had little effect on the agronomic indexes and total alkaloid and reducing sugar levels of cured leaves. Transplants grown in peat pots, paper pots, and seedbeds produced similar yields. Seedbed plants flowered later, and peat pot plants had higher levels of total alkaloids, than the other types. When transplanting was delayed, yield and levels of total alkaloids decreased, but the grade index was unaffected. The survival of transplants in the field was enhanced by reduction of greenhouse seeding rate and amount of water application, and by outside exposure. For seedling growth, muck was superior to commercial compost, field sand or sphagnum moss with vermiculite, and processed cellulose.

Paper Mulch and Frost Control

Compared with control plots, paper mulch adversely affected grade index and yield; protein foam for frost control in mulched plots improved yield only; and protein foam

alone improved yield and resulted in similar quality.

Leaf Age

With increasing leaf age, reducing sugars and shatter resistance decreased; alkaloids, petroleum ether extractives, Ca, and lamina weight increased; and N, Mg, K, and ash varied little.

Filling Value

Values of mechanically measured filling varied with speed of piston descent for compression. Compression pressure was related to relaxation of pressure after compression and to compressibility of cigarettes made from the same tobaccos.

Chemical Control of Weather Fleck

Carbathiin sprays caused some green fixation in cured leaves, thereby reducing quality. Total alkaloids and ash increased, and reducing sugars decreased, with the spray treatment.

Harvesting and Curing

Alkaloid levels in chopped green leaves and chopped yellow leaves were much lower after curing than in whole leaves harvested and cured in the conventional manner. The reduction was less for yellowed than for green leaves. Levels of reducing sugars were very low in chopped green tissue but normal in chopped yellow tissue. Since levels of starch were very high in the former, chopping green tissue prevented conversion of starch to sugar. Ethrel sprays accelerated ripening but caused a reduction in quality, yield, and reducing sugars.

Sucker Inhibitors

Seven C₈-C₁₀ and three C₁₀ fatty alcohol formulations were approved and recommended to be registered for the 1973 season on a temporary basis. One application 3 or 4 days before the plants were topped was normally sufficient to control sucker growth. Growth regulators are now included under the Pest Control Products Act of Canada, which includes all chemical sucker controls.

Gibberellic Acid

Gibberellic acid (GA) applied as a spray on tobacco after the inflorescence was removed (topping) caused significant reductions of starch in mature leaves. This resulted in lower reducing sugars after curing and improved tobacco quality. No other physical property or chemical constituent was adversely altered by the application of GA.

Tobacco treated with GA showed its greatest effect on the third priming, which included the mid-stalk leaves and represented approximately 45% of the total yield. The leaves of the fourth priming were similarly affected but to a lesser extent. Cigarettes prepared from the tobacco of the third priming were analyzed for total particulate matter (TPM) delivery, which is used as a measure of the harmful effect of smoke and related to biological activity. These cigarettes showed a 7% decrease in TPM delivery. When all primings were combined and cigarettes prepared, a 6% decrease in TPM delivery was found. Because of its consistent reduction of TPM, GA treatment of tobacco offers a possible means of reducing the effects of smoke on biological activity.

Uptake of DDT

Laboratory and greenhouse studies have established that *Nicotiana tabacum* L. can take up and translocate DDT added to the media in which plants grow. The largest quantity of DDT occurred in the mid-stalk leaves. DDT concentration in ppm was highest in the lowest pair of leaves. All parts of the plant, including the inflorescence, accumulated DDT. The most important factor in DDT uptake appeared to be the binding of the pesticide to soil particles. The plant took up only the portion of the pesticide that was unbound.

Leaf Position Analysis

Paired-leaf harvesting of Virginia 115 revealed that leaf-reducing sugars, yield, and return index increase from the bottom of the plant to leaves 11-14, and then decline slightly to the tip leaves. This developmental growth pattern was similar to that reported previously for the other major production variety, Delhi 34. Leaf lamina weights and total alkaloids were higher for Virginia 115 than Delhi 34, particularly in the upper eight leaves. Preliminary results show that for Delhi 34 smoke tar and nicotine per cigarette

increase linearly with stalk position by 137% and 163% respectively. Mainstream tar delivery per gram of tobacco smoke indicated a preferential concentration of leaf precursors to smoke tar in the upper half of the stalk. Simple linear correlation coefficients suggest that leaf lamina weight and cigarette pressure-drop are excellent indicators of smoke tar and nicotine.

Burley Farm Survey

Smoke analysis on 12 burley farm samples in 1971 showed that tar and nicotine levels varied 84% and 246% respectively. Mean burley tar and nicotine values were 40% and 19% respectively below similar measurements for flue-cured tobacco.

GENETICS AND PLANT BREEDING

Synthetics Increase Variability

Three generations of selfing following the production of an eight-variety randomly mated synthetic population has resulted in the development of breeding lines that have considerable variability in agronomic characters such as leaf number and size, plant height, yield, and quality. Synthetic lines that vary from 1.71% to 4.15% in total alkaloids have been selected in an attempt to develop varieties with lower total particulate matter (tar) in the smoke phase.

Breeding Disease-tolerant Varieties

Advanced breeding lines have been developed that have the black root rot immunity of *Nicotiana debneyi* Domin. and high tolerance for weather fleck. Many progeny lines are immune to black root rot under field and severe laboratory conditions. Several lines in which the variety McNair 20 was used as a backcross parent showed very little weather fleck under heavy irrigation and fairly high levels of ozone, one of the causative agents of weather fleck. By crossing lines immune to black root rot with lines that have very high tolerance for weather fleck, weather fleck tolerance has been increased to a highly satisfactory level in all lines.

Mutagenic Agents Affect Chemical Stability

Seeds of the flue-cured tobacco varieties Delhi 34 and Strain 205 were treated with

mutagenic agents, ethyl methane sulfonate, and gamma irradiation. M₂ plants were individually self-pollinated and the leaf harvested, cured, and analyzed for total alkaloid content. Total alkaloid content varied from 1.34% to 4.72% in Delhi 34 mutagenic lines and from 0.57% to 2.22% in Strain 205. The 198 M₃ progenies of the two treated varieties varied considerably in leaf number, leaf size, relative maturity, and cured leaf characteristics. Therefore, physical qualities and alkaloid content should also vary in relation to smoke tar content.

PLANT PATHOLOGY

Black Root Rot

Fumigating sandy loam soil heavily infested with *Thielaviopsis basicola* (Berk. & Br.) Ferr. with Terr-O-Cide 30 at up to 67 litres/ha in the row had no effect on black root rot. Benomyl (Benlate) in the planting water at 250 and 500 ppm active ingredient reduced root lesion rating by more than 50%. Laboratory tests indicated that benomyl suspensions reduced the population of *T. basicola* in the soil. Thiophanate-methyl (NF44) in the planting water at 350 and 700 ppm reduced root lesion rating by 45%, whereas at 700 ppm with the addition of Tween 20 the reduction was about 60%.

Damping-off

Early applications of benomyl at 5.4 and 10.8 g/m² in different tobacco greenhouses protected tobacco seedlings against damping-off, whereas late applications stopped the advance of the disease.

Pole Rot

Studies on the chemical control of pole rot caused by *Rhizopus arrhizus* Fischer were continued. Dipping leaf butts in a suspension of 0.16% dichloran (Botran) significantly reduced pole rot severity. Laboratory tests indicated that *R. arrhizus* could severely damage cured tobacco leaves stored up to 4 mo at room temperature at relative humidities higher than 88%.

Severe cases of pole rot on burley tobacco were noticed in the Cedar Springs area. The most common organism was *Botryosporium* sp. in association with *Botrytis* sp. and *Alternaria* sp.

Of the pathogens *Botrytis cinerea* Pers., *Rhizopus reflexus* Bain., *Alternaria* sp., and *Fusarium tricinctum* (Cda.) Sacc. isolated from cigar tobacco in Quebec, *B. cinerea* was the only one that caused severe damage to cigar tobacco leaves.

ENTOMOLOGY

Cutworms

Bionomic studies of *Euxoa messoria* (Harris) revealed that overwintered eggs of this species hatched in early April. Head width measurements of larvae showed seven instars, but individual rearing data showed that a few passed through six and an occasional larva through eight. The larvae were active at night and rested in the soil during the day. Slight cannibalism was observed in the fourth to seventh instars when the food supply was low, but not in first to third instars. Prepupae occasionally fed slightly, but usually they remained semidormant in the soil. Pupation occurred from late July to

mid-August. Adults emerged from mid-August to October with a peak between the last week in August and the second week in September, and they were weakly attracted to light traps. Oviposition occurred during the same period. Eggs were laid 6 to 12 mm (1/4 to 1/2 in.) below the surface of the soil and were completely developed before winter. The mean duration of the larval, prepupal, pupal, and adult stages was 87, 30, 22, and 12 days respectively.

Laboratory tests showed that first to third instar larvae of *E. messoria* were susceptible to the *Bacillus thuringiensis* preparations Thuricide 90TS, Thuricide-HP, Biotrol BTB 183, and Dipel. Larvae in the fourth to seventh instars had low mortality. Thuricide 90TS and Biotrol BTB 183 were ineffective for control of this species in the field.

Root Maggots

The neoaplectanic nematode DD 136 in transplanting water protected tobacco transplants as effectively as diazinon from serious stem tunneling by *Hylemya* spp.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

<i>Trade name</i>	<i>Manufacturer</i>
Benlate	DuPont of Canada Ltd.
Biotrol BTB 183	Nutriline Products Inc.
Botran	Upjohn Company of Canada
Dipel	Abbott Laboratories
Ethrel	Amchem Products Inc.
NF44	Ciba-Geigy Canada Ltd.
Terr-O-Cide 30	Great Lakes Chemical Corp.
Thiabendazole	Merck Sharp & Dohme Canada Ltd.
Thuricide-HP	International Minerals and Chemical Corp. (Canada) Ltd.
Thuricide 90TS	International Minerals and Chemical Corp. (Canada) Ltd.
Tween 20	Atlas Chemical Industries Canada Ltd.

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Research Station Harrow, Ontario

PROFESSIONAL STAFF

G. C. RUSSELL, B.S., M.S., Ph.D.	Director
D. H. LEE	Administrative Officer
K. M. SUTHERLAND (Miss), B.S., B.L.S.	Librarian

Chemistry and Weed Science Section

G. M. WARD, B.Sc., M.A., Ph.D.	Head of Section; Greenhouse crops nutrition
A. S. HAMILL, B.Sc., M.Sc., Ph.D.	Weed ecology
P. B. MARRIAGE, B.S.A., M.S., Ph.D.	Weed physiology
W. J. SAIDAK, B.S.A., M.S., Ph.D.	Weed science
F. G. VON STRYK, Dipl. Chem., Ph.D.	Pesticide chemistry

Crop Science Section

C. G. MORTIMORE, B.S.A., M.S.	Head of Section; Corn breeding
L. J. ANDERSON, B.S.A.	Varietal evaluation
J. W. AYLESWORTH, B.S.A., M.S., Ph.D.	White bean breeding
B. R. BUTTERY, B.Sc., Ph.D.	Soybean physiology
R. I. BUZZELL, B.S., Ph.D.	Soybean breeding
W. A. SCOTT, B.S.A.	Burley tobacco management

Entomology Section

C. D. F. MILLER, B.S.A., M.S.A., Ph.D.	Head of Section; Cereal and forage crop insects
W. M. ELLIOTT, B.Sc., Ph.D.	Vegetable insects
W. H. FOOTT, B.S.A., M.S.A., Ph.D.	Field and vegetable crop insects
R. P. JAQUES, B.S.A., M.S.A., Ph.D.	Insect pathology
P. W. JOHNSON, B.S.A., M.Sc., Ph.D.	Plant-parasitic nematodes
R. J. McCLANAHAN, B.A., M.Sc., Ph.D.	Greenhouse insects
B. C. SMITH, B.A.	Ecology of field crop insects
H. W. WRESSELL, B.S.A.	Field and vegetable crop insects

Horticultural and Soil Science Section

J. M. FULTON, B.Sc., M.S.A., Ph.D.	Head of Section; Soil moisture and irrigation
E. F. BOLTON, B.S.A., M.S.A., Ph.D.	Soil management
W. I. FINDLAY, B.Sc., M.Sc., Ph.D.	Soil fertility
R. E. C. LAYNE, B.Sc., M.S., Ph.D.	Tree fruit breeding
V. W. NUTTALL, B.S.A., M.S.A.	Vegetable breeding
H. A. QUAMME, B.S.A., M.Sc., Ph.D.	Tree fruit breeding

Plant Pathology Section

C. D. MCKEEN, B.A., M.A., Ph.D.	Head of Section; Vegetable diseases
B. N. DHANVANTARI, B.Sc., M.Sc., Ph.D.	Tree fruit diseases
J. DUECK, B.S.A., M.Sc., Ph.D.	Bacterial diseases
L. F. GATES, B.S., Ph.D.	Cereal viruses and corn diseases
J. H. HAAS, B.S., Ph.D.	Soybean and white bean diseases
R. N. WENSLEY, B.S.A., Ph.D.	Soil microbiology

Soil Substation, Woodslee, Ontario

J. W. AYLESWORTH, B.S.A., M.S., Ph.D.	Officer in Charge
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VISITING SCIENTIST

G. EVANS, B.Sc. (Agr.), Ph.D. Research Station, Tamworth, N.S.W., Australia. National Research Council postdoctorate fellow 1971-72	Plant pathology
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EXTENSION SERVICES¹

J. C. FISHER, B.S.A.	Greenhouse crops
J. F. HOPKINS, B.Sc. (Agr.)	Fruit crops
W. E. KAYLER, B.Sc. (Agr.), M. Dipl.	Vegetable crops

¹ Provided by Ontario Department of Agriculture and Food.

INTRODUCTION

As in previous reports, this report briefly summarizes work completed at the Research Station, Harrow, during the year. More detailed information may be obtained from individual research scientists and from the publications listed at the end of the report. These and previous publications are available on request. Address correspondence to: Research Station, Research Branch, Agriculture Canada, Harrow, Ont. N0R 1G0.

G. C. Russell
Director

FIELD CROPS

Cereals and Forages

Insects. The accompanying table shows changes in the density of the cereal leaf beetle throughout Ontario since 1970.

In 1972, efforts were continued to establish *Tetrastichus julis* (Walker), a parasite of cereal leaf beetle larvae, in a field nursery at this Station.

A parasite of the eggs, *Anaphes flavipes* (Foerster), imported from Europe and established in a number of areas of the United States, was recovered for the first time at this Station on June 28, 1972.

Viruses. Average incidence of plants infected with wheat spindle streak mosaic virus was 43% in Essex County, 35% in Kent County, and 37% in Lambton County. Yield loss would be 3½–4% based on 1967–68 figures. Fumigation with methyl isothiocyanate (Vorlex) did not affect disease incidence. In mid-May, Genesee showed 96% infection, whereas Blueboy showed 22% and Miro 11% infection. In late May, infection was much more widespread in Blueboy and Miro, but symptoms were much less severe than in Genesee. Seven lines had a very much lower rate of infection than Genesee and Talbot. Fredrick and Yorkstar were similar to these two varieties in their rate of infection.

Surveys of viruses in alfalfa, red clover and wild clovers indicate a high incidence of alfalfa mosaic virus in alfalfa crops, about 10% in the first season of cutting and 40% in the second and later seasons taken together.

Corn

Breeding. Production rights to a modified single cross corn hybrid involving four Harrow inbreds were granted to Otto Pick & Sons Seeds Ltd., and the hybrid will be marketed as Pickseed 323. Based on performance in Ontario corn tests in 1972, two hybrids developed at Harrow were declared eligible for license by the Ontario Corn Committee.

Drainage. Although there did not appear to be any flooding at Oil City during the growing season, corn yield showed a marked response to tile drain spacing in 1972. The closest spacing of 6.1 m (20 ft) on Brookston clay soil at this Lambton County site resulted in the largest yield, 7,225.3 kg/ha (115.2 bu/ac). At the 9.1-m (30-ft) spacing, yield decreased to 5,287.3 kg/ha (84.3 bu/ac), and beyond 12.2 m (40 ft) yield ranged from 3,360.0 to 3,920.0 kg/ha (60.0 to 70.0 bu/ac).

Insects. Evidence was obtained that almost all the observed yield reductions in field corn resulting from corn leaf aphid feeding occur

Estimated absolute density of cereal leaf beetle per hectare
at peak larval periods during 1970, 1971, and 1972

County	1970	1971	Increase (times)	1972	Increase (times)
Essex	14,080	14,970	0.0	173,900	11.6
Kent	2,884	2,654	0.0	6,329	2.4
Middlesex	808	2,943	3.6	9,687	3.4
Bruce		3,508		18,090	5.1
Wellington		6,211		35,960	5.8
York		3,709		8,006	2.3
Peterborough				788	
Renfrew				36	

before and during pollination. The systemic insecticide oxydemeton-methyl (Meta-Systox) applied as a spray to the whorls of plants 9 days before pollination provided excellent control of this aphid.

Leaf blights. Northern leaf blight of corn was more frequent this year in southern Ontario than it has been since the peak years 1961 and 1962. Southern leaf blight of corn was found in several fields of corn hybrids with Texas male-sterile cytoplasm.

N for corn. In 1970, 1971, and 1972, corn planted after wheat on Brookston clay soil yielded 38.6, 62.5, and 81.2 q/ha (61.4, 99.4, and 129.2 bu/ac) grain without additional N. Yield increases of 23.6, 9.6, and 9.3 q/ha (37.5, 15.3, and 14.8 bu/ac) were obtained from N at 156.8 kg/ha (140 lb/ac) in 1970 and 112 kg/ha (100 lb/ac), or less, in each of the other 2 yr. Although the commercial recommendation for N at 140 kg/ha (125 lb/ac) is probably a realistic compromise, management of the potential nitrogen supply in the soil is prevented by our inability to measure this potential.

Root and stalk rot. In corn plots fumigated with methyl isothiocyanate (Vorlex) at 560 litres/ha (50 gal/ac) to determine whether there was any advantage in reducing the population of root rot fungi after continuous corn, the disease was reduced by 16% on July 31. On August 16, roots from the fumigated plots were still visually less diseased; however, methyl isothiocyanate had no effect on stalk rot in any of the hybrids.

Weed control. Herbicides that inhibit photosynthesis in grass weeds did not show synergistic or antagonistic interactions with herbicides that act on other areas of seedling metabolism. The grasses differed in their order of susceptibility to the herbicides, and the combinations containing the least amount of herbicide required to control problem species can be calculated.

Phytobland oils, oil-surfactant concentrates, and surfactants were used with post-emergence atrazine in an attempt to improve control of annual grasses. Negligible differences in performance were noted among additives, although phytobland oil afforded the highest level of initial phytotoxicity. None of the additives used were phytotoxic to the corn.

Soybeans

Biochemical genetics. Some of the sugars of the flavonol glycosides found in soybean leaves have been identified; this is a step toward understanding their physiological effects and the underlying gene action. They are a monoglucoside, four disaccarides, and four trisaccarides (all containing glucose plus rhamnose, or glucose). Genetic data suggest that genes *Fg1* and *Fg3* control the addition of glucose units, and *Fg2* and *Fg4* the rhamnose units.

Physiology. The variety-density tests indicate that most varietal comparisons of net assimilation rate, specific leaf weight, and so forth should be valid, whether conducted at high or low densities, up to the time of maximum leaf area but not later in the season. The regression method of growth analysis was found to exaggerate treatment effects in some cases.

Tobacco

Harvesting and curing burley tobacco. In a tobacco barn modified to provide controlled curing conditions for primed burley tobacco leaf, a minimum temperature of 18°C and relative humidity between 65% and 75% were maintained. These conditions were found satisfactory in earlier tests in a pilot barn. Leaves sewn together by machine at the petioles and suspended clothesline-fashion between hanger rails at four densities in this barn had 1-4% loss from barn rot, whereas leaves sewn the same way but hung on tobacco sticks in a conventional manner suffered 24-64% barn rot loss.

Weed Control

A mail survey of the weed problems in Essex, Kent, and Lambton counties was conducted. Information was obtained on the location of new and perennial weed problems. A weed identification garden and herbarium have been established at the Station to aid the farmers in identifying problem weeds.

White Beans

Breeding. Total protein content ranged from 16.9% to 36.3% among 144 plant introductions (PI). Seed of the variety Sanilac grown at Paincourt, Erieau, and Harrow in 1971 contained 21.6%, 25.1%, and 32.5% protein respectively. Seed of the variety Seafarer contained 21.9%, 21.3%, and 29.4%

protein for each of the above locations. Crosses were made involving the high-protein line PI 186493.

Pathology. Under normal conditions, *Xanthomonas phaseoli* (E.F.Sm.) Dowson bacteria, which cause common blight, do not move systemically in white bean plants. The survival of the bacteria on uninfected leaves is restricted to the surface of leaves that are expanding at the time of inoculation. Also, infections occur only on these leaves.

Two fungicides proved effective for control of white mold, *Sclerotinia sclerotiorum* (Lib.) de Bary. Benomyl (Benlate) is now registered for use on white beans. Thiophanate-methyl (NF-44) is equally effective. White mold reduced yield by 19% in the test plots on commercial farms.

For the second consecutive year, ozone levels and bronzing incidence were low. This disease had been important for at least the previous 7 yr.

HORTICULTURAL CROPS

Field Vegetables

Cabbage

Insect pathology. It was demonstrated that viruses and commercial preparations of the bacterium *Bacillus thuringiensis* are good alternatives to chemical insecticides for control of the imported cabbageworm and cabbage looper on late cabbage. A spray program for integrated control of these insect pests has been developed.

Granulosis virus of the cabbageworm and nuclear-polyhedrosis virus of the cabbage looper, accumulated from natural epizootics in 5 yr in nontreated plots of cabbage, protected the crop. Foliage damage was less in the long-term plots in 1972 than in plots first planted with cabbage in 1972.

Cucumber and Pepper

Breeding and testing. From field plots of pickling cucumbers artificially inoculated with angular leaf spot, caused by *Pseudomonas lachrymans* (Gm. & Bryan) Carsner, three highly tolerant plant introductions of the U.S. Department of Agriculture, 192940, 169400, and 234517, were used to initiate breeding for resistance to the disease.

Selection for commercially acceptable white-spined picklers was continued. From crosses between Harrow inbreds and Morden Early, F₂ selections flowered 7 to 10 days before SMR58, commonly used as a pollinator for commercial gynoeocious hybrids.

Gross returns from six varieties at a density of 43,000 plants/ha and picked six times were twice to three times the returns from the same cultivars at 247,100 plants/ha picked once to simulate a once-over machine harvest. At the low density, high dollar value grades ranged from 65% to 71%, and at the high density, 16% to 32%.

Four Harrow F₁ hybrids had the commercially required 3:1 ratio of length to diameter. H71.21 was among the best initial-test hybrids that grossed in excess of \$2,718 per hectare after six picks.

Bacterial diseases. Symptoms of angular leaf spot of cucumber and bacterial leaf spot of pepper typical of those observed in the field were produced in the controlled environment of a dew chamber. Infection occurred without mechanically forcing bacteria into the plant tissue.

The rate of development of an angular leaf spot epidemic in the field was substantially slower in the tolerant variety Premier than in the susceptible varieties Pioneer and SMR58.

Corn borer control. A 5-day schedule of carbaryl gave significantly better control of the European corn borer, *Ostrinia nubilalis* (Hbn.), in pepper than a 7-day schedule.

Verticillium wilt. Many isolates of *Verticillium dahliae* Kleb. obtained from sweet peppers in southwestern Ontario were pathologically distinct from those infecting other vegetable crops. Whereas most of the pepper isolates caused severe disease in eggplant, many eggplant and tomato isolates were either nonpathogenic to pepper or very weakly pathogenic.

Muskmelon

Plant age and length of time seedlings are treated before being transplanted into infested soil, application of the systemic fungicides benomyl and thiophanate-methyl, and the kind of container used to culture muskmelon are important interrelated factors of resistance to fusarium wilt, growth, and yield. Although both thiophanate-methyl and benomyl control wilt and enhance yield,

some differences in their action and benefits indicate that recommendations should be made separately.

Potatoes and Beans

Green peach aphid. Numbers of aphids in the initial flights from peach trees were low in 1972. The flights in the last week of July were the highest for that time of year in six seasons, but the late-summer peak of flights was low. It was possible to make six predictions of short-term population increases and five weekly increases. Of these, six and four respectively were satisfactory.

Insect control. Granular disulfoton, phorate, and carbofuran applied below the seed pieces gave excellent control of all potato insects including a heavy infestation of the Colorado potato beetle.

Pest control. Tests demonstrated that water formulations with pesticides and silica were superior to higher concentrations of pesticides alone for control of *Leptinotarsa decemlineata* (Say) on potato and for reducing the adult survival and egg production of *Tetranychus urticae* Koch on broadbean.

Verticillium wilt. In seven commercial fields of Onaway potatoes, 50% of the plants showed severe wilt by mid-July, and *Verticillium albo-atrum* Reinke & Berth. was isolated. A lower but yet appreciable incidence of severe wilt was found in fields planted with the variety Superior. Only traces of severe wilt were found in Irish Cobbler and Kennebec. Irish Cobbler and Kennebec seed was obtained from the Maritime Provinces of Canada, and Onaway and Superior seed was obtained from Michigan and Minnesota respectively. Our previous findings show that *V. albo-atrum* does not normally overwinter in field soil at Harrow, so this fungus, which causes severe wilt, must have been introduced on the seed. Because severe wilt has reduced yield in some varieties by 25% in certain years, the incidence of seed-borne *V. albo-atrum* is of great concern to potato growers in southwestern Ontario.

Sweet Corn

Corn borer egg laying. A method of determining if female corn borer moths had mated or laid eggs was developed.

Corn borer control. Control of second-generation corn borers was excellent with leptophos (Phosvel), good with carbofuran,

carbaryl, and methomyl, and fair with fenitrothion and trichlorfon.

Tomatoes

Sap beetles. Populations of the sap beetle *Glischrochilus quadrisignatus* Say, which infests damaged tomatoes during the period between harvest and delivery to the factory, continued to increase. From spring to fall, 2,732,948 beetles were captured in 46 traps placed around the periphery of two tomato fields in Kent County. Movement of beetles to damaged tomatoes was greater when beetles were starved for several days. Harvested tomatoes that were moved quickly from the field to the factory were barely infested by the beetle. Tests indicated that a sufficient amount of insecticide might adhere to the plastic bottoms of hampers to provide some beetle control.

Insecticide residues in canned tomato products. Whole-pack tomatoes and juices made from fruit that had been in contact with five insecticides used in the sap beetle control program were analyzed for residues. Only small amounts, less than the safety levels set by the Food and Drug Directorate, were detected.

Irrigation and plant populations for processing tomatoes. Irrigation experiments conducted with processing tomatoes since 1969 have established with reasonable certainty that the average daily rate of evapotranspiration associated with maximum crop yield is 2.5 mm (0.1 in.) per day. When grown on a coarse sandy loam (Fox series), processing tomatoes are able to extract 5 cm (2.0 in.) of water from the soil initially at field capacity without restricting growth or final yield. Thus a balance sheet system, which debits 2.5 mm (0.1 in.) of water each day and credits rainfall received, can be used to schedule irrigation water. When the total deficit reaches 5 cm (2.0 in.), the crop grown on Fox sandy loam will require irrigation. On finer-textured soils the permissible deficit will increase in proportion to the water storage capacity of the soil.

The minimum plant population necessary for maximum yield of the transplanted crop is 24,700 plants/ha and for the direct-seeded crops 37,100 plants/ha. Increasing populations beyond these limits did not produce any further increase in yield.

In the transplanted crop, increasing plant populations from 12.4 to 24.7, 37.1, and 49.4

thousand plants/ha decreased the number of fruit per plant from 121 to 99, 99, and 58 respectively. The higher populations also advanced maturity. On August 25, 35%, 38%, 45%, and 53% of the fruit were ripe at 12.4, 24.7, 34.1, and 49.4 thousand plants/ha.

Placement of black plastic mulch for processing tomatoes. Yield of Heinz 1350 tomatoes transplanted through a black plastic film 91.4 cm wide in rows 1.5 m apart was 75.58 t/ha. Where plastic covered the soil between the rows leaving a strip of bare soil 15.2, 30.5, and 45.7 cm wide adjacent to each side of the row, yields of tomatoes were 86.26, 80.42, and 86.04 t/ha respectively. Yield of tomatoes with no plastic mulch was 65.86 t/ha. The results indicate that a black plastic mulch placed between the rows was more effective in increasing yield than plastic over the row.

Tomato tolerance for trifluralin. The tolerance of tomato transplants for trifluralin incorporated in the soil at different tillage intensities and applied at recommended and double the recommended rates was studied at Harrow (Fox sandy loam) and Woodslee (Brookston clay loam). The treatments used had no significant effect on yield at Harrow. Similar treatments at Woodslee resulted in a significant reduction in tomato yields. The yield reduction was accentuated by the use of excessive rates of trifluralin incorporated at high tillage intensities.

Greenhouse Vegetables

Cucumber

Breeding and testing. HG73 seedless cucumber was selected as a potential distinctive variety for greenhouse production. It is similar to HG72, but shorter (26–30 cm). A new gynocious test hybrid, HG70.72, was produced. In overall appearance, including length (32–36 cm), it is similar to HG72, but it has improved eating quality. HG72 and HG70.72 were widely distributed for trial.

Progress was made with HG70.78 and derivatives of outcrosses from it toward the development of gynocious, bitter-free, seedless varieties with resistance to powdery mildew, *Sphaerotheca fuliginea* (Schlecht ex Fr.) Poll., and scab, *Cladosporium cucumerinum* Ell. & Arth., and tolerance for cucumber mosaic virus, *Marmor cucumeris* var. *vulgare* Holmes.

HG72 and HG73 were comparable in productivity with the European cultivars Toska and Sporu. Both the Harrow and European cucumbers were marketable after 4 wk in storage at 12.2°C and 80.5% relative humidity. After 1 wk on the shelf at normal room temperature, only HG72 and HG73 were marketable. The kilogram force required to puncture the skin of unpeeled fruits and to probe the flesh of peeled fruits suggested a relationship between skin and flesh texture and storing quality.

A high level of tolerance for the root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood, was found in *Cucumis ficifolius* A. Richard (USDA accession PO 196844), but in crosses this species was incompatible with *C. sativus*.

Cultivar differences in nutrition. Burpee Hybrid, High Mark II, and Meridian T cultivars were grown for 3 yr with four rates of complete fertilizer. Burpee produced the most fruit per plant and the greatest weight of fruit. Meridian T produced the largest plant but a low fruit yield. No evidence was found that High Mark II or Meridian T can be successfully produced with less fertilizer than Burpee Hybrid.

Integrated pest control. The use of the whitefly parasite *Encarsia formosa* Gahan increased threefold in 1972. A rearing facility, supported indirectly by growers, was established near Leamington to supply parasites for both cucumber and tomato crops.

Virus infection. The varieties of European seedless cucumbers Toska 70 and Sporu are highly susceptible to cucumber mosaic virus (CMV). Sudden wilting and early death of infected plants are symptoms of virus infection. Summer and fall commercial crops failed in 1972, as in previous years, because CMV gained entry into greenhouses through viruliferous melon aphids, *Aphis gossypii* Glover.

Tomatoes

Nematodes. In natural greenhouse soil, regardless of the control method employed against *M. incognita*, nematodes below the 100-cm depth infested the next crop.

In microplots of tomatoes, infestations of 4,400 *M. incognita*/kg of soil in the top 30 cm resulted in a yield reduction of 18.8%. Infestations of 4,400 *M. incognita*/kg of soil 135–150 cm below the surface resulted in a

yield reduction of 7.9%. Galls were observed on roots from all depths in both infestations. Nematode populations, sampled at 15-cm intervals to 150 cm, were considerably greater at all depths than were the initial levels at the depth of inoculation.

Sucker growth to increase yield. Axillary side shoots or suckers are usually removed from greenhouse tomato plants to promote optimum fruit production or main stem clusters. Total plant yield can be increased by permitting selected suckers to grow and produce additional clusters. The yield of Michigan-Ohio hybrids was increased by 47% and the yield of Vendor by 50%. In both cases, the size of tomatoes on suckers was about 10% greater than that of fruit on main stems. If the suckers permitted to grow are too low on the main stem or too numerous, the total plant yield is decreased and fruit size is reduced because excessive foliage shades the plant. Success of the technique depends upon judicious selection of vigorous suckers near the top of the plant at the right stage of growth.

Tree Fruits

Apricots

Cold hardiness. Controlled freezing tests of detached scions with a cooling rate of 5°C/h were useful in determining the relative and absolute cold hardiness of promising selections in comparison with Goldcot (hardy), Veecot (medium-hardy), and Viceroy (medium-tender). All flower buds were killed at -30°C. At -27°C, the buds of 17 out of 22 Harrow selections were more hardy than buds of Goldcot, and 10 had sufficient live buds for a normal crop. Cold injury to flower primordia was greater than to bud scales. The phloem was the most sensitive of the stem tissues, followed by the cambium and xylem. The pith and cortex were the most cold resistant. Although -30°C was lethal for flower primordia, the stem tissue sustained only moderate injury at that temperature.

Measuring texture of canned apricots. Texture measurements of canned apricot halves made with a Kramer shear press (KSP) and the Ottawa texture measuring system (OTMS) were compared and correlated with subjective measurements of texture made by a trained taste panel. Firmness as measured by the OTMS was highly

correlated ($r = 0.74$, $P < 0.01$) with sensory perception of firmness, but firmness as measured by the KSP was not correlated with the OTMS measurements or with taste panel assessments. Firmness as measured by the OTMS was also correlated with percent sugar ($r = 0.58$, $P < 0.01$), pH ($r = 0.83$, $P < 0.01$), and percent malic acid ($r = 0.65$, $P < 0.01$). The OTMS with a 20-cm² wire extrusion cell was superior to the KSP for measuring texture of canned apricots.

Peaches

Cold hardiness. In mid-January 1972, an unusually warm period of 7°C was followed by a sudden drop to -23°C in 3 days. This natural freeze was lethal to flower buds of most cultivars in the tender (Loring), medium-tender (Collins), and medium-hardy (Redhaven) classes. Only cultivars that were more hardy than Redhaven produced a crop. The Harrow collection includes over 200 peach cultivars and selections. Only three cultivars had a very heavy crop: Harrow Blood, Lemon Free, and Babygold 8; five had a heavy crop: Tzim Pee Tao, Bailey, Gold Drop, Veteran, and Rutgers Red Leaf. Those with a medium crop included Madison, Kalamazoo, Envoy, Sunapee, Babygold 5, Suncling, Loadel, and Babygold 7. In general, the nonmelting clingstone cultivars were more cold hardy than the freestone cultivars. Greater emphasis was placed on the use of some of these cultivars as parents when breeding for cold hardiness. It appeared that cultivars that had the ability to reharden quickly were the least injured.

Herbicide residues in orchard soil. Samples of orchard soil that had been treated annually for a number of years with atrazine, simazine, and linuron were analyzed to determine whether a buildup in the soil had occurred. Small amounts of residues were detected, but no accumulation had developed over a period of 7 yr.

Insects and canker. Egg-laying scars of the blackhorned tree cricket were not infected by canker and healed over satisfactorily. In 1972, the population of ambrosia beetles, *Xyleborus saxeseni* Ratz., was about one-third that in 1971, in the Harrow variety orchard. The 1971 beetle damage to trunks had healed by 1972, without invasion by canker. The main flight period for ambrosia beetles was the third week of May.

Microbiology. In studies of the recoverability of *Phytophthora cactorum* (Leb. & Cohn) Schroet. from soil, zoospore populations often fell below the threshold level of detection by fruit-baiting techniques. In manipulating the production of sporangia and zoospores, regulation of the water-air-drying regime proved most important. Excellent recovery of the fungus was achieved from steam-sterilized soil when numbers of zoospores added to the soil exceeded the threshold level of recovery. Unknown factors in nonsterile soils hostile to zoospores precluded their recovery and detection.

Peach bacterial spot. Seasonal changes in epiphytic populations of the causal organism of peach bacterial spot, *Xanthomonas pruni* (E.F.Sm.) Dowson, and associated microflora were monitored at weekly intervals in buds during May and on leaves until the end of October in 1972 on the peach cultivars Loring, Redhaven, and Babygold 5. *X. pruni* was generally present in the buds of most of the trees in May. The incidence and population levels were higher on Babygold 5, but sporadic and at barely detectable levels on Loring and Redhaven until the third week in July. From then on, after increased precipitation, population levels of *X. pruni* increased on all cultivars and remained high until the end of October.

Peach canker. Winter injury was related to the incidence of canker caused by *Leucostoma cincta* (Fr.) Hoehn. and *L. personii* (Nits.) Hoehn., partly because flower buds injured by low temperatures provided a major site for infection during and after the dormant season. Scions of Siberian and Blood peaches developed cankers around the buds when they were subjected to controlled freezing temperatures of -27 and -30°C and subsequent inoculation with conidia of the canker fungi. Flower buds of unfrozen controls were mainly uninjured and did not develop cankers upon inoculation.

Peach seedling responses to dichlobenil. In greenhouse studies, seedlings of eight peach cultivars were shorter and lighter in weight when the herbicide dichlobenil was incorporated into the soil at a rate equivalent to 9 kg/ha, but surface application at this rate had no effect. The reduction in plant weight was similar for all cultivars, but heights varied because certain cultivars recovered

from inhibition. Treated Kalamazoo seedlings grew faster than the control during the last stages of growth and had lower impedance after cold treatment and greater apical stem injury after freezing. Rutgers seedlings had decreased stem diameter and a distinct bending of the stem in response to dichlobenil.

Rootstock influence on bud hardiness. Evidence from natural freezing indicated that some peach rootstocks have a direct and significant influence on cold hardiness of scion varieties budded on them, to the extent that yields may be significantly affected. Siberian-C rootstock significantly increased the hardiness of Redhaven and Babygold 5 flower buds, resulting in significantly greater bud survival, heavier bloom, and greater yield than four other rootstocks tested. Babygold 5 on Siberian-C produced 58% more fruit than Babygold 5 on Harrow Blood. Yields varied from a commercial crop of Babygold 5 on Siberian-C rootstock to only a trace of fruit for Babygold 5 on Harrow Blood.

Pears

Breeding. This year, two selections were propagated for retest on the basis of fruit size, appearance, quality, and fire blight resistance. A total of 9,200 seedlings were screened for fire blight resistance. Hybridizations were made that mainly involved backcrosses of fire blight resistant selections developed at Harrow and other research stations with Bartlett and Comice. Crosses were also made between the resistant selections and other varieties with good processing and dessert quality, such as Aurora, Laxton's Progress, and Devoe. A total of 15,700 seeds were obtained from these crosses for screening next year.

Fire blight. In a comparison of inoculation techniques, high-pressure inoculation of young pear shoots with *Erwinia amylovora* (Burr.) Winsl. et al. by means of a hypospray resulted in the same percentage infection as inoculation with a hypodermic syringe. However, a syringe fitted with a microapplicator attachment permitted more precise control of inoculum dosage. Several other methods tried were less effective.

Chemical control of fire blight was tested during the blossom period in a commercial Bartlett pear orchard. Four sprays of streptomycin sulfate (100 ppm) applied with or

without two postbloom sprays gave good control of the twig blight phase. A similar spray program in a Lodi apple orchard yielded inconsistent results.

The epidemiology of fire blight was studied. Assays for the presence of *E. amylovora* on pear and apple shoots free from fire blight symptoms indicated that populations of bacteria were very low in May and June, increased to a peak in August, then declined. Numbers of bacteria appeared to be related to the presence of blighted shoots in the vicinity.

Bactericidal dip treatments to rid apple fruits of *E. amylovora* were developed. Acetic acid followed by streptomycin sulfate was the most effective treatment. A mixture of isopropanol, ethanol, and methanol followed by acetic acid was also effective.

Pear rootstocks. The testing and development of dwarfing rootstocks for pears that are more winter-hardy than Quince A began this year at Harrow. The first phase of the testing program, the collection of pear and quince clones having dwarfing potential and adequate levels of winterhardiness, began this year. Promising *Pyrus* rootstocks include clones of Old Home × Farmingdale, developed in Oregon, and *P. calleryana* Decne. var. *fauriei* (C.K.Schneid.) Rehd., a dwarf species that grows in Korea. Quince selections that may be more hardy than Quince A are also being collected. These include selections from Russia, Czechoslovakia, Poland, and France. A limited number of crosses were made between Old Home with rooting potential and several natural dwarf selections. The objective is to select a winter-hardy, dwarfing pear rootstock that is easy to propagate clonally.

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Research Station Ottawa, Ontario

PROFESSIONAL STAFF

F. K. KRISTJANSSON, B.S.A., M.S., Ph.D.	Director
L. H. LYALL, B.S.A., M.S.	Assistant Director
J. G. R. LOISELLE, B.Sc. (Agr.), M.Sc., Ph.D.	Plant gene resources
R. W. MARTIN	Administrative Officer

Cereal Crops Section

V. D. BURROWS, B.S.A., M.Sc., Ph.D.	Head of Section; Plant physiology, oats and barley
A. T. BOLTON, B.Sc., M.Sc., Ph.D.	Plant pathology
R. V. CLARK, B.Sc. (Agr.), M.Sc., Ph.D.	Plant pathology
I. DE LA ROCHE, B.Sc., M.Sc., Ph.D.	Quality
G. FEDAK, B.S.A., M.Sc., Ph.D.	Barley
S. O. FEJER, Ing. Agr., Dr. Sc. Tech.	Barley
J. E. FISHER, B.S.A., M.Sc., Ph.D.	Morphology
V. A. HELSON, B.A., M.A.	Environmental physiology
D. P. HOLMES, B.Sc., Ph.D.	Growth analysis
A. G. PLESSERS, B.Sc. (Agr.), M.S., Ph.D.	Hybrid winter wheat
D. R. SAMPSON, B.Sc., A.M., Ph.D.	Oat genetics
J. T. SLYKHUIS, B.Sc., M.Sc., Ph.D.	Virology
S. SYMKO, Ing. Agr.	Barley and triticale

Crop Loss Section

V. R. WALLEN, B.Sc., M.Sc., Ph.D.	Head of Section; Aerial photography, methodology
P. K. BASU, B.Sc., M.Sc., Ph.D.	Surveys and methodology
W. C. JAMES, B.Sc., Ph.D.	Surveys and methodology
W. L. SEAMAN, B.Sc., Ph.D.	Surveys and Editor, Canadian Plant Disease Survey

Cytogenetics Section

T. RAJHATHY, Ing. Agr., M.Sc., D. Agr. Sci.	Head of Section; Cereal crops
K. C. ARMSTRONG, B.S.A., Ph.D.	Forage crops

B. E. MURRAY (MISS), B.S.A., M.Sc., Ph.D.

Protein genetics

Entomology Section

D. G. HARCOURT, B.S.A., Ph.D.

Head of Section; Population dynamics

R. BOCH, Dr. Rer. Nat.

Physiology and behavior of bees

T. BURNETT, B.S.A., Ph.D.

Population ecology

T. A. GOCHNAUER, B.A., M.S., Ph.D.

Pathology of bees

J. C. GUPPY, B.S.A., M.S.

Population dynamics

M. K. MUKERJI, B.Sc., M.Sc., Ph.D.

Population dynamics, energetics

Forage Crops Section

W. R. CHILDERS, B.Sc. (Agr.), M.S., Ph.D.

Head of Section; Legumes and grasses

H. BAENZIGER, Ing. Agr., M.Sc., Ph.D.

Legumes

L. M. CASSERLY, B.A., B.S.A., M.Sc.

Corn

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

Plant pathology

L. DESSUREAUX, B.A., B.Sc., M.S., Ph.D.

Alfalfa genetics

L. S. DONOVAN, B.S.A., M.S., Ph.D.

Corn and soybeans

D. R. GIBSON, B.Sc. (Agr.)

Corn

R. W. ROBERTSON, B.S.A.

Plant introduction

H. D. VOLDENG, B.S.A., M.Sc., Ph.D.

Plant physiology

F. S. WARREN, B.S.A., M.Sc., Ph.D.

Corn

Horticultural Crops

L. H. LYALL, B.S.A., M.S.

Vegetables and fruit crops

G. R. JOHNSTON,¹ B.S.A., M.S.A.

Potatoes

Experimental Farm, Kapuskasing, Ont.

J. M. WAUTHY, B.Sc. (Agr.)

Superintendent; Crop management and evaluation

Experimental Farm, Smithfield, Ont.

H. B. HEENEY, B.Sc. (Agr.), M.Sc.

Superintendent; Plant nutrition and irrigation

H. L. HOUSE, B.S.A., Ph.D.

Insect physiology and nutrition

S. J. LEUTY, B.S.A., M.S., Ph.D.

Fruit crop management

¹Stationed at University of Guelph, Guelph, Ont.

S. R. MILLER, B.Sc., M.Sc., Ph.D.
W. P. MOHR, B.S.A., M.S.A., Ph.D.
L. G. MONTEITH, B.S.A., M.S.A.

Plant physiology and biochemistry
Food processing
Fruit management, pest control

Experimental Farm, Thunder Bay, Ont.

W. B. TOWILL, B.S.A.

Superintendent; Crop management
and evaluation

Departures

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

Resigned April 1972

Wheat

R. M. MACVICAR, B.S.A., M.Sc.

Retired February 1972

Head of Section; Grass breeding,
corn and soybean management

INTRODUCTION

The program at the Research Station, Ottawa, Ont., now emphasizes research on animal feed crops, including cereal, corn, and forage crops. Research on tree fruits and small fruits has either been concluded or been transferred to other stations, and tomato research will be discontinued by the end of 1973.

This was a productive year for the plant breeding programs. Nine new cereal and forage cultivars were licensed, including one barley, two oat, two alfalfa, one orchardgrass, and three corn hybrids. One tomato variety was introduced for commercial canning.

Mr. R. M. MacVicar retired in 1972 after 41 years of valuable service to agriculture. A pioneer in grass breeding, he originated 15 cultivars, 12 of which are now licensed in Canada. The most outstanding of these is Climax timothy, which remains an international standard for the species.

This report summarizes some of the more important research results from the Station during 1972. Requests for further information should be directed to: Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

F. K. Kristjansson
Director

CEREAL CROPS

Wheat

Winterhardiness. Growth at hardening temperatures (2°C) resulted in greater fatty acid unsaturation and phospholipid synthesis than growth at 24°C. Ten phospholipids were identified in dry seed and seedlings at various stages of development; the main components were phosphatidyl choline, lysophosphatidylcholine, *N*-acyl lysophosphatidylethanolamine, *N*-acylphosphatidylethanolamine, and phosphatidylethanolamine. The changes in phospholipids during growth at the two temperatures were caused by phospholipid biosynthesis in the developing embryo and by phospholipase D action on the phospholipids of the endosperm. In general, phospholipid composition was similar in morphologically similar seedlings grown at 2°C and 24°C. Lipid, respiration, and electron spin resonance analyses of the mitochondria isolated from these tissues support the hypothesis that the membrane is the primary site of freezing injury. "Hardening off" of tissues causes quantitative and qualitative membrane changes that make the tissues less susceptible to freezing injury.

Winter triticale breeding. Several valuable strains have been developed using hexaploid winter wheats as female and durum wheat × winter rye as male parents. These strains have 41 to 56 chromosomes and they are characterized by high tillering, strong straw,

good fertility, and plump seeds; some surpass Kent wheat in yield, winterhardiness, and protein content. The strains that cross readily with common wheats provide new possibilities for improvement in common winter wheat.

Spring triticales. Six vigorous, highly fertile plants ($2n = 42$) with plump seeds were obtained from crosses between a durum wheat (Kubanka × Pelissier) F_1 as the female and a winter rye (Sangaste × Symko) F_1 as the male parent. The necks of the spikes were glabrous, a characteristic not previously reported in triticales. The F_2 plants tillered well and produced tall, strong straw that was resistant to lodging. These plants were fertile, with large but shriveled seeds, and crossed readily with Mexican strains of spring triticale.

Quality. The repeatability and heritability of various rheological tests have been determined on a great many wheat species and triticale genotypes. This has made it possible to determine the most appropriate prediction tests to use for early generation material.

The differences in baking quality of Talbot, Selkirk, and Pitic 62 are caused by major differences in the quantities of gliadin, glutenin, and residual proteins in the flour, and not by differences in neutral lipids, glycolipids, or phospholipids.

Oats

Breeding. The cultivar Scott (OA18-35)

was licensed and distributed to seed growers in Ontario in 1972. It is yellow-seeded and combines the yield potential of Dorval with the good agronomic qualities of Garry. A high-protein, milling oat, OA123-33, has been tested by two manufacturers with promising results. OA123-1 has large white seeds and thin hulls; it is resistant to lodging and smut and may also be useful as forage.

Genotype-environment interaction for yield. The relative grain yields from 10 of 28 crosses of an eight-parent half-diallel of oats differed greatly between 1970 and 1971 ($r = .097$, N.S.). In 1970 there was drought during the grain filling period, whereas in 1971 there was adequate moisture. The general combining ability (GCA) of the parents for yield, based on the means of the two years, ranked them from highest to lowest: OA123-1, Kelsey, Bento, Marino, N.Y. 5279, Clintford, Stormont, and Purdue. The contribution of each cross to the genotype-environment (G-E) interaction sum of squares was calculated, and from these the GCA effects of each parent for G-E interaction were obtained. The ranks of the parents, in the order listed above, were 8, 6, 1, 7, 4, 5, 3, and 2. Rank 1 was assigned to the parent with the least interaction variance. This is almost the reverse of the order for yield, except for Bento, which proved to be a good parent for yield and the best parent for yield stability.

Barley

Spring barley. The barley selection OB95-21 from the Ottawa Research Station has been approved for licensing under the name Vanier. It is a six-rowed, white aleurone, feed barley, well adapted to conditions in eastern Ontario.

Crosses between winter and spring barley may provide useful new sources of variability for the breeding of spring barley. Of 25 hybrids evaluated, 16 exceeded their spring parents in grain yield and 12 in seed size.

Growth and Development

Possible origin of the spike characteristic of Mexican wheats. The semidwarf Mexican wheats owe much of their yield potential to their large ears with many spikelets, each of which contains several seeds. Their pattern of development in the early to middle stages of head formation is similar to that of rye. This was originally traced to Norin 10, the progenitor of the Mexican wheats, and

subsequently to Daruma, a Japanese land race from which Norin 10 was developed.

Under the stress of photoperiod reversal, Daruma segregated into classes with head types resembling *Triticum aestivum* ssp. *compactum* (Host) MacKey (club wheat), *T. aestivum* ssp. *sphaerococcum* (Perc.) MacKey (Indian shot wheat), and *T. aestivum* ssp. *vulgare* (Vill., Host) MacKey (common wheat). The Mexican cultivar, Pitic 62, showed some signs of this type of segregation, but other standard wheat cultivars did not.

These observations suggest that Daruma and similar semidwarf wheats from Eastern Asia evolved from crosses between club, Indian shot, and common wheats. Rye chromatin possibly became incorporated into some of the subspecies, or into a hybrid of them. Present morphological evidence suggests that rye chromatin became incorporated into a club wheat prior to hybridization with Indian shot and a common wheat. This could have occurred in Afghanistan, the Punjab, or Northern India, where all three wheat subspecies and rye are common in a great many types.

Senescence of assimilate sources in wheat during grain filling. Defoliation of shoots of Marquis wheat 1 wk after anthesis delayed the rate of grain growth, the loss of chlorophyll from the assimilatory tissues of the spike, and the rate of grain maturation, but it had no significant effect on the number of grains per spike or the final grain size. These observations indicate that a compensatory mechanism operates to partially stabilize grain yields under conditions of stress that result in destruction of assimilatory tissue.

Growing plants in controlled environments. The screening procedure developed to predict yield of oat cultivars in the field from early vegetative growth in growth chambers was tested, using the 1969 and 1971 Eastern Cooperative Oat Tests. In the 1969 test of 15 oat cultivars, there was a highly significant correlation ($r = .707$) between fresh weight of seedling leaves and mean groat yield from all stations. However, in the 1971 test of 20 oat cultivars, seedling growth and average seed yield from all stations showed no significant correlations. The reason for the

differences in the results between the two years is not yet known.

Pathology

Wheat spindle streak mosaic. Wheat spindle streak mosaic virus developed in soil in which wheat was grown frequently, and invaded the roots most rapidly in October. This rapid invasion was caused by the favorable temperature and an increase in infectivity of the soil. Soil samples were more infectious during the 2-wk period after collection in October, than if collected any time from May to September. Soil collected in May was less infectious when tested immediately than when tested after drying for 4 mo.

Soil kept moist, but without plants for several weeks, was not infectious during the first 2 wk wheat was grown in it, but was infectious during the second and third 2-wk test periods. This indicates that the growing wheat roots stimulate the activity of the infecting agent in the soil.

Soil infectivity was stimulated by the addition of 0.5% sugar, but was inhibited by 2% sugar. It was also inhibited by 0.5% NH_4NO_3 , but not by a combination of 2% sugar and 0.5% NH_4NO_3 . This indicates that the C:N balance affects the process of infection in the soil.

Two cultivars of winter wheat, Miro and Blue Boy, were resistant to the virus in field tests but were susceptible when inoculated artificially by the leaf spray technique.

FORAGE CROPS

Alfalfa

Two new cultivars, Angus (an early, Flemish type) and Algonquin (a standard type), have been licensed. Both were equal to or better than the respective control varieties, Saranac and Vernal, in forage yield trials at various locations in Ontario, Quebec, and Western Canada. Both varieties were resistant to bacterial wilt. Breeder seed of Angus was produced in 1972 on a 0.2-ha (half-acre) plot at the Research Station, Melfort, Sask. This plot produced 165 kg (365 lb) of cleaned seed. Algonquin was increased at the Experimental Farm at Indian Head, where

84 kg (185 lb) of seed were obtained from 0.3 ha (0.7 ac).

Angus and Algonquin are the first Canadian-bred alfalfa varieties adapted to Eastern Canada. Seed growers in the Prairie Provinces who use leafcutter bees for pollination will be encouraged to produce Foundation and Certified seed.

Grasses

Orchardgrass. The cultivar Juno, which has the same maturity and similar plant characteristics to the Swedish cultivars Frode and Tardus II, has been licensed. It has higher seed weight and good seed-yielding potential, as well as improved digestibility as determined by an in vitro method.

Timothy. A pasture-type strain, S3-9, equal in yield to Champ, is tall and has higher seed-producing potential. This and two other strains will be considered for licensing by the Ontario Forage Committee in 1973.

Bromegrass. The synthetic, B-9, demonstrated superior seed-yielding ability in eight tests in the Prairies and Ontario and has been entered in provincial trials in the Maritimes, Quebec, and Ontario. It is equal to Redpatch in forage yield, but produces 25% more seed. A 1.2-ha (3-ac) Breeder seed field was established in 1972.

Corn

Development of hybrids. Three experimental hybrids, OX412, OX422, and OX429, qualified for licensing on the basis of 1972 Ontario Corn Committee trials. Others were tested at several locations outside the province that had less than the 2,650 heat units normally available at Ottawa. Four of these, OX401, OX402, OX419, and OX428, when grown at two 2,200-heat-unit locations (Lethbridge and Brandon), had 25.6–35.0% grain moisture at harvest; litre (bu) weights at Brandon (0.64–0.68 kg; 51–54 lb) were not as high as those at Lethbridge (0.70–0.73 kg; 56–58 lb), probably because of the later planting date, May 26 rather than May 1.

In the development of hybrids for eastern Ontario and southern Quebec increasing attention is being paid to single and three-way crosses and less to double crosses. In Ontario Corn Committee trials grown for grain, single crosses generally outperform double crosses, which is resulting in the

gradual disappearance of double crosses from the Recommended List.

Corn diseases. Southern leaf blight, caused by *Helminthosporium maydis* Nisikado & Miyake, was found on leaves of normal cytoplasm corn in several locations in eastern Ontario during August and September, but did not reach epidemic proportions. In most cases, the source of infection was corn stored in cribs.

Thirteen hybrids on the recommended list for eastern Ontario were tested for resistance to southern leaf blight by spraying them in the field with a suspension of *H. maydis* spores. Although all hybrids contained normal cytoplasm, there was considerable variation in the degree of resistance to the disease. By September 28, DeKalb 007 had 38% of its leaves completely necrotic, whereas the more resistant hybrids had 10–15% necrotic leaves.

Corn plants containing Texas male sterile cytoplasm were planted in the field and inoculated with *H. maydis*, 7, 9, 11, and 13 wk after planting. At the 7-wk stage, infection was severe and resulted in a grain yield loss of approximately 50%. At 9, 11, and 13 wk, the yield losses were 25%, 10%, and 10% respectively. Total weight losses were 47%, 26%, 18%, and 10% respectively.

Corn growth and development. The response of corn to stress imposed by interplant competition was studied by varying three factors: row width, distance between plants within the row, and number of plants per hill. Plant arrangement had only a small effect on the yield of grain; population density was the critical factor.

In a controlled environment, tillering of corn is favored by high light intensity and low ambient air temperature.

Agronomic practices. Herbicidal weed control, cultivation, and N fertilization each contributed to increased yields of corn silage and grain. In an area badly infested with annual grass and broadleaf weeds, the most productive combination of these practices resulted in grain yields of over 8,000 kg/ha. Herbicide treatments produced the greatest yield increases, and of these butylate combinations were the most effective. However, yield increases nearly as large were obtained more economically with one or two cultivations. Each N increment up to 90 kg/ha

resulted in yield increases, but these increases were barely economic at the higher rates.

Soybeans

Breeding. Six hundred and four single plant selections were made within 25 populations of S2-3 resulting from three-way crosses that included a high-oil variety or strain from the I-II, 00, and 000-0000 maturity groupings. These populations have a wide genetic base because they contain material ranging from middle corn belt varieties, currently recommended Ontario varieties, and Swedish strains developed at a location near 54° N latitude.

Three-way crosses are also being used to establish gene pools for developing high-protein lines. This has involved crossing exceptionally high protein lines, which characteristically have some agronomic defects, with adapted high-oil varieties and then with reciprocal backcrosses.

Seed of three wild species, *Glycine gracilis*, *G. ussuriensis*, and *G. clandestina*, was analyzed and found to be high in linoleic and linolenic fatty acids. Protein levels were as high as 55% in *G. gracilis*.

Pathology

Fusarium root rot of alfalfa. A protein peptide extracted from alfalfa roots showed strong inhibition to *Fusarium oxysporum* Schlecht. and *F. solani* (Mart.) App. & Wr. The inhibitory fraction has a yellow pigmentation and shows fluorescence under ultraviolet light.

The amino acid fraction in alfalfa plants is correlated with resistance to fusarium root rot. Amino acid yield was found to be higher in susceptible plants than in resistant ones. Using chromatographic techniques, 13 amino acids were isolated from crushed roots of resistant Vernal plants and 17 from Saranac.

Prior inoculation of *Rhizobium* bacteria on alfalfa roots reduced subsequent cortical infection of *Fusarium* spp. and permitted effective nodulation. However, there was no reduction of disease development when seedlings of alfalfa were concurrently inoculated with *Fusarium* and *Rhizobium*.

Introductions

Promising introductions were: alfalfas, *Medicago sativa* L., from Turkey and the USSR that outyielded the control (DuPuits) in forage production; bromegrasses, *Bromus*

inermis Leyss., from the USSR and Germany that outyielded Redpatch; a hardy orchardgrass, *Dactylis glomerata* L., from the USSR that was higher yielding in forage production than Rideau; a low-growing, creeping, dense timothy, *Phleum nodosum* L., $2n = 14$, that could be useful as a lawn or pasture grass; a timothy, *Phleum pratense* L., from Germany that was 1 wk later in maturing than Champ and outyielded it.

Tests to determine the relationship between planting dates and winter survival of hairy vetch, *Vicia villosa* Roth., showed that mid-August was the optimum seeding date.

Ninety-four unlicensed cultivars of legumes and 124 grass cultivars were tested under the Organization for Economic Cooperation and Development Plan. Among these, three timothy cultivars showed promise.

HORTICULTURAL CROPS

Apples

Hardy rootstocks. The fully dwarfing clonal rootstock Ottawa 3, when used with McIntosh or Quinte as the scion variety, increased its superiority over Malling Merton 26 and showed the highest ratio of yield to tree size. It assured annual bearing in Quinte, which had started to alternate on less dwarfing rootstocks. Genetic studies with the clonal rootstocks showed very high general combining ability, not only for acids and total sugar in leaves as found previously in scab-resistant material, but also for leaf phenols. Simple inheritance and high heritability were indicated for these leaf constituents as well as for fruit acids. Leaf phenols were correlated with leaf sugars and acids as found earlier, and leaf sugars with fruit sugars, reaffirming the possibility of early selection based on these factors.

This program is being discontinued at Ottawa, but evaluation will be continued at Smithfield.

The hybrid seedling rootstock OH-2 maintained its semidwarfing effect and showed the highest ratio of yield to tree size. When McIntosh or Quinte were used as the scion variety, yields were generally similar to those of the clonal rootstocks. These hybrid rootstocks formed a 4×4 diallel. Genetic analysis of the increase in trunk circumference over 8 yr showed significant general, but

not specific, combining ability effects, indicating simple inheritance. This was confirmed by the relative uniformity of progenies.

This research has now been discontinued at Ottawa.

Raspberries

Diallel crosses. The importance of general and specific combining ability for yield, and the need for a two-step breeding program, as found earlier in inbred line \times tester crosses, was confirmed. Heterosis and inbreeding depression were also indicated. Some progeny averages were greater than for all control cultivars, indicating the presence of some very high yielding plants.

This research has now been discontinued at Ottawa and resulting selections have been transferred to other stations.

Tomatoes

New cultivars. Commercial trials of Ottawa 78 on medium-heavy soils in southern Ontario were very successful in 1971 and 1972. This variety is now in full-scale production for whole-pack canning under the name Ottawa 78. It is a medium-small plant that is characterized by resistance to verticillium wilt, reliable fruit set, crack resistance, and very good grades for whole-pack canning.

Rideau VR is a verticillium-resistant type developed from a backcrossing program with Rideau. It outyielded Rideau at Ottawa in 1971 and 1972 and will be introduced as a replacement for Rideau in eastern Ontario and southern Quebec.

Two new selections, Ottawa 91 and Ottawa 94, show promise as processing types. They are productive, verticillium resistant, and crack resistant, and they are able to retain their fruit in good condition on the vine for extended periods. They have potential as hand-harvested, whole-pack canning tomatoes and are promising for machine harvesting.

This tomato program is being phased out at Ottawa and will be discontinued by the end of 1973.

Potatoes

Potato breeding and testing. Fredericton-bred F 58010 can be recommended for release to growers as soon as sufficient seed is multiplied. It is equal to Netted Gem in cooking quality, but is significantly higher in yield of marketable tubers. The U.S. variety

Abnaki, which is resistant to prevalent strains of verticillium wilt and mosaic-type viruses, has good potential as a maincrop, tablestock introduction. Guelph-bred G 6880-1, when grown in mineral or organic soil, produced excellent chips in its first replicated trials. New York-bred NY 41, which is resistant to the golden nematode, significantly outyielded present Ontario maincrop standard varieties in 1972. It will soon be released to growers in New York State as the variety Hudson.

CYTOGENETICS

Oats

Cytogenetic architecture. Two new diploid species have been discovered. One of these, *Avena damascena* Rajhathy & Baum, collected in Syria, has a distinct karyotype designated A_d . Its genome is closely homologous to that of *A. prostrata* Ladizinsky, but it has several segmental differences. The other, *A. canariensis* Baum, Rajhathy & Sampson, has a symmetrical karyotype, a similar phenotype to *A. magna* Murphy & Terrell ($4x$) and to *A. sterilis* L., and bidentate lemmas, which is a unique trait among the diploids. *A. macrostachya* Bal., the only perennial oat species, was found to be an outbreeding diploid ($2n = 2x = 14$).

Gene pool. The CAV collection has been increased by nearly 2,000 samples from Ethiopia, Kenya, North Africa, and the Canary Islands; these have been classified and cataloged. Nine accessions of *A. sterilis* L. from Ethiopia were found to be short-day insensitive; their emergence-heading period took only 67–73 days under 12 h daylength.

Interspecific gene transfer. A Moroccan genotype of *A. longiglumis* Dur. was found to suppress the effect of the diploidizing gene in the hexaploids, thus inducing homoeologous pairing. The usefulness of this gene in increasing recombination in interspecific hybrids is being explored.

Electrophoretic studies in Avena. Populations of *Avena* from natural habitats in the Mediterranean and Middle East revealed geographical areas of diversity in esterase allozyme patterns. Diploid *A. hirtula* from the eastern Mediterranean had greater diversity in allozyme patterns than populations from the western part of the region. Diploid *A. barbata* from the Mediterranean had

limited variability, whereas those from the Middle East had diverse allozyme patterns. Specific allozymes or allozyme patterns could not be identified with any one particular ecogeographical region. In natural populations of hexaploid *A. sterilis* from different soil-climatic zones in Iran, certain allozymes were more frequently associated with one zone than with another, indicating that selection or adaptation of allozymes in the hexaploid spectrum was influenced by environmental conditions.

Recently identified diploids *A. damascena* and *A. canariensis* were analyzed electrophoretically to determine their relationships with other diploids and their role as ancestral donors of tetraploids and hexaploids.

Preparatory to the identification of primary trisomics in diploid *A. strigosa*, and of nullisomics in hexaploid *A. sativa* cv. Kanota, the allozyme spectra of each species were determined.

Bromegrass

Chromosome pairing was studied in interspecific hybrids from *B. erectus* Huds. ($2n = 28$) \times *B. inermis* Leyss. ($2n = 56$). Chromosome pairing was complete and indicated that the genome structure of the hybrid was AAAABB, and therefore that *B. erectus* and *B. inermis* were AAAA and AAAABBBB respectively. The karyotype of the A genome prepared from *B. erectus* allowed the preparation of the karyotype of the A and B genomes from *B. inermis*. The two genomes differed in that the A genome was characterized by one chromosome with a large satellite and one subterminal, whereas the B genome was characterized by two subterminal and four submedian to median chromosomes. The longer subterminal carried a small satellite. These ideograms confirm the usefulness of karyotype analysis in searching for species containing the A and B genomes.

CROP LOSS ASSESSMENT

Methodology

Aerial photography. A method was developed using aerial infrared color photography and scanning procedures to determine the extent of aphid infestation in corn caused by *Rhopalosiphum maidis* (Fitch) in the Chatham area in 1970. Results showed that of 1,796 ha (4,436 ac), which represented 162 cornfields photographed from the air, 10.4%

of the crop was infested with the corn aphid. Field infestation percentages ranged from 6.7% to 64.5%.

Results from 1970 aerial infrared color photographs recently completed for bean blight determination showed that of the 40 fields comprising 357.5 ha (882.7 ac) under the flight path in the Hensall area of southwestern Ontario 23.5 ha (57.9 ac) were infected. The overall infection levels in 1968 and 1970 ranged from 4% to 6% of the crop.

Potatoes. Experiments at Ottawa and Fredericton showed that black scurf on seed tubers did not result in seed decay or stem cankers and did not affect the tuber yield. According to the percentage surface area covered by sclerotia of *Rhizoctonia solani*, seed pieces were classified into three disease categories: 0–1%, 1.1–5%, 5.1–15%. The same relationship between the disease categories was found in the progeny tubers, although the actual amount decreased.

Cereals. Field experiments were conducted to establish the optimum size and shape of plots for estimating yield losses from cereal foliage diseases. Data from uniformity trials on healthy and diseased crops of wheat and oats showed that the coefficient of variation for yield decreased as plot size increased and became nearer to square in shape. Infection with septoria blotch of oats and powdery mildew of wheat did not appear to affect yield variability. Plots larger than 5-m (rod-row) size, in which 5 m (16 ft) of the center row of three rows was harvested, were found to have a 10% difference in yield between the two treatments.

A mathematical model was developed that described the relationship between severity and incidence of leaf rust and powdery mildew on winter wheat in Ontario. Disease severity could be adequately estimated from the incidence at an early stage of development, thus simplifying the procedure for disease survey.

Surveys

Ergot. Field surveys for the incidence of ergot in cereal crops were conducted in 1972 on 157 fields of wheat, barley, and rye in the three Prairie Provinces. Cooperating pathologists at Lethbridge, Lacombe, Saskatoon, and Winnipeg carried out complementary surveys that covered a large geographic area and a late stage of crop maturity. In the main survey, the overall incidence of ergot-affected

fields was 32% for wheat, 3% for barley, and 40% for rye. Infection levels in individual fields were generally less than 0.1%. The survey showed that roadside grasses and volunteer rye were important reservoirs of ergot inoculum, and indicated a potentially effective and inexpensive means of reducing levels of ergot in cereal crops.

Peas. Compilation of the results of surveys done in 1970 and 1971 by nine cooperating research stations on the prevalence and severity of diseases of processing peas has been completed. Using a uniform method of sampling and assessing disease, approximately 10% of the contracted area of green peas (*Pisum sativum*) grown for canning and freezing in seven provinces was surveyed each year. In most provinces, fusarium root rot was the predominant disease, affecting 83% and 86% respectively of the fields examined in the two years. Ascochyta diseases, gray mold, rust, and downy mildew followed in decreasing order of prevalence.

Septoria disease of oats. A 3-yr study showed that spraying cultivars with the fungicide maneb increased average yields at Charlottetown and La Pocatiere by 16% and 6% respectively, but did not improve them at Kentville and Ottawa. Septoria was most severe at Charlottetown, somewhat less severe at Kentville and La Pocatiere, and least severe at Ottawa. Disease control was not obtained at any location, but maneb was particularly ineffective at Kentville. Test plots were also grown for 2 yr at Lacombe, Alta., where septoria does not occur. The combined results indicated that the cultivar Dorval has considerable tolerance for this disease.

ENTOMOLOGY

Insect Population Dynamics

Alfalfa weevil. Numbers of eggs of the alfalfa weevil, *Hypera postica* (Gyll.), in study plots within a population epicenter at Stirling, Ont., averaged 331/100 cm² (308/ft²). Numbers declined by 44% from hatching to adult eclosion. Loss of first instar larvae owing to misadventure during movement to the terminal buds was 22%. Mortality was 13% during the second to fourth instars, partly as a result of rainfall. Parasites claimed 17% of those spinning cocoons.

Analysis of aggregation patterns showed

that counts of the larvae are overdispersed and conform to the negative binomial distribution. They are also described by Taylor's Power Law and the Morisita $I\delta$ -index. Variance may be stabilized by logarithmic conversion of the data.

In a comparison of sampling techniques, it was found that a 12-stem bouquet of foliage formed an effective and reliable sample unit for estimating numbers of eggs and larvae. For cocoons and adults, the appropriate unit comprised all of the foliage and ground litter in a 0.09-m² (1-ft²) quadrat. The efficiency of counting larvae in foliage samples was maximized by placing them in heated extraction funnels; 14% more larvae were recovered by this method than by hand sorting, and the number of man-hours required to examine a set of samples was reduced by 75%. Sweeping was an unreliable indicator of population densities.

Tarnished plant bug. The relationship of "mean crowding" to mean density showed that counts of nymphs and adults of the tarnished plant bug, *Lygus lineolaris* (Beauv.), on birdsfoot trefoil conformed to the negative binomial distribution. Aggregation increased gradually from the first to the fourth instar, then decreased through the adult stage. The mortality process from the first to the fifth instar was inversely dependent on density.

Intersample variance was the chief cause of population variance, but significant population variance was occasionally associated with blocks and plots as a result of heterogeneity of the host stand. The most appropriate sample unit was a 0.28-m² (3-ft²) area of foliage and substrate. This was divided into four quarters; in most cases, one of the quarters was optimal for subsampling the different stages. The number of samples required to attain a given level of precision varied inversely with population density.

Colorado potato beetle. Component analyses of 12 life tables revealed that progressive mortality from physiological causes during the larval stage is the key factor for *Leptinotarsa decemlineata* (Say) on field tomato. It is now evident that such secondary hosts play an important role in the life system of the species. Although the rate of survival is low, this ensures that the alternative resource is not depleted and that part of the population is carried over. When the primary host is again available, beetle numbers increase and

quickly overshoot the food supply. This is followed by mass starvation of the larvae, and emigration of the adults. However, sufficient numbers of the insect remain on secondary hosts to perpetuate it locally, and if the primary resource is renewed on an annual basis (that is, planted by man), its populations rise and fall in cycles of increasing amplitude.

Honey Bees

Behavior. The queen pheromone, 9-keto-*trans*-decenoic acid, is now known to be augmented by synergistic substances. One such substance has been isolated, but has not yet been chemically defined. Field and laboratory studies in 1972 showed that the queen produces pheromone and adjuvant substances in amounts that vary according to age and physiology. The workers recognize these variations in their queen and can distinguish between her and a foreign queen during swarming. When a swarm was given a choice between its own queen and a foreign queen, worker bees found their own queen and released the Nassenoff scent, which attracted more workers. Workers attacked the foreign queen and released alarm pheromones from sting and mandibular glands. When worker bees that were vigorously scenting the cage containing their own queen were exposed to a vial of synthetic alarm odor, all scenting ceased and no new workers were attracted to the queen.

Diseases. Three proteases have been detected in honey bee larvae killed by the causal organism of American foulbrood, *Bacillus larvae* White. One is a copper- or cobalt-mediated enzyme, which is produced during vegetative growth of the pathogen. The other two are not inhibited by chelating agents or serine protease inhibitors; they are of larger molecular size and are more closely linked to sporulation.

Chalkbrood, a larval disease caused by the fungus *Ascosphaera apis* (Maassen ex Claussen), was discovered for the first time in Canada in 1971. In 1972 it was found in apiaries in Ontario, British Columbia, and Quebec.

PLANT GENE RESOURCES

Barley, tomato, and alfalfa cultivars and genetic stocks. A total of 6,000 barley, 10,350

tomato, and 3,100 alfalfa stocks are maintained in Canadian collections. Information on each stock, such as pedigree, morphological and agronomic characters, reactions to diseases and insects, and quality, is being obtained from individuals through their completion of a record form that was prepared for each crop. The information will be used to establish data banks for barley, tomato, and alfalfa. TAXIR, a computer system for information storage and retrieval developed in the United States, has been tested successfully with the small existing barley data bank and likely will be adopted to produce the planned Catalog of Canadian Plant Gene Resources and to provide a "query service" on genetic resources that will be available to plant breeders and other plant scientists.

EXPERIMENTAL FARM, SMITHFIELD, ONT.

Vegetables

Soggy-centered french fries. The flabby middle region of soggy-centered french-fried potatoes was shown to coincide with the tuber's pith region, which contains much less starch and more absorbed fat than the perimedullary and cortex regions. These contrasting tissues within the same french fry strip cause this flabby texture. Incidence and severity of the problem depend largely on the relative amount of pith tissue in the tuber and on the orientation of strip removal. The involvement of variety-dependent factors suggests the possibility of genetic manipulation to reduce this problem.

Growth regulators on pickling cucumbers. Pioneer cucumbers, grown at 16 plants/m² (1.5 plants/ft²) and treated at the third-leaf stage with Ethrel (Amchem Products, Inc.) at 250 ppm, and with a morphactin at 100 ppm applied 2-3 wk before harvest, gave returns of \$1,872/ha (\$734/ac), compared with \$1,079/ha (\$437/ac) from untreated plots. Application of Ethrel at 250 ppm increased the number of fruit by 39.6%. Treatment 3 wk before harvest with a morphactin at 100 ppm, in addition to Ethrel, increased the number of fruit produced by 50-60% over untreated plants.

Tomato breeding. The selection ST-12, released in 1971, has been named Trimson. Moira (ST-11) was named and released for

commercial production in 1972. Moira is a high-yielding, high-quality, midseason variety carrying the crimson gene, *og^c*. It has good crack resistance, foliage cover, and internal structure. Fruit storage on the vine is excellent. It produces a high-quality juice and whole-pack product.

The line ST-19, also containing the *og^c* gene, combines verticillium resistance with field and processing performance similar to Trimson and Moira. The early line ST-16 combines high crimson color with maturity and quality similar to the early cultivar New Yorker.

Apples

Evaluating scab-resistant apples. Six seedlings from the Ottawa Research Station breeding program were given introduction numbers, bringing the total to 47 under advanced testing. Three selections (0-531, 0-545, and 0-546) are promising and should be tested at other locations. They are attractive, store very well, and are commercially acceptable in size and quality.

Gibberellin content and growth of apple tissues. The total gibberellin in fruiting cluster bases collected from Red Delicious trees decreased from early June to mid-September. In the Red Spy variety, the gibberellin level was initially lower than that of Red Delicious, decreased until late June, and then increased. The axillary shoot of fruiting clusters of Red Spy was longer than that of defruited clusters. The more fruit present per cluster in the early summer, the longer the axillary shoot. The level of gibberellin in cluster bases forming flower buds was much lower in the early summer than in those not forming flower buds. The hypothesis that endogenous gibberellins inhibit the formation of flower buds and promote vegetative growth was supported by the data.

Apple maggot pheromones. Newly emerged, laboratory-reared apple maggot females, added alive to tanglefoot bait traps, increased the proportion of trapped male flies. Because wild females were attracted to traps, the total number of flies trapped was higher in traps with pheromones. Attractiveness of laboratory-raised caged females decreased below that of wild trapped females after 24 h, indicating that use of caged

females would require frequent changing of laboratory-raised females.

EXPERIMENTAL FARM, THUNDER BAY, ONT.

Forage Management

Use of companion crops. In northwestern Ontario, where forage crops are seldom harvested in the year of seeding and chemical control of weeds is inconsistent, forages have been most effectively established when grown with a companion crop of oats, sown at 38.1 kg/ha (34 lb/ac), or barley, sown at 53.8 kg/ha (48 lb/ac), and managed for grain and straw. On well-drained sandy loam soils, a mixture of Alfa alfalfa at 11.2 kg/ha (10 lb/ac) and Saratoga brome grass at 8.9 kg/ha (8 lb/ac) was superior to alfalfa alone at 13.4 kg/ha (12 lb/ac). A mixture of red clover and timothy, each sown at 6.7 kg/ha (6 lb/ac), outyielded alfalfa sown alone or in mixture with brome grass in the first crop year. Yields in succeeding years declined rapidly as a result of the poor persistence of red clover.

Effect of fertilizers on grass yields. Brome grass, timothy, and reed canarygrass grown in loam soils that contained adequate P and K responded to N applied in early spring. Brome grass and reed canarygrass outyielded timothy; the greatest growth of brome grass was with N at 134.5 kg/ha (120 lb/ac) and reed canarygrass with N at 178.8 kg/ha (160 lb/ac). Maximum production of timothy was obtained at an N rate of 89.4 kg/ha (80 lb/ac). In 1972, at all levels of applied N, the three species reached maximum growth by July 20. Brome grass had the highest average yield for all treatments, followed by reed canarygrass and timothy.

Oats for silage. On sandy loam soils, maximum production of oats for silage was influenced by variety, rate of seeding, and level of fertilization with N and P.

Dorval oats sown in 23-cm-row (9-in.-row) spacings at a rate of 76.2 kg/ha (68 lb/ac)

and fertilized with N and P in a ratio of 1:1 at 134.5 kg/ha (120 lb/ac) produced 19% more fodder than Harmon and 50% more than Sioux. Harmon and Sioux yielded less than Dorval under low N fertilization, but both showed superior growth responses as N applications were increased to 134.5 kg/ha (120 lb/ac). Varietal response to increased rates of seeding was less than that resulting from application of N and P, but significant yield increases were recorded with Dorval, demonstrating its superiority over Sioux or Harmon, particularly under conditions of low soil fertility.

EXPERIMENTAL FARM, KAPUSKASING, ONT.

Cereal Crops

Frost seeding of cereals. The climate in the Kapuskasing area severely limits grain production. A 5-yr trial has shown that to take full advantage of the limited growing season it is necessary to sow as early as possible in the spring. Seedbed preparation was done in the fall, usually followed by light harrowing in early spring to minimize soil compaction. Oat grain yields were 4,071 kg/ha, compared with 2,138 kg/ha from normal seeding in late spring. Spring wheat gave similar results, but barley yields were not greatly increased. This early seeding permits earlier harvesting, thus avoiding unfavorable fall weather.

Continuous grain with minimum tillage. Cereals have been tested under a continuous grain system since 1966. Straw yields decreased considerably in the first two years, probably because of the lower level of soil organic matter. There was also a marked decrease in lodging in the years after the second year of testing. Grain yields of oats and barley remained over 3,800 kg/ha with adequate levels of P and K and with N at 168 kg/ha. When N was added at 84 kg/ha, oats yielded more crude protein than barley or spring wheat. With no N fertilization, oats, barley, and spring wheat produced equal amounts of crude protein.

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Research Station Vineland Station, Ontario

PROFESSIONAL STAFF

A. J. MCGINNIS, B.Sc., M.S., Ph.D.	Director
L. P. RYAN	Administrative Officer
M. BOWRING (MRS.)	Librarian

Fruit Protection Program

J. H. H. PHILLIPS, B.S.A., M.Sc., Ph.D.	Program Leader; Insect ecology
W. R. ALLEN, B.A., Ph.D.	Nuclear stock, fruit viruses
E. A. C. HAGLEY, B.Sc. (Agr.), M.Sc., Ph.D.	Insect ecology D.I.C.T.A.
J. NORTHOVER, B.Sc., Ph.D., D.I.C.	Diseases
R. TROTTIER, B.Sc., M.Sc., Ph.D.	Insect ecology

Vegetable Protection Program

W. G. KEMP, B.A., M.A.	Program Leader; Vegetable viruses
A. A. REYES, B.S.A., M.S.A., Ph.D.	Vegetable diseases
A. B. STEVENSON, B.Sc. (Agr.), M.Sc., Ph.D.	Vegetable insects

Pesticide Program

M. CHIBA, B.Sc., D.Sc.	Program Leader; Residue chemistry
R. W. FISHER, B.Sc. (Agr.), Ph.D.	Biological efficiency of spray systems
D. H. C. HERNE, B.A., M.S.A., Ph.D.	Acaricides
D. R. MENZIES, B.Sc., M.Sc.	Agricultural engineering
C. M. SIMPSON	Coordinator, pesticide evaluation

Nematology Program

C. F. MARKS, B.Sc. (Agr.), M.S.A., Ph.D.	Program Leader; Nematocides
T. H. OLTHOF, B.Sc. (Agr.), Ph.D., D.T.A.	Host-parasite relations
J. W. POTTER, B.S.A., M.S.A., Ph.D.	Nematode ecology
J. L. TOWNSHEND, B.Sc., M.Sc., D.I.C.	Nematode ecology

Virology Program

W. R. ALLEN, B.A., Ph.D.

T. R. DAVIDSON, B.Sc., M.Sc.

H. F. DIAS, Eng. Agr., Ph.D.

W. G. KEMP, B.A., M.A.

Program Leader; Fruit-tree viruses

Fruit-tree viruses

Small-fruit and soil-borne viruses

Vegetable viruses

VISITING SCIENTISTS

A. A. OSMAN, B.Sc., M.Sc., Ph.D.

National Research Council postdoctorate fellow

A. TEKAUZ, B.Sc., M.Sc., Ph.D.

National Research Council postdoctorate fellow

Predacious mites

Fruit tree pathogens (peach
canker)

INTRODUCTION

Economic control of insects and mites in three commercial peach orchards and in one commercial apple orchard was achieved with only about one-half the generally recommended amounts of insecticide and acaricide. This was made possible by monitoring the orchards for pest populations throughout the season and applying the pesticides at appropriate times for effective control.

A new and potentially hazardous grapevine virus was found in a local vineyard. The infected vines were stunted and the flower clusters withered and dried up after blossoming without setting fruit. The virus has been isolated and characterized but is serologically different from other spherical viruses examined. Evidence to date suggests that it is soil borne.

The virus testing program for raspberry and strawberry stocks was transferred to this Station from Ottawa in 1972. Responsibility for obtaining and maintaining virus-tested, true-to-name cultivars of tree fruits, grapes, strawberries, and raspberries now rests with this Station.

Research continued on the biology and control of nematodes that attack vegetables, fruit trees, tobacco, and forage crops. Studies also continued on diseases and insects that attack vegetable crops, growing on both muck and mineral soils.

For more information on our research projects or for reprints of published papers, please write: Director, Research Station, Research Branch, Agriculture Canada, Box 185, Vineland Station, Ontario.

A. J. McGinnis
Director

PESTICIDES

Application

Assessment of conventional sprayers. Coverage of strawberry plantings with an air-blast row-crop sprayer was generally poor. On berries and receptacles, coverage increased greatly as the row width decreased from 90 to 60 cm (36 to 24 inches); this change was not noted for leaves. Coverage and deposit were low in row 1, maximum in rows 2 and 3, and progressively lower to row 6 (the farthest from the sprayer).

A hydraulic-boom sprayer with drop arms and four nozzles per row gave very good coverage and controlled *Botrytis* rot on 60-cm rows of the strawberry cultivar Earlydawn.

Strawberry plot sprayer. A self-pumping plot sprayer was designed, fabricated, and calibrated for use in fungicide evaluation trials. The design enabled applications to be made even in severe winds and without jeopardizing adjacent plots. With minor modifications the machine can be used in pesticide evaluation trials on vegetables.

Experimental orchard-sprayer. A sprayer was designed to use standard atomization

techniques and emit droplets within a selected size range. The unit also permits adjustment in the rate and direction of air flow and in the rate of pesticide application. It will be used for field experiments in 1973.

Biological relationships and spray characteristics. Studies continued on the effects of number and size of droplets and concentration of pesticide on the mortality of mites. Relationships were derived for dilute field concentration and 4× and 16× concentrations of dicofol (Kelthane 50 WP) droplet sizes from 100 to 350 μ m in diameter; and numbers of droplets from 25 to 1,500 cm^2 . Three-dimensional graphs of concentration, number of droplets/ cm^2 , and mortality show the following:

- (1) Mortality is negligible at any concentration with 20 or less droplets/ cm^2 , probably because of insufficient numbers of contacts.
- (2) Dilute concentration does not produce more than 60% mortality with 100- μ m droplets at 1,500/ cm^2 , or with 200- μ m droplets at 120/ cm^2 .
- (3) With 4× concentration, 80% mortality is caused by 192- μ m droplets at 100/ cm^2 , or by 300- μ m droplets at 60/ cm^2 .

- (4) With rates of dicofol greater than $1 \mu\text{g}/\text{cm}^2$, there is no advantage in increasing droplet size or number to more than $60/\text{cm}^2$.

Chemical Control

Evaluation of insecticides. Thirteen compounds were screened in the laboratory as substitutes for DDT to control the tarnished plant bug. Subsequent field experiments showed that dimethoate, fenitrothion (Sumithion), and tetrachlorvinphos may be satisfactory.

Fungicidal control of Leucostoma canker of peach. In 1971-72, two dilute sprays of captafol and benomyl applied at leaf-fall reduced shoot infection by 78% and 84% respectively, whereas two sprays of captafol during spring dormancy failed to reduce infection below the level in the water-sprayed and unsprayed controls. A four-spray program, consisting of two captafol sprays at leaf-fall and two during spring dormancy, was not significantly more effective than the program of two sprays at leaf-fall only.

INSECTS AND MITES

Ecology and Integrated Control

Relationship between codling moth infestation and rainfall. The mortality of codling moth larvae was highly correlated with total rainfall. Mortality was greatest (18%) in the first instar when the larvae were beneath the epidermis of the fruit, and least (3%) in the third instar when they were primarily in the seeds. During periods of maximum larval emergence, particularly in early summer, the number of infested fruit decreased as the amount of rainfall increased. It was also apparent from preliminary observations that oviposition by first-generation females was reduced as rainfall increased during the period from the last week of June to mid-July.

Integrated control of peach pests. A reduced spray program designed to make maximum use of parasites and predators for insect and mite control was used in three commercial peach orchards, totaling 26 ha (64 acres). The sex pheromone Orfamon (Zoecon Corp.) in 3M Sectar traps, and bait

pails that contained a brown sugar solution plus terpinyl acetate, were used to monitor numbers and activity of the oriental fruit moth. Insect injury and parasitism were estimated from weekly samplings of twigs and fruit. Numbers of the European red mite and predacious mites were monitored by periodic sampling of leaf clusters.

A routine spray of phosmet was applied at the shuck-split stage of fruit development and again 14 days before fruit harvest. Additional sprays of phosmet and of the acaricide propargite at 4.48 kg/ha were applied where necessary. Fruit moths throughout the area were more abundant than for many years but parasitism was relatively low, averaging about 30%. Because of the large population of fruit moths and the relatively high value of the peach crop in 1972, phosmet was applied to control second-generation fruit moths in two orchards but not in the third, where parasitism was above average. Cool weather delayed development of the red mite and a single spray applied in early August, to late-ripening cultivars only, kept this pest under control. Mite predators were scarce in all orchards.

Insect injury of fruit at harvest ranged from 6% on some midseason cultivars to 2% on late and early cultivars, but it was no greater than in orchards that received the recommended schedule of five insecticidal sprays. Nearly all fruit moth injury of harvested fruit resulted from feeding by second-generation larvae and damaged fruit was generally easily removed during sorting.

Predacious mites in Ontario apple orchards. The major predatory mites in Ontario apple orchards collected and identified in 1972 from leaf samples include Phytoseiidae: *Amblyseius fallacis* (Garman), *A. finlandicus* (Oudemans), *A. andersoni* (Chant), *Typhlodromus* (= *Galendromus*) *longipilis* Nesbitt, *T.* (= *Neoseiulus*) *caudiglans* Schuster species-complex, *T. vulgaris* Ehara; Stigmaeidae: *Zetzellia mali* (Ewing), *Agistemus fleschneri* Summers; and Erythraeidae: *Ba-laustium putmani* Smiley. Predators common to four of the five orchards sampled were *A. fallacis*, *Z. mali* and *B. putmani*. *Tyrophagus neiswanderi* Johnston & Bruce (Acaridae) was also identified.

Phytoseiid predators were scarce in orchards that received full rates of pesticides, but became abundant by late August of the third season in orchards where insecticides

were applied less frequently. *Balaustium* and *Zetzellia* were also abundant in many orchards. In most cases at least one acaricide had to be applied to control the European red mite, before it reached peak numbers about August 22.

The relative toxicity of seven acaricides to predacious mites was determined in two field experiments. Animert (N. V. Philips-Duphar), propargite (Omite), Plictran (Dow Chemical Co.), and chinomethionat (Morestan), in that order, were least toxic to phytoseiids whereas Galecron (Ciba-Geigy Canada Ltd.), formetanate hydrochloride (Carzol), and dicofol were most toxic. In contrast, Animert, formetanate hydrochloride, Galecron, and dicofol were least toxic to *Zetzellia*, and chinomethionat, Plictran, and propargite were most toxic. Generally, *Balaustium* was more numerous on bark than on leaf samples. In plots treated with dicofol, formetanate hydrochloride, propargite, and Galecron the populations were much larger than in plots treated with chinomethionat, Plictran, and Animert.

Hatching of the European red mite. For the second consecutive year, the date of first hatch of overwintering eggs of the European red mite was predicted accurately in the field. First hatch occurred when 155 degree-days had accumulated above the temperature threshold of 5.6°C. The relationship, degree-days = $\frac{1}{2}[\text{max.} + (\text{min.} \geq 5.6)] - 5.6$

was an improvement over the one previously used and allowed first hatch to be predicted to within 1 day at Simcoe, Vineland, and Smithfield.

Monitoring the codling moth. Felt bands, 7.5 cm wide, impregnated externally with Bird Tanglefoot and fixed around the tree trunk 30 cm above the ground were effective for monitoring over-wintering larvae; 13 times as many larvae were found under the felt band as were under the same width of unbanded bark. The relationship degree-days = $\frac{1}{2}[\text{max.} + (\text{min.} \geq 11)] - 11$ accurately predicted first hatch of codling moth eggs in the field. Egg hatch occurred when 150 degree-days above the threshold (11°C) had accumulated after the first adults were caught in pheromone traps.

Trapping the apple maggot. 3M Sectar yellow pull-down traps, prebaited with a combination of Hy-Case hydrolysate and

ammonium acetate, were as effective as conventional yellow sticky-board traps for monitoring the onset of seasonal activity. Zoecon Pherotrap I and 3M Sectar I yellow traps were ineffective. All traps lost more than half their effectiveness after exposure for 1 week in the field. Catches on red sticky balls, placed at different positions on the outside of the tree canopy, were significantly greater on the south side of the tree than on any other side. Catches were greater at 2 m above ground level than at either 1 or 3 m.

Control of the carrot rust fly in the Holland Marsh. Progress was made in the development of a control program for the carrot rust fly. Carbofuran applied to the seed furrow in a granular formulation containing 1.12 kg active ingredient/ha (1 lb ai/acre) protected the crop against injury by first-generation rust flies, and also appeared to control the aster leafhopper and carrot weevil. The need for a summer spray program and the appropriate time for spraying were determined by monitoring the emergence of adult rust flies. Emergence dates were established by noting the emergence of flies in cages on an infected plot, and by monitoring the presence of flies with sticky traps placed in various commercial plantings. In 1972, four plantings were monitored. Flies occurred in all plantings and growers were advised when to spray. Effective control was obtained in two plantings but results were unsatisfactory in the other two. It is unknown whether these failures resulted from unsatisfactory application of pesticide, or from inadequate numbers and inappropriate location of traps.

NEMATODES

Ecology

Nematode survival in soil. The sugarbeet-cyst nematode, *Heterodera schachtii* Schmidt, survived as active larvae and as eggs in cysts at depths of 0–45 cm in both frozen and unfrozen soil under cabbage and rhubarb. Surviving nematodes at midwinter were most numerous in the upper 15 cm of soil, but were distributed to the 45-cm depth. In early spring, however, fewer active larvae were present than at midwinter in the upper 38 cm, and more were present below 38 cm, well below the frost line.

Hosts of the spiral nematode. Host range of

the spiral nematode, *Helicotylenchus digonicus* Perry, Darling & Thorne, was determined in the greenhouse; a Guelph loam containing 1,000 nematodes/kg was used. The number of nematodes/kg of soil 20 weeks later was used as the index of host suitability. The order of decreasing suitability of the crops tested was rye cv. Tetra Petkus, oats cv. Stormont, barley cv. Herta, Ladino clover cv. Merit, winter wheat cv. Genessee, timothy cv. Climax, red clover cv. Ottawa, corn cv. Pride 137, orchard grass cv. Rideau G2686, alfalfa cv. Saranac, brome cv. Saratoga G3256, and trefoil cv. Empire. The nematode counts in soils under orchard grass, alfalfa, brome, and trefoil at the conclusion of the test were less than 1,000/kg, an indication that these crops are unsatisfactory hosts.

Population densities and crop loss. Vegetables were grown in field microplots consisting of 20-cm clay tiles that contained 0, 666, 2,000, 6,000, or 18,000 *Heterodera schachtii* larvae/kg of Vineland loam. At the highest density, losses of marketable produce were: cabbage cv. Market Prize, 15%; cauliflower cv. Idol, 13%; beets cv. Detroit Dark Red, 28%; spinach cv. Cold Resistant Savoy, 50%; and rutabagas cv. Laurentian, 35%. At similar densities of *Meloidogyne hapla* Chitwood, the number of marketable tomatoes cv. Veebrite was reduced by 15% and 42%, at densities of 6,000 and 18,000/kg, respectively. *M. hapla* at a density of 1,800/kg soil reduced the yield of marketable carrots cv. Gold Pak by 30% and increased the proportion of forked carrots to almost three times that of the uninfested control. At the high densities of *M. hapla* the marketable weight of commercial varieties of onions in muck soils was also greatly reduced.

Nematicidal action of Vydate (DuPont 1410). Sugarbeet-cyst nematodes, *Heterodera schachtii*, in pots of Fox loamy sand in a greenhouse were exposed to Vydate (DuPont 1410) [*s*-methyl-1-(dimethylcarbamoyl)-*N*-(methylcarbamoyl) oxythioformimidate] as a drench (6 kg ai/ha), either 7 or 14 days before cabbage was planted. After 35 days, the number of mature cysts was 90% and 80% lower, respectively, than in controls treated with water. Foliar sprays of Vydate (0.36 kg ai/100 litres water) applied to leaves of cabbage seedlings also provided protection against the nematode. The results indicate that Vydate or an active metabolite is translocated downward into the root system

within 7 days. Moreover, it appears that the active chemical moves from the roots into the soil about 14 days after foliar application.

Soil management practices. Soil management practices in peach orchards influence the numbers of root-lesion nematodes, *Pratylenchus penetrans* (Cobb) Filipjev. & Stekhoven. 1941, in Fox sandy loam soils. In many Ontario peach orchards, the management practice of clean cultivation until July 1, followed by a weed cover, resulted in large numbers of *P. penetrans* in the soil. Greenhouse and growth-room experiments on host suitability of orchard cover crops for *P. penetrans* demonstrated that Sudan grass was a good host and creeping red fescue (*Festuca rubra* L.) was a poor host for the population of *P. penetrans* used in our studies. A nematode control program that employs preplant nematicides, herbicides to limit weed growth in the tree row, and a poor host cover crop such as creeping red fescue between the rows should effectively reduce nematode problems in peach orchards.

PLANT DISEASES

Fruit Virology

A new virus disease of grapes. A grapevine virus not previously described was isolated from vines of Joannes Seyve (26205). Symptoms included severe stunting, mottled leaves, and clusters that withered and dried up after blossoming without setting fruit. The disease was found in one vineyard only and seems to be soil borne. Highly infectious preparations were obtained by the butanol-chloroform method and two components were detected by density gradient centrifugation. Both components were found to be highly infective and contained particles about 25 nm in diameter. The virus was not serologically related to the grape fanleaf virus group, or to 12 other spherical viruses that were tested.

Peach X-disease or a disease very similar to it was prevalent in peach orchards in 1972. Some of the symptoms were typical of X-disease but others were atypical, making conclusive diagnosis impossible.

Ontario superior fruit stock program. In support of the provincial and federal efforts to produce a nucleus of virus-tested, true-to-name, fruit tree stock from which budwood

and seed may be secured, the various industries concerned have organized the Ontario Superior Fruit Stock Association. The objectives of the Association are to establish and maintain sources of certified true-to-name, virus-tested propagating materials of commercially important fruit crops, and to distribute these materials for use in the production of nursery stock; and to ensure that these propagating materials are used, maintained, and handled in the nursery site according to procedures and requirements approved by the Association.

Vegetable Mycology

Clubroot of crucifers in Ontario. Studies continued on the distribution, pathogenicity and chemical control of clubroot, caused by *Plasmodiophora brassicae* Woronin, in Ontario. Of 20 isolates of *P. brassicae*, most of which were found near Toronto, four were identified as race 2 and 15 as race 6; one was unclassified. The pathogenicity of the races differed on weeds. Except for radish, however, all cultivated crucifers recommended in Ontario are susceptible to *P. brassicae*. Benomyl (Benlate) (methyl 1-butylcarbamoyl-2-benzimidazole-carbamate) protected cabbage plants against clubroot in the greenhouse. It was phytotoxic to cabbage, however, when 400 ml of solution (1 g ai/litre) were applied to potted cabbage plants as a soil drench at transplanting and again one month later, but not when applied at half that concentration. Benomyl effectively controlled clubroot in the field.

Vegetable Virology

A chytrid-transmitted virus of carrots. A previously reported but unidentified virus detected in roots of carrot with lateral root necrosis proved to be a strain of tobacco

necrosis virus (TNV). Zoospores of *Olpidium brassicae* (Woronin) Dangeard, liberated from disinfected chytrid/virus-infected carrot roots into sterile tap water and subsequently added to the roots of carrot seedlings grown aseptically in quartz sand, induced TNV infection. Some root necrosis resulted from the chytrid/virus infection. Under sand culture the symptoms were not as severe as those associated with lateral root necrosis found, under field conditions, in muck soils in Ontario. Transmission of TNV appears to be associated with the capability of the particular isolate of *O. brassicae* to infect carrots.

Influence of plant density on the incidence of stilet-borne viruses in pepper. For the third consecutive year it was demonstrated with three pepper cultivars that plant densities well in excess of those now used can increase yields and decrease virus infection per unit area. Plant density did not affect earliness of fruit set or of maturity in any of the three cultivars.

Effect of plant barriers on the incidence of stilet-borne viruses in pepper. Corn barriers arranged in various patterns around small rectangular field plots of pepper did not reduce the virus incidence in any of the plots, whether the barrier was sprayed with demeton or left untreated. The demeton-treated barriers did, however, increase the percentage of marketable fruit in the total yield to 30% from 20% in unprotected plots.

Effect of weeds on the epidemiology of stilet-borne virus diseases in pepper plantings. By regulating the weed populations in small plots of pepper, it was shown that the incidence of virus disease in the crop was partly related to the availability to the vectors of host plants other than pepper. At harvest, however, fewer fruit were present in weedy than in weed-free plots.

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Animal Research Institute

Ottawa, Ontario

PROFESSIONAL STAFF

R. S. GOWE, B.S.A., M.S., Ph.D.	Director
D. A. LEGER, B.Sc.	Technical Requirements Officer
G. B. MATTHEWS	Chief, Administration and Resources
G. T. SPURR, B.A.	Administrative Services
J. E. GAZELEY (MRS.), B.A., B.L.S.	Librarian

Scientific Support

G. P. KAVANAGH	Computer systems
K. B. LAST ¹	Computer systems and programming
C. P. O'BRIEN, ¹ B.Sc.	Computer programming
M. ZAWALSKY, ¹ B.S.A., M.S.	Computer systems and programming

Dairy Cattle Breeding Section

G. R. BARR, B.S.A., M.S.A., Ph.D.	Chief of Section; Dairy cattle breeding
C. G. HICKMAN, B.S.A., M.S., Ph.D.	Dairy cattle breeding
J. NAGAI, B.A., D.Agr.	Mouse genetics

Poultry and Sheep Breeding Section

E. S. MERRITT, B.Sc. (Agr.), M.Sc., Ph.D.	Chief of Section; Poultry breeding, broilers and geese
J. S. GAVORA, Ing., C.Sc.	Poultry breeding, disease resistance
R. S. GOWE, B.S.A., M.Sc., Ph.D.	Poultry breeding, egg production
A. A. GRUNDER, B.S.A., M.Sc., Ph.D.	Poultry breeding, disease resistance
K. G. HOLLANDS, B.A., B.S.A., M.S.A.	Poultry breeding, physiological traits
W. E. LENTZ, B.Sc., M.Sc., Ph.D.	Poultry breeding, egg production
H. F. PETERS, B.S.A., M.S., Ph.D.	Sheep breeding

Monogastric Nutrition Section

G. A. LODGE, B.Sc., Ph.D.	Chief of Section; Swine, energy metabolism
J. R. AITKEN, B.S.A., M.Sc., Ph.D.	Poultry nutrition, proteins
J. D. CIPERA, Ing., M.S.A., Ph.D.	Poultry nutrition, proteins
J. I. ELLIOTT, B.S.A., M.Sc., Ph.D.	Swine nutrition, baby pigs
D. W. FRIEND, B.Sc., M.S., Ph.D.	Swine nutrition, sows
J. R. HUNT, B.S.A., Ph.D.	Poultry nutrition, egg quality
N. K. SARKAR, B.Sc., M.Sc., Ph.D.	Poultry, protein metabolism
I. R. SIBBALD, B.Sc., M.Sc., Ph.D.	Poultry, energy utilization

Ruminant Nutrition Section

F. D. SAUER, D.V.M., M.S., Ph.D.	Chief of Section; Fat metabolism, ruminants
J. D. ERFLE, B.S.A., M.S., Ph.D.	Intermediary metabolism, ruminant metabolic diseases
L. J. FISHER, B.S.A., M.Sc., Ph.D.	Dairy cattle nutrition, proteins and energy, and pollution
D. P. HEANEY, B.S., M.S., Ph.D.	Forage conservation and evaluation
W. A. JORDAN, B.S.A.	Beef cattle nutrition
J. R. LESSARD, B.A., B.S.A., M.S., Ph.D.	Forage conservation
E. E. LISTER, B.Sc., M.Sc., Ph.D.	Beef cattle and calf management and nutrition
S. MAHADEVAN, B.Sc., M.Sc., Ph.D.	Short-chain and long-chain fatty acid metabolism, ruminants
D. S. WALSH (MRS.), B.A.	Hormones of energy metabolism

Trace Minerals and Pesticides Section

K. J. JENKINS, B.Sc., M.Sc., Ph.D.	Chief of Section; Selenium metabolism and nutrition
T. S. FOSTER, B.Sc., M.Sc., Ph.D.	Pesticide metabolism and residues
M. HIDIROGLOU, D.V.M., D.N.	Selenium and vitamin E nutrition
J. K. G. KRAMER, B.Sc., M.Sc., Ph.D.	Pesticide syntheses and analyses

Reproductive Physiology Section

L. AINSWORTH, B.Sc., M.Sc., Ph.D.	Chief of Section; Hormones and reproduction
W. G. HUNSAKER, B.S.A., M.S.A., Ph.D.	Reproductive physiology
H. A. ROBERTSON, ² B.Sc., Ph.D., F.R.I.C., F.R.S.E.	Reproductive physiology
C. P. W. TSANG, B.Sc., M.Sc., Ph.D.	Steroid conjugates in plasma
F. A. VANDENHEUVEL, B.Sc., M.Sc., Ph.D., D.I.C., F.C.I.C.	Steroids and biological membranes

VISITING SCIENTISTS

National Research Council postdoctorate fellows

A. S. ATWAL, B.Sc., M.Sc., Ph.D., 1972-73	Ruminant ketosis
H. M. MUKHOTY, B.V.Sc., M.Sc., Ph.D., 1972-73	Sheep breeding and meat quality

¹Seconded from Data Processing Service.

²Chief of Section until November 30, 1972.

INTRODUCTION

Early in 1972 the Animal Research Institute scientific staff were reorganized from four scientific-discipline sections into the six program-related sections shown at the beginning of this report. This reorganization brings together most of the scientists working toward the same objectives, and facilitates planning the research and interchange of information.

During the past year, a new barn for intensive rearing of market lambs was constructed to complete the sheep facilities at the Institute's Greenbelt Farm. Another building was started to provide facilities for large animal surgery, large animal radioisotope studies, small and larger animal autopsy, and incineration of dead animals and certain other combustible wastes.

Animal waste pollution research was expanded this past year in cooperation with soil scientists and engineers of the Branch and microbiologists in the Department of the Environment. A research program was also started on the nutritional value of oil from different varieties of rapeseed.

Only the highlights of our research program in 1972 are recorded in this report; more detailed information is given in the publications listed at the end of the report. These reprints and copies of this report are available on request; correspondence should be addressed: Animal Research Institute, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R. S. Gowe
Director

DAIRY CATTLE BREEDING

Dairy Cattle

Field test of Finnish Ayrshires. A comparison of Finnish proven, Canadian, and young Canadian Ayrshire sires was started with the cooperation of 60 breeders of registered Ayrshires in Quebec and Ontario. Each cooperator has agreed to breed eight cows to bulls from each group, and to report the births of calves from these matings. Compensation will be paid to breeders for milk records based on the completion of first lactation of daughters of all bulls in the project. Some consideration is being given to testing the growth and carcass characteristics of males born in the project.

Semen was distributed early in the year and the first births took place in December. To date, the conception rate has been acceptable for the three groups of sires, though it was slightly higher in the two Canadian groups than in the Finnish bulls. Cooperating breeders appear to be satisfied with the calves born to date and are supporting the project enthusiastically.

Evaluation of selection and crossbreeding. Productive and reproductive efficiency are of primary importance in dairy cattle. It has been determined theoretically that increasing

the average number of calvings in a cow's lifetime from four to five can increase the opportunity for culling by 50%, increase the average milk yield of the herd by 230 kg, and decrease the variance within the herd by 20%.

A project was designed to take advantage of these factors and to test the effect of heterosis on longevity. A method was developed by which the commercial milk producer could maintain a hybrid herd of cows with replacements from within the herd. Two lines, one Holstein and the other Ayrshire, with the infusion of Brown Swiss, Norwegian Red, and Finnish Ayrshire germ plasm will be used for biological tests of the method.

A data acquisition system is being developed for testing and use in the project. The system is being designed to monitor and assist in routine herd management as well as to collect research data, and part or all of the system has potential for direct commercial application.

Pilot Animals

Mouse research. Inbred mice and F₁ hybrids were used to evaluate the performance of progeny from the offspring produced by young and aged parents. Age of young and aged parents bred for producing the offspring was respectively 10 and 41 wk in

inbreds, and 13 and 57 wk in F_1 hybrids. Litter size at birth was recorded and sex ratio was calculated for each litter. Body weights at birth and at 12, 20, and 42 days and body weight of dams after parturition were recorded. In both inbreds and F_1 hybrids, none of these measurements differed significantly between the progeny from the two age groups of parents. Segregation in coat color at the F_2 generation did not change with age of F_1 parents. It was concluded that age had no genetic effect on performance examined.

POULTRY AND SHEEP BREEDING

Poultry

Genetic differences in blood pressure and in associated mortality. Indirectly measured systolic blood pressures were obtained from five consecutive generations of three egg-type strains of chickens. Two strains were under continuous selection for improved egg production and the third was bred at random and maintained as a control. The mean 165- to 175-day blood pressure in females of the three strains was 148 mm Hg and the estimated heritability was 26%. The mean blood pressure of females that died before the completion of the test period (500 days) was lower than that of the survivors in two of the strains, but not in the third. The two strains (control and one selected) showing the similar blood pressure - mortality relationship were related in origin. All genetic and phenotypic correlations between blood pressure and performance traits were low; they were positive for body weight and egg quality traits but negative for egg production. Limited data on male blood pressures indicated a significant interaction between strain and sex.

Genetic resistance to Marek's disease. Continuing studies on genetic resistance to Marek's disease were carried out in cooperation with the Animal Diseases Research Institute, Hull, Que. The main emphasis was on development and testing of inbred lines. Strains under selection for egg production were used as the source stock for the lines, and the criteria in the selection of individuals as foundation breeders were high egg production and family livability. In a challenge test by injection with Marek's disease virus, 41 of 81 newly derived lines showed no mortality from Marek's disease or lesions

associated with the disease. These lines are being retained for further inbreeding and testing. After two generations of inbreeding, 13 of 163 previously developed lines challenged by injection of Marek's disease virus showed no evidence of Marek's disease. Further experiments included testing certain specific crosses of inbred lines and crosses of inbred lines with the base selected strains; the crosses were compared for performance with each other, with susceptible control (Cornell strain S), and with a high-performance commercial strain. Over a 322-day test period, Marek's disease losses in the crosses averaged 13.6%, in the susceptible control 30.0%, and in the commercial strain 4.7%. One cross showed slightly less mortality (3.1%) than the commercial strain. Performance was evaluated on the basis of an overall economic index; 6 of the 10 crosses tested performed approximately as well as the commercial strain, but none exceeded it.

A type of genotype \times environment interaction was observed in an experiment designed to assess the response of progeny to immunization of their female parents against Marek's disease. In the experiment, both vaccinated and nonvaccinated progeny from both vaccinated and nonvaccinated female parents were tested. Vaccinated progeny of all four strains tested showed a lower incidence of Marek's disease than nonvaccinated progeny. In three of the strains there was no difference in Marek's disease incidence between the vaccinated progeny of vaccinated dams and nonvaccinated dams. In the fourth strain, however, progeny from vaccinated parents showed a higher incidence of Marek's disease than progeny from nonvaccinated parents. A filtered-air, positive-pressure facility was brought into operation at this Institute and to date (291 days) it has prevented infection of the flock by Marek's disease virus.

Esterase genotypes and performance traits in meat-type chickens. Electrophoretic variants of a serum esterase were found to be controlled by three codominant alleles, designated Es^A , Es^B , Es^C . In a previously reported study relating age at first egg (AFE) to enzymatic activity of this esterase system, activity and AFE were significantly and positively correlated. The analytical results of the study also suggested that some of the genetic differences in AFE might be explained by variation in esterase genotype.

MONOGASTRIC NUTRITION

Additional studies involving 3,208 meat-type females from six lines of breeding have confirmed this. It was also observed that birds heterozygous for esterase alleles had a significantly greater AFE than those that were homozygous. In all cases, mean AFE's for each heterozygote were greater than means of the corresponding homozygotes, suggesting a strong overdominance effect of these alleles at this locus. No differences were found between esterase genotypes for five reproductive traits and body weights at different ages. Heterogeneity for allelic frequencies was observed among the lines, despite the fact that all lines originated from the same base population. The most obvious differences were higher frequencies of Es^A and Es^B and a lower frequency of Es^C in the lines selected for high body weight than in the unselected control lines.

Sheep

Lamb production of Finnish Landrace and Finnish crossbred ewes. At the Institute's Greenbelt Farm in 1972, 24 mature Finnish Landrace ewes averaged 2.6 lambs born per ewe joined with rams and 2.7 lambs born per ewe lambed, and 97 mature Finnish crossbred ewes (50% Finnish Landrace) averaged 2.0 lambs born per ewe joined and 2.1 lambs born per ewe lambed. By contrast, 59 ewes of the MM line (an Ottawa four-breed synthetic strain) and 60 mature Suffolk ewes averaged 1.5 and 1.6 lambs born per ewe joined, and 1.6 and 1.8 lambs born per ewe lambed.

Introduction of Ile de France and East Friesian rams. Eleven Ile de France rams and five East Friesian rams imported from Scotland were mated with Ottawa MM, Shropshire, and Suffolk ewes, to assess their breeding value for production traits. Based on their performance, sires will be selected for use in the development of crossbred foundation stock for specialized sire and dam lines; these will be used ultimately for production of crossbred lambs in confinement. The Ile de France, a large, thickly fleshed breed with Merino and Leicester ancestry, is to be combined with the Ottawa MM, Lincoln, Leicester, and certain other breeds for production of fast-gaining and muscular sire lines. The East Friesian, a large, prolific dairy sheep, will be combined with the Finnish Landrace, Shropshire, Suffolk, and Dorset, and certain other breeds for production of prolific dam lines.

Poultry

Growth restriction of broiler breeder stock. Diets of corn-oats, rye, or rye - linseed meal full-fed in the rearing phase to broiler breeder stock were compared with a corn-soy, 14% protein control diet fed on alternate days. In the laying phase, egg production, egg size, fertility, hatchability, and survival of chicks were similar to the control in one strain of commercial broiler breeders but not in another, which produced fewer eggs when fed a corn-oat rearing diet. All systems gave the desired delay in sexual maturity and larger egg size in early stages of production. Simple, low-protein diets can be full-fed in the rearing phase, to minimize growth and rearing costs while producing satisfactory laying phase performance; this provides a useful alternative to current labor-intensive restricted or skip-a-day systems.

In another trial, whole wheat only was fed from the age of 8, 12, or 16 wk to 21 wk; this diet was compared with a 14% protein control diet fed on alternate days. Unlike Leghorn-type birds, broiler breeder stock developed rickets within 4 wk when consuming whole wheat only. Addition of a Ca-P-vitamin D₃ source in an oil carrier to whole wheat corrected the problem but required mixing, thus reducing the economic benefits of whole grain feeding. Only the control and whole wheat diets fed from 8 to 21 wk of age produced body weights of 2 kg (4.5 lb) or less. Birds on the control treatment in this test grew 0.45 kg (1 lb) heavier than those in the previous test. To limit body weight at point of lay, controlled feeding systems must be applied at an earlier age than 8 wk.

Factors affecting eggshell formation. Feeding trials were started to determine the effect of crystal type and particle size of dietary Ca on shell quality. A 2-day isotope trial technique was developed to measure the rate of Ca incorporation into eggshell. Encapsulation of ⁴⁵Ca in gelatin delayed incorporation; trypsin treatment only partly reduced the delay. The rate of Ca excretion showed an association with eggshell formation. A method for estimating the contribution of medullary bone to Ca supply for eggshell formation has been developed.

Three particle sizes of each of two Ca sources, limestone and oystershell, supplying

two-thirds of the dietary Ca in the laying diet, were compared with pulverized limestone (feed grades) as the control. No differences in eggshell quality (specific gravity or compression strength) were noted in the 20-wk test. In all treatments, gizzard contents showed the presence of CaCO₃ particles 12 h after the removal of feed. The gizzard's ability to retain the fine CaCO₃ particles of the control diet was previously unknown.

Analyses of oviduct tissues indicated that an elevated lipid content of shell gland tissue was associated with the presence of an egg, possibly indicating lipid as a source of CO₂ for formation of the carbonate radical of shell CaCO₃.

Evaluation of dietary protein quality. The protein-synthesizing capacity of a cell-free preparation of chicken liver was found to be low, only 30–35% of that of similar rat liver preparations. Efforts were directed toward increasing the protein-synthesizing capacity and polyribosome content of chicken liver by adding ribonuclease inhibitors, such as bentonite, dextran, and partly purified ribonuclease inhibitor from rat liver, to the homogenizing medium. Partly purified ribonuclease inhibitor proved best and raised synthesis to 75–85% of the levels noted with rat liver preparations. The technique should now be capable of measuring the protein synthesizing capacity of the chicken liver.

Another approach to evaluating protein quality is by using in vitro digestibility techniques. Alfalfa, rapeseed, soybean, fish, and meat meals were separately digested, first by pepsin at pH 2.0 for 1 h and then by chicken pancreatin at pH 8.0 for different lengths of time. The amounts of protein digested at each time interval were determined by measuring the absorbance at 280 nm of deproteinized materials and assaying individual amino acids on the amino acid analyzer. The amino acid content of the protein was determined by measuring individual amino acids released after digestion with 6 N HCl for 12 h at 110°C. The pepsin-pancreatin digestion index (absorbance at 280 nm) seems to reflect the protein quality and, with measurement of the individual amino acids released during digestion, can predict the limiting or excess amino acids available for growth and maintenance. Work continues on developing rapid, accurate methods for estimating protein quality.

Swine

Age of puberty in gilts. Gilts fed a basal corn diet plus tryptophan (T), the same basal diet plus tryptophan and lysine (L), or a positive control diet containing soybean meal reached puberty 12 to 24 days earlier than gilts fed the basal diet only or the basal diet plus lysine. Rate of gain was significantly ($P < 0.01$) greater on the control diet and the basal diet plus L and T than on the basal diet plus either L or T alone.

Self-selection of feeds. Gilts were given free access to fresh water and to salt solution to determine whether they showed any varying pattern of salt intake when fed a salt-deficient diet. Some trends were apparent with a 0.5% salt solution, notably an increased intake during lactation.

Nutrition of sows and piglets. The inclusion of 10% corn oil, in place of starch, in the diet of lactating sows showed increased fat content in the milk of the sows and in the body composition of the sucking piglets at 5 wk of age; there were increased proportions of linoleic acid, the main (40%) fatty acid in corn oil, in both milk fat and body fat. This phenomenon was apparent also in the backfat of the pigs carried to market weight.

RUMINANT NUTRITION

Sheep

Intensive rearing of lambs. Approximately 600 lambs, removed from their dams at 8–30 h postpartum, were weaned from milk replacer feeding at 21–34 days of age. Two commercial milk replacers were used, one of which caused digestive disturbances. With a good-quality milk replacer, weaning age had little effect on gains of lambs up to 60 days of age, but with the unsuitable milk replacer earlier weaning resulted in better overall gains to 60 days of age. The type of creep feed (high-energy pelleted vs. medium-energy meal) did not affect lamb gains up to 60 days of age. During the finishing period (60 to 140 days of age), there was a positive response to increased protein in the ration (17% vs. 14%) up to 100 days of age, and to pelleting for the full feeding period.

Energy needs of the pregnant ewe under intensive management. The effects of feed allowance during pregnancy on the postpartum performance of suckled lambs and

lambs reared on milk replacer were studied. Feed allowance during pregnancy was found to be more critical, in terms of survival, when lambs were reared on milk replacer than when suckled.

Dairy Cattle

Influence of prepartum intake on postpartum performance of lactating cows. Nine pairs of Holstein cows were fed only hay for 6 wk prepartum at either maintenance level (A) or 1.8 times maintenance (B). Postpartum, all cows were fed both hay and concentrates ad lib.

Cows on treatment A lost significantly more weight ($P < 0.01$) during the prepartum period than those on treatment B (92 vs. 53 kg). During the first 16 wk of lactation, the cows on treatment A recovered their initial weight loss, ate more concentrates (12.4 vs. 11.4 kg/day), and produced milk with less fat (3.32% vs. 3.57%), more protein (3.39% vs. 3.23%), and more lactose (5.14% vs. 5.05%) than cows on treatment B ($P < 0.05$). There were no significant differences in postpartum hay intake, total dry matter intake, milk yield, or calf birth weight.

The experiment was continued for 38 wk of lactation to determine differences in late lactation. Both treatment groups increased in weight but there were no significant differences between treatments (104.5 vs. 73.8 kg).

In this latter period, however, cows on treatment A produced significantly more milk (19.1 vs. 18.4 kg) with a higher lactose content (4.95% vs. 4.76%) ($P < 0.05$). Fat and protein contents were not significantly different ($P < 0.05$). The greater milk and lactose production of group A corresponded to dry matter intakes that were also significantly higher ($P < 0.05$). The cows on treatment A consumed 4.34 kg/day of hay dry matter and 17.0 kg/day of concentrate, whereas the animals on treatment B consumed 5.50 and 12.5 kg/day.

The antiketogenic properties of propylene glycol and glycerol. In two experiments with a total of 120 cows, concentrate mixtures containing 0%, 3%, 6%, or 9% propylene glycol (PG) or 3% or 6% glycerol were fed for the first 8 wk of lactation. Results showed that additions of glycerol were not an effective method of reducing the incidence of ketosis in dairy cattle. At all levels of supplementation, cows fed PG had lower

plasma free fatty acids, ketones, and incidence of ketosis than cows that received no supplement. On the basis of this study it is recommended that PG be added to the concentrate fed to cows during the first 6 wk of lactation, at the rate of 3% for normal herds (incidence of ketosis $< 10\%$) and at 6% to problem herds (incidence of ketosis $> 10\%$).

Data obtained from cows in these experiments were analyzed for correlations of relevant blood parameters, energy balance, and efficiency. Blood glucose was found to be negatively correlated with blood acetoacetate (AcAc), β -hydroxybutyrate (B-OH), and free fatty acids (FFA). FFA levels were positively correlated with AcAc and B-OH and negatively correlated with energy balance. A high positive correlation was obtained for AcAc and B-OH levels. Preliminary analyses indicate there may be a positive correlation between FFA levels and efficiency, and further experiments are planned to verify this.

Effect of physical form on the utilization of alfalfa forage. Alfalfa was cut at the bud stage and stored as hay (H), as silage preserved with formic acid (S), or dehydrated and pelleted (P). The dry matter digestibilities of the three forms of forage fed singly to sheep were 65.3%, 67.0%, and 64.4%, and that of rations containing 50% alfalfa and 50% corn silage on a dry-weight basis was 66.2%, 67.9%, and 66.6% for the S, H, and P forages respectively. Lactating cows consumed all three mixed forage rations satisfactorily, but they consumed slightly more P and H alfalfa than S alfalfa. Milk yield of cows on the P ration was highest but fat test was lowest (3.1 vs. 3.5 for S and 3.6 for H).

Beef Cattle

Energy:protein ratios in milk diets for calves. Two experiments were completed in which the energy:protein ratio of whole milk was altered by addition of glucose and the resulting diets fed to a total of 60 male Holstein calves. The biological value of cow's milk containing 22–24 kcal digestible energy (DE)/g digestible crude protein (DCP) was 73–78, whereas supplementation with glucose to provide 28 kcal DE/g DCP increased the biological value to 84–86. Mean growth rates were 824 and 1,004 g/day at the low and high energy:protein ratios, respectively.

Early weaning of beef calves in confinement. When Limousin × Shorthorn calves from continuously confined cows at Kapuskasing were weaned early (at 48 h), they had a lower growth rate to 120 days of age than calves weaned at 56 or 120 days. Calves weaned at 56 days gained more slowly to 120 days than those weaned at that time. Cows nursing their calves were unable to consume sufficient grass silage to maintain their postcalving weights. In the postweaning period, calves weaned at 56 days tended to gain faster than those weaned at 120 days so that by approximately 1 yr of age there was little difference in mean weight. However, those weaned at 48 h did not compensate entirely for the early low growth rate. Calves kept out of doors gained less and received lower grades than those kept indoors.

Formic acid silage for beef cattle. At Kapuskasing, Shorthorn heifers fed grass silage (without legumes) preserved with 0.2% formic acid grew faster than another group fed wilted silage (0.78 vs. 0.47 kg/day). There was no benefit from using 0.4% or 0.6% formic acid, provided the distribution of the acid was uniform. Heavy consolidation of the silages in the horizontal silos was not beneficial with formic-acid-preserved silages but improved the efficiency of utilization of the wilted silage and the gains of heifers on that treatment.

Pollution

Chemical and bacteriological effects of liquid manure on cropland. In cooperation with the Engineering Research Service and the Soil Research Institute, data were collected in a continuing study to assess the impact of liquid manures, used as a source of plant nutrients, on the quality of ground and surface water and on plant composition. The chemical characteristics of the liquid manures from cattle, sheep, and poultry were respectively 7.96%, 10.02%, and 9.74% dry matter; 0.23%, 0.31%, and 0.68% N; 0.051%, 0.092%, and 0.262% P; 0.202%, 0.274%, and 0.225% K; and 997, 1,285, and 4,130 ppm NH₄-N. Samples of crops grown on soil fertilized with liquid manures are also being analyzed.

The staff of the Bacteriological Laboratories of the Environmental Protection Service, Department of the Environment, collected samples over a crop season and estimated the bacterial content of samples of liquid manure

and surface and groundwater runoff from fields where this manure was applied. Preliminary data showed that the storage of liquid manure lowers its content of fecal coliforms, and that the fluctuations in bacterial content of the runoff are partly associated with the amount of rainfall on the area.

TRACE ELEMENTS AND PESTICIDE RESIDUES

Trace Minerals

Prevention of muscular dystrophy in farm animals. Experiments were conducted to determine the possibility of preventing nutritional muscular dystrophy (NMD) in lambs and beef calves by incorporating low levels of Se and vitamin E in mineral mixes fed to their dams during pregnancy and early lactation. The method was completely successful in preventing NMD in both calves and lambs when both Se and vitamin E were included in the mineral mix, at levels equivalent to 0.07 ppm Se and 13 ppm vitamin E added to the ration. Vitamin E in the absence of Se was only partly effective. Preliminary analyses indicated that Se levels in tissues from animals fed the supplemented diet were not different from those in tissues of the control animals.

Metabolism of selenomethionine in the gastrointestinal tract of ruminants. An investigation on the availability of selenomethionine in mature sheep, involving the isolation of the rumen by surgical methods and cannulations, revealed that the selenoamino acid was not absorbed in the rumen and not metabolized appreciably by the rumen protozoa. Very little selenomethionine occurred in the free form (not bound to protein) in the forestomach, but unbound selenomethionine increased markedly in concentration up to the midsection of the small intestine, the main site of selenoamino acid absorption.

Selenium supplementation of swine rations. High-Se ROP rations were supplemented with Se (0.1 ppm) and fed as the starter ration to swine from 16 to 22 kg (35–50 lb) liveweight, or as the starter ration and finishing ration up to 57 kg (125 lb), or for the entire growing–finishing period. The Se contents of the liver, heart, kidney, loin, and shoulder of swine fed supplementary Se were no higher than those of the unsupplemented controls. This suggests that growing–finishing

swine rations could be supplemented across the board with 0.1 ppm Se for prevention of deficiency conditions, without incurring an undesirable increase of tissue Se residues, when adequate Se is already present in the ration.

Pesticide Residues

Pesticide residues and metabolism. A study of the metabolism of methoxychlor in laying hens was begun. The distribution of metabolites was partly established, by use of ^{14}C -methoxychlor. No radioactivity was detected in eggs because of the low level fed (0.1 ppm). Excreta were found to contain 80% of the radioactive dose. This radioactivity was separated into four fractions by solvent extraction, indicating a variety of metabolites. Simultaneously, six of at least 26 possible metabolites of methoxychlor were synthesized chemically and characterized by their chromatographic properties on thin-layer chromatograms in several solvent systems, by gas chromatography by use of an electron capture detector, and by their spectroscopic properties measured by mass spectrometry and infrared and nuclear magnetic resonance spectroscopy.

The study of the metabolism of atrazine in the laying hen was expanded. No atrazine or hydroxyatrazine, its major metabolite, was detected in eggs after feeding 100 ppm for 1 wk. However, two metabolites, as yet unidentified, were detected in eggs. From their gas chromatographic retention times they appeared to be identical to metabolites of atrazine produced in vitro by acid hydrolysis. When rations containing atrazine were fed, the residues of these "hydrolysis" metabolites increased with time but decreased to control levels in 7 days when normal feeding was resumed. These metabolites were also present in control eggs and in the standard rations that contained 50% corn for which atrazine had been used extensively as the herbicide. The identity of these metabolites is being investigated.

REPRODUCTIVE PHYSIOLOGY

Steroid Hormones

Identification. A procedure based on a correlation of gas-liquid chromatographic retention time with steroid structure has been developed to identify all neutral steroids extracted from body fluids and tissues that

can be resolved by gas-liquid chromatography.

Quantitative estimation. A routine radioimmunoassay procedure for quantitation of estrone, estradiol-17 α , and estradiol-17 β in plasma and a method for isolation and separation of estrogen glucosides, glucuronides, and sulfates from plasma have been developed.

Changes in plasma levels of unconjugated estrogens during pregnancy. Changes in plasma levels of unconjugated estrone, estradiol-17 α , and estradiol-17 β have been determined during pregnancy in the cow and the ewe, particularly in relation to parturition. Measurable levels of estrogens were detected in pregnant ewe plasma at 96 h before parturition. A rapid increase in plasma concentrations of all three estrogens began about 40 h before parturition and reached a maximum at the time of parturition. The peak levels of estradiol-17 α and estradiol-17 β lay within the range of 100–150 pg/ml, whereas the level of estrone was approximately double (200–350 pg/ml). By 12 h after parturition, the concentration of estrone and estradiol-17 β had fallen to < 15 pg/ml. The decline in concentration of estradiol-17 α was less rapid and did not fall to < 35 pg/ml until 48–60 h after parturition. In the pregnant cow, measurable levels of estrogens were detected in plasma at 40 days before parturition. A steady increase in levels of all three estrogens began at 20 days before parturition and peak levels of 4–5 ng/ml estrone, 300 pg/ml estradiol-17 α , and 450 pg/ml estradiol-17 β were reached just before parturition. The levels dropped dramatically over the first 24 h after parturition and by 48 h postpartum the plasma levels had dropped to < 15 pg/ml for estrone and estradiol-17 β and < 35 pg/ml for estradiol-17 α .

Fetoplacental steroid relationships. Continuing in vitro studies on the biosynthesis of steroid hormones by the fetus and placenta of domestic species have established that preparations of fetal liver and placenta from the sheep and pig are capable of forming cholesterol from acetate. The ability of the fetal adrenal gland of the pig to form cortisol and corticosterone increases with gestational age. Further work on the synthesis of steroid sulfates by fetal and placental tissues of sheep has demonstrated that fetal liver and

placental tissue preparations are capable of synthesizing sulfates of neutral and phenolic steroids.

Effects of Environment on Reproduction

An experiment on the effect of different light regimes on the egg-laying potential of several breeds of geese has continued. A light regime consisting of a 10-h light period and a 14-h dark period each day over 11 consecutive months has resulted in higher egg production, which more than doubled for some breeds. An individual goose has produced 150 eggs with this lighting system. The

geese tended to lay the eggs uniformly over the experimental period.

Physiological and Behavioral Changes in the Ewe Associated with Estrus

A multichannel automatic data acquisition system has been utilized to monitor continuously various physiological, environmental, and behavioral parameters of a group of six ewes over several weeks. Preliminary analysis of the data suggested that changes in circadian body temperature rhythms, rather than absolute changes, may be related to the initiation of estrus and time of ovulation.

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Chemistry and Biology Research Institute Ottawa, Ontario

PROFESSIONAL STAFF

G. FLEISCHMANN, B.A., M.A., Ph.D.	Director
M. G. BOTTEN (MRS.)	Administrative Officer

Agricultural Microbiology

L. R. BARRAN, B.Sc., M.Sc., Ph.D.	Fungal metabolism and enzymology
C. MADHOSINGH, B.S.A., M.S., Ph.D.	Enzymology of pathogenic fungi
R. W. MILLER, B.S., Ph.D.	Fungal metabolism and enzymology
E. A. PETERSON, B.Sc., M.S., Ph.D.	Rhizosphere fungi
R. B. PRINGLE, B.Sc., M.Sc., Ph.D., F.A.A.A.S.	Host-specific toxins
J. W. ROUATT, B.S.A., M.Sc., Ph.D.	Rhizosphere bacteria and culture collection
E. F. SCHNEIDER, B.Sc., M.Sc., Ph.D.	Rest period and dormancy

Cell Bioengineering

R. M. BEHKI, B.Sc., M.Sc., Ph.D.	Cell fusion
S. M. LESLEY, B.Sc., M.A., Ph.D.	Plant cell hybridization

Frost Hardiness and Dormancy

C. J. ANDREWS, B.Sc., Ph.D.	Winter survival of seed
F. D. H. MACDOWALL, B.Sc., M.Sc., Ph.D.	Frost damage; chloroplast membrane
M. K. POMEROY, B.Sc., M.Sc., Ph.D.	Frost resistance; biochemistry and cytology
D. SIMINOVITCH, B.Sc., M.Sc., Ph.D., Ph.D.	Frost hardiness; lipids and membrane
J. C. SIROIS, B.A., B.Sc., M.Sc., Ph.D.	Growth regulators

Host-Parasite Relationships

L. N. CHYKOWSKI, B.S.A., M.Sc., Ph.D.	Leafhopper-transmitted viruses
Y. C. PALIWAL, B.S.A., M.Sc., Ph.D.	Transmission by aphids and microscopic vectors
R. C. SINHA, B.Sc., M.S., Ph.D.	Virus and mycoplasma vector relationships

General Analytical Chemistry

M. IHNAT, B.Sc., Ph.D.	Inorganic chemistry
D. A. SHEARER, B.A., M.A., Ph.D., F.C.I.C.	Organic chemistry
J. C. YOUNG, B.Sc., M.Sc., Ph.D.	Organic chemistry

Pesticide Residues

R. GREENHALGH, B.Sc., Ph.D.	Organophosphorus compounds
H. V. MORLEY, ¹ B.Sc., Ph.D.	Organochlorines
R. PURKAYASTHA, ² B.Sc., M.Sc., Ph.D.	Herbicides

Electron Microscope Centre

G. H. HAGGIS, B.Sc., Ph.D.	Head
J. BRONSKILL (MISS), B.A., Ph.D.	Postal service
Y. C. PALIWAL, B.S.A., M.Sc., Ph.D.	Advisor

Instrumentation Centre

R. GREENHALGH, B.Sc., Ph.D.	Advisor
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Technological Services Unit

D. A. SHEARER, B.A., M.A., Ph.D., F.C.I.C.	Advisor
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Departures

D. S. GAMBLE, B.Sc., M.Sc., Ph.D. Transferred April 1, 1972, to Soil Research Institute	Physical chemistry
I. L. STEVENSON, B.S.A., M.S.A., Ph.D. Transferred; Associate Director, Research Station, Lethbridge, Alta.	Cytology and physiology of soil microorganisms

VISITING SCIENTISTS

H. ROHLER, B.Sc., M.Sc., Ph.D., 1971-72

Pesticide analysis

O. P. SEHGAL, B.Sc., M.Sc., Ph.D., 1972-73

Virus characterization

National Research Council postdoctorate fellows, 1972-73

R. G. FULCHER, B.A., M.Sc., Ph.D.

Electron Microscope Centre

G. THOTTAPPILLY, B.Sc., M.Sc., Ph.D.

Virus and mycoplasma vector
relationships

¹Seconded to Coordination as Acting Coordinator (Environmental Quality).

²Deceased January 6, 1973.

INTRODUCTION

The Chemistry and Biology Research Institute, established in 1971 by amalgamation of the former Analytical Chemistry Research Service with the former Cell Biology Research Institute, completed its first full year of operation in 1972. During the year our research programs were carefully examined to determine their relevance to Branch objectives and goals. Program reviews were undertaken by scientists of this Institute, coworkers and directors of other institutes and establishments, and members of Branch coordination. Critical areas in need of investigation were identified, and research teams were established to work on these problems.

The Institute is actively engaged in research on winter survival of plants and seed dormancy; reduction of plant diseases by investigation of host-parasite interactions of viruses, mycoplasmas, bacteria, and fungi with related crop plants; development of new plant hybrids by using bioengineering techniques such as antherculture, cell fusion, and exogenous incorporation of DNA; new chemical methodology, particularly for analysis and recovery of pesticide residues, and other organic and inorganic systems.

The Technological Services Unit provides Branch establishments with a comprehensive technical service in analytical chemistry, which includes analyses for a wide spectrum of chemical elements and constituents of agricultural materials. The Unit performed analyses at less than a third of the commercial cost of the work.

The Instrumentation Centre provides the Branch with sophisticated equipment and a competent staff for work in newly developing areas.

The Electron Microscope Centre was expanded this year to include a Postal Service. Branch establishments not in possession of the necessary equipment are now able to send specimens and material for scanning EM characterization.

The members of the Institute were saddened recently by the loss of Dr. R. Purkayastha, one of our ablest research scientists, who died suddenly on January 6, 1973.

This report records the highlights of our progress in research and analytical services provided during 1972. Detailed information is available in the published papers listed at the end of the report. Reprints are available on request from the Chemistry and Biology Research Institute, Research Branch, Canada Department of Agriculture, Ottawa, Ont. K1A 0C6.

G. Fleischmann
Director

AGRICULTURAL MICROBIOLOGY

Growth Control of the Soil-borne Pathogen *Fusarium oxysporum*

The partly purified peptide inhibitor (mol wt 1,000-5,000) of *F. oxysporum* isolated from alfalfa roots exhibits fluorescence, contains 17% protein and 12% aspartic acid, and inhibits growth of the organism up to 100%. Further purifications are in progress.

A peptide inhibitor of tyrosinase (mol wt ca 2,000) containing aspartic acid, glutamic acid, and phenylalanine was isolated from *Agaricus campestris* by affinity and ion exchange chromatography. Degradation and synthetic studies are under way.

The inhibition of sterol biosynthesis in *F. oxysporum* by glycerol and ICS, a peptide inhibitor from a mammalian source, was

demonstrated. Sterols have been implicated in temperature tolerance and survival of soil-borne pathogens. The specific enzyme system affected is being isolated and the inhibitor of sterol synthesis (ICS) is being purified.

Biochemistry of Fungal Pathogens

An in-depth study to compare directly key enzymes of pathogenic and nonpathogenic fungi has emphasized the importance of a copper-containing enzyme, superoxide dismutase. This enzyme is essential for protection of all aerobic organisms against the lethal effects of superoxide anion. Inhibition or inactivation of superoxide dismutase leads to a rapid death of fungi, because of the inherent high rate of oxidative metabolism in rapidly proliferating cells. Superoxide dismutase was isolated in pure form from both *F.*

oxysporum and *Neurospora crassa*. Characterization of the enzyme was carried out with the use of an assay instrument, which was designed and built in our laboratories. Electron spin resonance (ESR) and optical and fluorescence spectroscopy revealed similarities in the physical and chemical properties of the enzyme from the two fungal sources. Compounds such as caffeic acid (the catechol moiety of chlorogenic acid) and epinephrine were readily oxidized by the fungal enzyme preparation to the semiquinone (free radical) forms. It appears that the enzyme may represent a site of interaction between catechols and superoxide anion. Because one of the chief objectives of this project was to assess the feasibility of selectively inhibiting the metabolism of fungal pathogens, a comprehensive study was done on the allosteric inhibition of enzymes. Because of species differences in the response of metabolic pathways to inhibitors, this approach shows promise.

Host-specific Toxins

Because plants that have been bred for desirable characters often carry linked genes for susceptibility to host-specific toxins of fungi, the crop is often highly and uniformly susceptible to epiphytotic outbreaks of disease. Studies of host-specific toxins are therefore being continued with particular attention to common root rot of cereals caused by *Cochliobolus sativus*.

Root Rot of Cereal Crops

In a study of factors affecting the development of root diseases in cereal crops, lytic bacteria, which are capable of lysing various fungal propagules (hyphae, spores), were isolated from the rhizosphere of two varieties of spring wheat that differ in degree of susceptibility to *C. sativus*, an agent of common root rot. Representative isolates from both varieties were grown in the presence of, but not in contact with, different strains of the root rot pathogen in sealed dual plates so that only the atmosphere within each culture vessel was common to both the fungus and the test bacterium. Measurements of fungal colony size at short intervals over 3 wk showed that the presence of lytic bacteria from the root zone of the root rot susceptible variety stimulated growth of *C. sativus* strains, whereas those from the root zone of the more resistant variety depressed fungal

growth. The results suggest a possible implication of volatile metabolites from root zone microorganisms in the root rot reaction of specific cereal varieties.

Formation of Chlamydo spores in *Fusarium*

In *Fusarium* spp., the rest period of the macroconidia is regulated by the concentration of conidia. At concentrations of more than 75,000 conidia/ml, germination is zero, even after 3 mo in culture. A simple system has been developed in which the macroconidia redifferentiate into thick-walled chlamydo spores. In some species, such as *F. oxysporum*, chlamydo spore production is preceded by germination, whereas in other species, *F. sambucinum* and *F. coeruleum*, one or more cells in the conidia are converted into chlamydo spores. Light and electron micrographs of conidia during the formation of chlamydo spores have shown some of the changes that occur during the process.

Ultrastructure of Chlamydo spores of *Fusarium* spp. During Germination and Outgrowth

Mature chlamydo spores incubated in a complete medium (Czapek-Dox), harvested at intervals between 0 and 4 h, and examined by means of electron microscopy showed the following sequence of changes. After 1 h, large areas of the previously homogenous cytoplasm became finely vesicular. The mitochondria, nucleus, lipid bodies, endoplasmic reticulum, and cell wall appeared to be unchanged at this early stage. After 2 h of incubation, there was an apparent increase in size of mitochondria and amounts of endoplasmic reticulum. Germ tubes first started to appear after 2 to 3 h of incubation. Even in the earliest state of germ-tube emergence, the germ-tube wall appeared as a single layer continuous with the inner wall layer of the parent chlamydo spore. It is significant that this inner layer was the most recently deposited during chlamydo spore formation. Germ-tube emergence did not appear to rupture the outer walls of the chlamydo spore. Evidence suggests that emergence coincided with the dissolution of the outer layers, resulting in a tapered continuum with the germ-tube wall. There appears to be a rapid migration of mitochondria, endoplasmic reticulum, and the aforementioned cytoplasmic vesicles to the germ tube, but initially the nucleus, as yet undivided, remained in the parent spore.

After 3 to 4 h the nucleus had divided and migrated, and nuclear bodies could be seen in both the chlamydospore and the developing germ tube. The final stage of germination was characterized by the development of a septum at the point of emergence of the germ tube from the spore, with Woronin bodies in close proximity.

Survival of *Arthrobacter pascens* Under Starvation Conditions

Preliminary studies were undertaken to determine if the revision of the pleomorphic rods (exponential phase) of arthrobacter to coccoids (stationary phase) in times of stress is a survival mechanism. Coccoid cells showed 50% survival after 42 days in a nonnutrient buffer solution, whereas only 2% of the pleomorphic rods remained viable. Concurrent electron microscope studies showed a marked deterioration of the nuclear material of the exponential phase cells after prolonged starvation, whereas the DNA of the stationary phase cells expanded but remained finely reticulated compared with that of nonstarved cells.

CELL BIOENGINEERING

Genetic Manipulation of Plant Cells

The production of haploid plantlets by anther culture was studied by using eight varieties of *Nicotiana tabacum*. On Nitsch's medium without hormonal supplements, the percentage of haploids produced in Burley-1 varied considerably from a low of 1.33% to a high of 59.4%. Attempts to improve the yield of haploids from low haploid-producing varieties of *N. tabacum* by culturing anthers containing pollen cells at different stages of development, i.e., pretetrad, tetrad, and posttetrad on media with and without the addition of hormones, by splitting the anthers to improve nutrient uptake by the pollen cells, and by culturing the sporocytes released from the anthers by gentle crushing or enzymatic treatment to overcome any repressive effect of neighboring cells have been unsuccessful. Before this aspect of haploid production can be resolved, more detailed research will have to be done on the morphogenesis and development of pollen cells and the control mechanisms that are involved.

The enzymatic conditions for the removal of cell walls from plant cells have been

determined, but successful fusion of protoplasts has not yet been achieved.

FROST HARDINESS AND DORMANCY

Membrane Lipids in Hardening

In cooperation with the Ottawa Research Station, new evidence of involvement of transformations of the plasma membrane in the mechanism of frost hardening was found. Extended analytical studies indicate that in addition to augmentation of phospholipids with hardening, the degree of unsaturation of the component fatty acids and indeed of all the lipid fractions increases concomitantly. This progressive unsaturation along with augmentation suggests that a process of selective synthesis of unsaturated membrane lipids occurs during hardening. Considering the properties of enhanced fluidity and accommodation to freezing stresses, which such a synthesis would bring to the membrane, this process could be an important event during hardening.

Rating of Hardiness in Winter Wheat

Statistical analysis of the data obtained during development of frost hardiness in winter wheat, under field and controlled environmental conditions, shows that differences in hardiness potential of wheat cultivars can be more precisely identified by ratings based on lethal dose temperatures than by ratings based on survival at a single minimum temperature.

Environmental and Respiratory Factors Associated With Acclimation to Low Temperature in Wheat

Winter wheat cv. Rideau acclimates to cold when germinated and grown continuously at 2°C in either dark or light. In dark, seedlings in petri plates attain hardiness to -11°C (the temperature at which 50% of the population is killed) after 5 wk, and in soil in light [1,500 ft-c (16,140 lx) 16 h/day] seedlings attain hardiness to -14°C after 7 wk. In contrast, Cappelle-Desprez, a cold-susceptible winter wheat, acclimates only to -6°C in dark, and -9°C in light under similar conditions.

In mitochondrial preparations from winter wheat seedlings grown in the dark at 24°C, respiratory studies show a higher oxygen

consumption, efficiency of oxidative phosphorylation, and respiratory control values than in those grown at 2°C. Studies on the lipid composition of mitochondrial membranes show that the unsaturated fatty acid, linolenic acid, increases more than twofold during germination and growth at 2°C.

Leaves of spring and winter wheat plants have more dense epidermal wax after 2 mo of plant growth under cold-hardening temperatures than at any time under nonhardening temperatures in the absence of other stresses.

Winter Survival of Dormoats

A seed treatment that increases the secondary dormancy of dormoats increases winter survival, but reduces the ability of the seeds to resist artificial freezing stresses. Treated seed germinated in the field in the fall about 60% less than untreated seed, yet the germination capacity of the ungerminated residue of both seed types was similar. Therefore, survival of dormoat seeds appears to be strongly associated with the induction of secondary dormancy in the seeds.

Dormancy of dormoat seeds can be broken without inducing germination by briefly immersing seeds in methylene chloride containing gibberellin. This treatment improves emergence and shortens the time between plantings in the breeding program.

Growth Regulators in Dormoats

Indoleacetic acid and scopoletin levels appear to be identical in dormoats and commercial oats. A still unidentified growth promotor has been isolated from dormoats and is being characterized.

HOST-PARASITE RELATIONSHIPS

Wheat Striate Mosaic Virus

An antiserum prepared against purified virus reacted specifically with the soluble antigen present in infected plants. In agar gel diffusion tests, the soluble antigen purified by an acid precipitation method produced one band mid way between the antigen and antiserum wells in about 24 h. Purified virus at concentrations from 0.75 to 6.00 mg/ml produced one band close to the antigen well in 3–5 days. When the virus at 0.188 mg/ml (a concentration too low to form a band) was treated with lipase, sodium deoxycholate,

sodium dodecyl sulfate, or Tween-ether, one band mid way between the antigen and antiserum wells formed within 48 h. Treatment of the virus at 0.375 mg/ml with lipase produced two bands, with Tween-ether three bands, and with the other reagents only one band. These results and the electron microscopic examination of various samples used in serological studies suggest that complete virus particles (250 × 75 nm) can not diffuse through agarose because of their large size.

Ryegrass Mosaic Virus

Although 16°C and 18,000 lx of fluorescent-incandescent light for a 15- or 16-h daily photoperiod were optimum for virus multiplication in ryegrass, *Lolium multiflorum*, supplemental mineral nutrition of plants with N, P, K, and trace elements was critical for high virus yields. The virus was purified by extracting the juice from infected leaves with 0.01 M sodium citrate and clarified by heating. The virus was purified further by precipitation with (NH₄)₂SO₄, differential centrifugation, and finally by sucrose density gradient centrifugation and dialysis overnight. Citrate was used to avoid side-to-side aggregation of particles and to obtain higher yields of virus. The average size of the virus particles was 703 × 18 nm (flexuous rods) and the sedimentation coefficient was about 150 S. The UV absorption spectrum of the virus showed a maximum at 259 nm which is typical of a nucleoprotein. The 280:259 absorption ratio suggested that ryegrass mosaic virus contains about 6% RNA.

Spotted Wilt Virus

Spotted wilt virus was found to occur in dahlias at Winnipeg, Man., and Vancouver, B.C., and in dahlias and tomatoes at one location in the Okanagan Valley, B.C. Clarified homogenates of 50 tobacco thrips, *Frankliniella fusca* (Hinds), prepared 18 days after the start of an acquisition access feed of 7 days, showed specific reactions to virus antiserum. Such homogenates also caused infection when they were inoculated into healthy plants, thereby suggesting the persistence of virus in the vector.

Clover Phyllody Disease

Several factors were shown to affect the transmission of clover phyllody agent (CPA)

by the aster leafhopper, *Macrostelus fascifrons* (Stal). Transmission by inoculative female insects, given various inoculation access periods on aster seedlings, increased from 11% at 1 h to 89% at 7 days. When single inoculative female leafhoppers were given 1-day inoculation access feeds on eight different plant species, the percentage transmission ranged from 10% with *Potentilla intermedia* L. to 100% with *Thlaspi arvense* L. More plants became infected when insects were allowed to feed on new leaves than when they fed on upper or lower surfaces of middle leaves, old leaves, or basal portions of the main stem. Two-week-old asters were more susceptible than were 4-, 7-, or 9-wk-old plants. Inoculative female leafhoppers were more efficient transmitters than were males. The average incubation period in plants inoculated by females (23.1 days) was shorter than in plants inoculated by males (27.6 days). CPA was shown to move out from its inoculation site in a leaf to the main part of the plant within 8 h.

A procedure for purifying mycoplasma-like organisms found associated with the disease was developed. Electron microscopic examination of preparations obtained showed typical mycoplasma cells.

GENERAL ANALYTICAL CHEMISTRY

Pheromones of the Honey Bee

A component of queen mandibular gland extract was isolated and found to be active as a synergist of queen substance.

Studies on the alarm releasers of worker bees have resulted in the production of an antipheromone, which, when presented at the hive entrance along with the natural alarm pheromone, completely suppressed the alarm response. Utilization of this substance in honey bee management is being investigated.

Analysis of Selenium in Foods

A spectrophotofluorometric technique utilizing 2,3-diaminonaphthalene for determining total selenium in food products was developed. The procedure introduces several modifications to the previously used method, the most important being the choice of a new digestion procedure, which eliminates sample charring and losses of selenium observed

with certain foods such as meat, flour, and skim milk powder. The sample destruction procedure consisted of treating the sample with nitric acid, boiling it down to a given volume, and completing the digestion with a mixture of perchloric and sulfuric acids and then with hydrogen peroxide. This method was successfully used on materials such as apples, potatoes, carrots, corn cereal, wheat cereal, oat cereal, skim milk powder, flour, meat, and fish for precise and accurate determinations of selenium content at levels down to 10^{-9} g/g.

PESTICIDE RESIDUES

Residue Analysis

Analytical methods were developed for detecting diazinon in blood, kidney, liver, muscle, fat, and the wool of sheep that had been treated with animal dips containing 0.02% and 0.04% diazinon. Three weeks after the dip was applied, the levels in all tissues and blood were less than 0.02 ppm. For the more dilute formulation, wool contained 27 ppm after 3 wk and 4 ppm after 6 wk. In all analyses, the residual levels were about double for the 0.04% treatment.

Dead bees from hives next to areas sprayed with methomyl (Lannate) contained 2 ppm of the insecticide. The honey in the hives was not contaminated, but honey could decompose methomyl when stored at room temperature. Under these conditions, the half-life of methomyl was about 48 h.

A gas-liquid chromatography (GLC) method for the simultaneous determination of the plant growth regulator herbicides 2,4-D, 2,4,5-T, and dicamba in soil and water was developed with the use of an electron capture detector. Residue levels of 0.03 ppm can be detected by this procedure. Low levels of atrazine (0.1-1.4 ppm) and two of its metabolites were detected in the feces of laying hens fed on rations containing 100 ppm of the herbicide. In eggs, atrazine could not be detected, but the two metabolites were found at a maximum level of 5 ppm after 6 days of feeding. These metabolites had the same retention time as products formed after hydrolysis of atrazine.

Tobacco leaves obtained from southwestern Ontario were analyzed to determine the levels of DDT and its metabolites remaining from pre-1970 usage. DDT was found at

levels of 0.2–0.9 ppm, even though no spraying had taken place since 1969.

Methoxychlor applied at recommended rates exceeded DDT in its efficacy for controlling horn flies on cattle. Residues in the fat were less than 2 ppm at 1 wk after the final treatment. Two formulations and several intervals of application were used. Toxaphene was also assessed for controlling horn flies; it was found to be as effective as DDT.

Detector Studies

The response of a Bendix flame photometric detector to sulfur and phosphorus compounds was studied with respect to different flame parameters. The detector was particularly sensitive to the oxygen-to-hydrogen ratio and to whether an air or oxygen flame was used. The sulfur response-to-concentration factor was determined for 31 pesticides, herbicides, and fungicides and was compared with the response of the Coulson conductivity detector in the pyrolytic mode.

The response characteristics of *s*-triazine herbicides on columns of OV-17, SE-30, Reoplex-400, and carbowax 200 M were evaluated with the use of a thermionic detector. Atrazine residues were determined in water at the 0.05 ppm level, and in soil and corn at the 0.1 ppm level.

An examination was made of the influence of interfering materials on the quantitative analysis of organochlorine pesticides extracted from soils, as determined by GLC with electron capture detection.

ELECTRON MICROSCOPE CENTRE

Besides its service work, the Electron Microscope Centre is concerned with developing new techniques and new preparative methods that will be useful to users of the Centre. The two main areas that are being explored are cryofracture and cathodoluminescence. In the cryofracture technique, the material to be examined is frozen, then fractured to reveal internal surfaces, and finally freeze-dried. Part of this program included making a cold stage for the scanning electron microscope for direct examination of frozen material. This stage is being tested under working conditions. It will be useful for examining any material where it is suspected that freeze-drying may cause some

shrinkage artifact, because on the cold stage the specimen, e.g., a small nematode, can be examined with the internal water still present as ice. The cathodoluminescence technique is similar in principle to that of UV-stimulated fluorescence in the light microscope. Photons knocked out of the specimen by the electron beam of the scan microscope are picked up by a photomultiplier to give an image of the light-emitting areas, which is displayed on a separate display tube alongside the secondary electron image. Little work has been done in this area, and we are exploring fundamental aspects of sensitivity and resolution. With our Cambridge Stereoscan, resolution is similar to that of UV fluorescence, or slightly better. Use of the cold stage will improve the cathodoluminescent resolution, because the increased light emission at low temperatures will cause less fading under the impact of the electron beam.

INSTRUMENTATION CENTRE

Mass spectrometry was used extensively to identify known and to characterize unknown samples isolated in conjunction with many projects within the Branch. Sampling was by direct probe and GLC interface. In work for our Institute, photodecomposition products of organophosphorus pesticides and pheromones from honey bees were identified. In projects for other institutes, carbohydrates and compounds present in the humic acid fraction of soil were characterized, and carotenoids, fatty acids, and the components of snow mold were identified. In work for the Plant Products Division, impurities were identified in pyrethrin formulations and in a dacthal formulation suspected of damaging turnips.

Other spectra recorded for various institutes included IR, NMR (^1H and ^{31}P), and ESR. Routine amino acid analyses of protein hydrolyzates were performed for the Ottawa Research Station, the Food Research Institute, and the Plant Products Division.

A spectral databank of mass, NMR, IR, and UV spectra was started for pesticides and herbicides used in Canada.

TECHNOLOGICAL SERVICES UNIT

The Technological Services Unit comprising one supervisor and ten technicians offers

the Branch over sixty different types of chemical analyses. During 1972, over 44,000 determinations were carried out on nearly 30,000 samples submitted by Branch establishments.

In February 1972 Dr. D. Shearer was asked to undertake a study of the role of this unit and make recommendations regarding the improvement of its services to the Branch. It is expected that during the coming year many of the recommendations put forward on the basis of this study will be implemented so that the Technological Services Unit will provide even more effective service to the Branch.

The Technological Services Unit analyzed 7,176 more samples during 1972 than during the previous year, an increase of 31% in productivity. During the last quarter, more samples were processed and more determinations made than in any of the previous seven quarters. Based on the prices charged by commercial firms, total costs of the analyses done by the Technological Services Unit, if contracted out, would be \$348,261. The actual costs including salaries of technicians, operation and maintenance, equipment, and travel were \$104,066.

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Entomology Research Institute Ottawa, Ontario

PROFESSIONAL STAFF

W. B. MOUNTAIN, B.Sc., Ph.D.	Director
W. B. ROSS	Administrative Officer
N. B. SUSSMANN (Mrs.), B.A., M.L.S.	Librarian
J. E. H. MARTIN	Head, National Identification Service

Aquatic Biology, Hemiptera, and Nematology

D. R. OLIVER, B.A., M.A., Ph.D.	Head of Section; Diptera: Chironomidae
R. V. ANDERSON, B.A., M.S., Ph.D.	Nematoda: Hoplolaimidae, Tylenchorhynchidae, Aphelenchoidea
K. G. A. HAMILTON, B.S.A., M.Sc., Ph.D.	Homoptera: Cicadellidae Hemiptera: Corixidae
L. A. KELTON, B.S.A., M.Sc., Ph.D.	Hemiptera: Miridae, Anthocoridae
R. H. MULVEY, B.Sc., M.S.	Nematoda: Heteroderidae, Tylenchidae
W. R. RICHARDS, B.Sc., M.Sc., Ph.D.	Homoptera: Aphidoidea, Coccoidea, Psyllidae, Collembola, Psocoptera, Thysanoptera
L.-Y. WU (Miss), B.S., M.S., Ph.D.	Nematoda: Criconematidae, Paratylenchidae

Coleoptera, Siphonaptera, and Arachnida

E. E. LINDQUIST, B.S., M.S., Ph.D.	Head of Section; Arachnida: Acarina
E. C. BECKER, B.S., M.S., Ph.D.	Coleoptera: Elateridae
D. E. BRIGHT, B.S., M.S., Ph.D.	Coleoptera: Scolytidae
W. J. BROWN, ¹ B.A., M.Sc.	Coleoptera: Chrysomelidae, Coccinellidae
J. M. CAMPBELL, B.S., M.S., Ph.D.	Coleoptera: Staphylinidae, Alleculidae
C. D. DONDALE, B.Sc., M.Sc., Ph.D.	Arachnida: Araneida, Opiliones
G. P. HOLLAND, B.A., M.A., D.Sc., F.R.S.C.	Siphonaptera

A. SMETANA, M.U.Dr., Cand. Sc. biol.

Coleoptera: aquatic families,
Staphylinidae

Diptera

J. F. McALPINE, B.S.A., M.Sc., Ph.D.

Head of Section: Lonchaeidae,
Chamaemyiidae

J. A. DOWNES, B.Sc.

Ceratopogonidae

B. V. PETERSON, B.S., M.S., Ph.D.

Simuliidae, Nycteribiidae

G. E. SHEWELL, B.Sc., M.Sc.

Lauxaniidae, Simuliidae

H. J. TESKEY, B.Sc., M.S.A., Ph.D.

Tabanidae, Diptera larvae

J. R. VOCKEROTH, B.A., M.A., D.Phil.

Syrphidae, Scatophagidae

D. M. WOOD, B.A., M.A., Ph.D.

Tachinidae, Simuliidae

Experimental Taxonomy

E. H. SALKELD (Miss), B.S.A., M.S.A., Ph.D.

Head of Section; Physiology
histochemistry

J. W. ARNOLD, B.A., M.Sc., Ph.D.

Hematology and morphology

J. R. BYERS, B.S.A., M.Sc., Ph.D.

Physiology, electron microscopy

C. F. HINKS, B.Sc., Ph.D.

Physiology, endocrinology

B. N. A. HUDSON (Miss), B.Sc., Ph.D.

Physiology, chemotaxonomy

R. MATSUDA, B.A., Ph.D., D.Sc.

Morphology and systematics

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

Genetics

Hymenoptera

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

Head of Section; Proctotrupoidea,
Bethyloidea, Evanioidea

J. R. BARRON, B.Sc., M.Sc., Ph.D.

Ichneumonidae, Trogositidae
(Coleoptera)

C. C. LOAN, B.A., M.S., Ph.D.

Ichneumonidae, Braconidae

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

Braconidae, Ichneumonidae

H. E. MILLIRON, B.S., M.S., Ph.D.

Apoidea, Symphyta, Chrysididae

O. PECK,¹ B.Sc., M.Sc., Ph.D.

Chalcidoidea

G. S. WALLEY,¹ B.S.A., M.S.

Ichneumonidae

C. M. YOSHIMOTO,² B.A., M.Sc., Ph.D.

Chalcidoidea, Cynipoidea

Lepidoptera and Trichoptera

D. F. HARDWICK, B.A., M.Sc., Ph.D.

Head of Section; Lepidoptera:
Noctuidae

W. C. MCGUFFIN,² B.A., M.A., Ph.D.

Lepidoptera: Geometridae

E. G. MUNROE, B.Sc., M.Sc., Ph.D., F.R.S.C.

Lepidoptera: Pyralidae

A. MUTUURA, B.Sc., Ph.D.

Lepidoptera: Pyralidae

F. SCHMID, Lic. ès. Sc. Nat., D. ès Sc. Nat.

Trichoptera

Departures

M. R. MACKAY (Miss), B.Sc., M.Sc.

Retired April 1972

B. E. HOPPER, B.S., M.A.

Resigned April 1972

Lepidoptera: larvae

Nematoda: Pratylenchidae, aquatic
nematodes

VISITING SCIENTISTS

G. A. BRADLEY, B.S.A., M.S., Ph.D.

Department of the Environment

Hymenopterous parasites

National Research Council postdoctorate fellows

R. E. LEECH, B.Sc., M.Sc., Ph.D., 1971-72

D. D. MUNROE, B.Sc., Ph.D., 1972-73

Taxonomy of spiders (Araneida)

Taxonomy of the Chrysomelidae
(Coleoptera)

¹Honorary Research Associate.

²Seconded from the Department of the Environment.

INTRODUCTION

The Entomology Research Institute provides the National Identification Service for Canada on insects, arachnids, and nematodes. To meet this responsibility, the Institute carries out extensive research in taxonomy, biosystematics, and faunistics. The Canadian National Collections of Insects, Arachnida, and Nematodes are maintained and developed by the Institute.

In the spring, the staff of the Institute was reorganized to permit the formation of a new section responsible for biosystematic studies of the Hemiptera, the Nematoda, and various aquatic groups.

Two scientists left the Institute in 1972; Miss M. R. MacKay retired after 18 years of service with the Institute, and Mr. B. E. Hopper resigned to accept a position with the School of Marine and Atmospheric Science, University of Miami. Dr. K. G. A. Hamilton completed graduate studies at the University of Georgia and joined our staff as specialist in the Cicadellidae.

Dr. J. R. Vockeroth is on a 1-year postdoctoral transfer to the Research Station, Vancouver, B.C., to study the aphidophagous Syrphidae of the region, and Dr. B. V. Peterson is participating in a scientific exchange program with Brazil to further his knowledge of the New World Simuliidae.

For more information, correspondence should be addressed: Director, Entomology Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

W. B. Mountain
Director

THE NATIONAL IDENTIFICATION SERVICE

During the year, 900 shipments of insects, arachnids, other arthropods, and nematodes containing more than 96,000 specimens were received for identification. The Department of Agriculture submitted 298 shipments comprising 11,332 specimens (11% of total submissions), and the Department of the Environment submitted 114 shipments comprising 40,926 specimens (42%). Canadian universities continued to make considerable use of the service, submitting 15,046 specimens (15% of the total for 1972).

More than 90,000 specimens of insects, arachnids, other arthropods, and nematodes were identified and returned. The accompanying table shows the number of specimens identified, their various sources, and the distribution within the group.

THE CANADIAN NATIONAL COLLECTION

Some 230,000 specimens were added to the Canadian National Collection. Approximately 160,000 specimens were collected by staff members, about 20,000 Hymenoptera,

10,000 Diptera, 13,000 Coleoptera, and 2,000 Lepidoptera were purchased, and some 20,000 Coleoptera, 3,000 Hymenoptera, and 200 Diptera were donated to the Collection.

The spider collection from the Research Institute, Belleville, Ont., comprising some 38,700 specimens, was transferred to this establishment. The preparation and incorporation of specimens for the Canadian National Collection continued; 8,000 Acarina, 42,000 Araneida, 81,000 Coleoptera, 51,500 Diptera, 11,000 Hymenoptera, 30,000 Lepidoptera, 3,000 Trichoptera, 29,000 Hemiptera, and 1,500 Nematoda were processed. The Hymenoptera collection was totally rearranged and miscellaneous material incorporated.

Loans from the Canadian National Collection to scientists throughout the world totaled 158 shipments of 29,595 specimens.

FIELD STUDIES, FAUNAL SURVEYS, AND MUSEUM VISITS

Field studies were conducted by eight scientists for about 35 man-weeks in the Northwest Territories, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Newfoundland. From these

Number of specimens identified during 1972

	Coleoptera	Diptera	Hemiptera	Homoptera	Hymenoptera	Lepidoptera	Siphonaptera	Other insects	Acarina	Other arthropods	Araneida	Nemotoda	Total
Canada													
Department of Agriculture	1,132	2,181	446	414	1,074	353	2	442	368	8	90	3,207	9,717
Department of the Environment	1,213	16,894	581	2,962	4,410	774	0	8,681	59	11	133	540	36,258
Other federal departments	112	1,112	27	71	4	48	5	370	-	3	2	-	1,754
Provincial departments	160	307	5	55	198	116	257	6	5	20	3	81	1,213
Industry	1	15	-	-	-	1	-	-	-	-	-	-	17
Universities	817	7,269	113	700	2,618	1,319	3	2,293	908	8	3,346	63	19,457
Private inquiries	1,208	198	23	294	52	133	6	170	10	17	35	-	2,146
United States													
Government departments	69	453	-	-	-	251	75	-	68	-	-	-	916
Universities	9,162	2,825	1,342	42	137	282	-	8	73	3	-	30	13,904
Private inquiries	666	63	-	40	-	121	2	-	-	-	-	-	892
Industry	-	10	-	-	-	-	-	-	-	-	-	-	10
Other countries													
	729	1,812	-	597	185	555	177	-	-	-	-	-	4,055
Total	15,269	33,139	2,537	5,175	8,678	3,953	527	11,970	1,491	70	3,609	3,921	90,339

RESEARCH

surveys, approximately 30,000 Coleoptera, 5,500 Diptera, 1,000 Hymenoptera, 5,000 Hemiptera, 2,200 Araneida, and 10,000 Acarina were added to the Canadian National Collection. Four scientists conducted field studies in the USA for a period of 22 man-weeks and collected some 20,000 Hemiptera and 1,000 Diptera. During a survey for cutworm moths, 8,000 Lepidoptera from the midwestern United States were collected.

Dr. E. G. Munroe returned on June 1 after a 9-mo visit to Brazil as part of an international scientific exchange program. Dr. Munroe visited several museums and other institutions while in that country and made a collection of some 75,000 specimens of Brazilian Lepidoptera.

Dr. J. F. McAlpine and Mr. J. A. Downes were delegates to the 14th International Congress of Entomology in Canberra, Australia. In about 3 man-weeks they collected some 2,200 specimens of Diptera in Tahiti, Fiji, Australia, and New Caledonia for the Canadian National Collection. Two scientists visited the British Museum and other major museums in Europe to study type-specimens, type-species, and other representatives of European and Asiatic genera. Nine members of the staff visited U.S. museums and major collections at U.S. universities.

Aquatic Biology, Hemiptera, and Nematology

Handbooks. Analyses and descriptions of 130 genera were completed for an illustrated key to genera of Canadian aphids. Further progress was made with handbooks on the *Lygus* bugs of North America, the Miridae of the prairies, and the Canadian Chironomidae. Work began on an illustrated key to species of Canadian plant-parasitic nematodes, and descriptions of 25 species were completed.

Aquatic insects. Three papers on the biology of High Arctic Chironomidae were published. In one study on the sex ratios of 20 species it was found that in the Tanypodinae and Chironomini sexes are about equal, but in the Tanytarsini and most Orthocladinae females predominate; parthenogenesis is a possible explanation. About 25 species of Odonata and a similar number of Chironomidae were reared as part of a program to associate immature and adult stages.

Hemiptera. Five papers on aphids were published, including a review of 14 species inhabiting *Solidago* and keys to Canadian species of *Acyrtosiphon* and *Aulacorthum*. A description of a new species of *Aulacorthum* inhabiting poison-ivy is in press. Four papers on Miridae were published, in which 21 new species were described and a review and key

to 14 species of Canadian *Dichroscytus* presented. Revisions of the Cicadellidae and Anthocoridae of Canada were begun.

Nematoda. Morphometric studies on *Pratylenchus* and *Paratylenchus* populations continued; one new species was described.

Predators. The European bug *Picromerus bidens* (L.) was reported from Canada for the first time. It was found in Quebec feeding on the larvae of the sawfly, *Gilpinia frutetorum* (F.).

Faunistics. New habitat and distributional records for the Monichidae of Sable Island were compiled and submitted for publication. Distribution data on the stoneflies of Eastern Canada were compiled.

New structures and functions. Supplementary studies on the terminal areas of white females and cysts of *Heterodera* were completed. Studies of the labial framework, vagina, esophagus, and intestine revealed new characters for distinguishing species of Tylenchorhynchinae and Hoplolaiminae. An electron microscope was used to resolve, for the first time, a network of two-component fibrillar bundles within the intestinal cells of *Tylenchorhynchus*.

Collaboration with other agencies. The research project of Miss A. Sponis, a graduate student at Carleton University, was supervised by Dr. D. R. Oliver. In cooperation with the Freshwater Institute, Canada Department of the Environment, a study of the aquatic insects of the Mackenzie River and its tributaries was started.

A collection of some 25,000 specimens of insects from the Ottawa area has been assembled to form an exhibit for the National Museum of Natural Sciences.

Coleoptera, Siphonaptera, and Arachnida

Handbooks. A handbook entitled *The Scolytidae of Canada and Alaska* is nearing completion and is expected to be submitted for publication in 1973. Fifty drawings have been completed for a handbook of the fleas of Canada, Alaska, and Greenland.

Arachnida. A key to the eight known species of the conifer-feeding eriophyid mite genus *Nalepella*, with notes on their host associations and economic importance, was published. A new species of tarsonemid mite was described that feeds on, and perhaps disseminates, fungi that damage stored grain.

Coleoptera. An illustrated paper revising the predaceous rove beetle genus *Tachinus* is now in press; it discusses the taxonomy, distribution, and bionomics of the 43 North American species. Research was completed for a large revision of *Cymbiodyta*, a genus of water beetles; 31 taxa were treated, of which 14 were described as new. Descriptions and distributional studies were completed for over 100 of the estimated 200 North American species of the bark beetle genus *Pityophthorus*. Three papers describing 40 new species of Neotropical bark beetles and three papers on the Elateridae of Nepal were submitted for publication.

Biosystematics. One paper was published discussing the diel periodicities of meadow arthropods. Two papers were published discussing laboratory breeding between European and North American populations of the spider *Philodromus rufus* Walckenaer, and fertility and survival of the spider *Achaeearanea tepidariorum* (C.L. Koch) when fed on a chemosterilized diet of mosquitoes.

Collaboration with other agencies. The graduate program of Mr. J. Robillard, who is specializing in acarology at Carleton University, is being supervised by Dr. E. E. Lindquist. Two postdoctorate fellows were attached to the Institute during 1972: Dr. Robin Leech, working on the systematics of spiders, and Dr. Douglas Munroe, working on the systematics of the Chrysomelidae (leaf beetles).

Diptera

Handbooks. Substantial progress was made on illustrations for a manual of the genera of North American Diptera; although texts for only two families were received, the others are expected well ahead of the 1975 goal for publication. Work is progressing on handbooks on the tachinid fauna of Canada north of the treeline, Nearctic Piophilidae, world Scatophagidae, Canadian Syrphidae, and chamaemyiid predators of Adelgidae.

Fossils. The Diptera section has taken the initiative within the Institute for much of the collecting, initial preparation, and cataloging of Canadian amber bearing fossil insects that date to the late Cretaceous period, 70 million yr before present. In 5,000 pieces of amber examined, 150 insects were found. Of the Diptera thus fossilized, descriptions of several species of Ceratopogonidae and a new

fossil *Hesperinus* (Bibionidae) are being prepared.

Biting flies. A taxonomic and bionomic treatment of prairie species of the biting midge genus *Culicoides* that attacks wild and domesticated birds and mammals was started and one new species was recognized. Eight species were described in studies leading to a revision of the black fly genera *Gymnopsis* and *Twinnia*.

Other Diptera. In studies of the insect parasite family Tachinidae, a new Nearctic species of *Masistylum* and a new Scandinavian species of *Allophorocera* were described. Keys to the genera of the tribe Voriini and the species of *Periscepsia* were prepared. Drawings were completed for a revision of Nepalese species and for descriptions of new Canadian species of Lauxaniidae. Studies of immature Diptera continued with the collection and rearing of previously unknown larvae of 12 species.

Biosystematics. The results of an investigation into the feeding and mating behavior of northern black flies, Ceratopogonidae, and other Diptera were presented at the International Congress of Entomology, Canberra, and in a seminar at the University of Toronto; papers are being prepared for publication. Large numbers of larvae, pupae, and adults of various species of horseflies and deer flies were collected to continue comparative biochemical and cytological studies on the family.

New structures and functions. A paper is nearing completion on the phylogeny of the culiciform Diptera as interpreted from the morphology of the larval mouthparts.

Experimental Taxonomy

Handbooks. The manuscript for a handbook for identifying the Aradidae of Canada and the northern United States was completed.

Biosystematics of Euxoa. Rearing procedures were improved and more insect material was made available for breeding experiments and for research. Hybrids derived from female *Euxoa campestris* × male *E. declarata* were reared, data on development rates at several constant temperatures were obtained, specimens of larvae and adults were preserved for taxonomic examination, and slides of male genitalia were prepared

for analysis and comparison with the parent stocks.

Nonspecific esterase patterns from thoracic muscle and from eggs of the parent stocks and of the hybrid await statistical analysis, but those of the hybrid appear to resemble the female parent more than the male parent. Similarly, the hemocyte of the hybrid larva is more characteristic of the female parent. There was no significant difference between the karyotype of the hybrid and its parents. The reciprocal cross of female *E. declarata* × male *E. campestris* has not yet been obtained, but a cross between the female hybrid × male *E. campestris* was successful. The hybrid has been successfully backcrossed and inbred.

Variations in the morphology of the genital rudiments in larvae were not found to be useful as taxonomic characters, but differences in the microsculpturing on certain areas of the cuticle are more promising. Color photographs of the penultimate and ultimate instars of 24 species of *Euxoa* larvae were collected for use in the keys that will be prepared for larval identification of *Euxoa* species.

New structures and functions. A paper was completed on the fine structure and surface architecture of the chorion of a noctuid moth, *Amathes c-nigrum* (L.), which lays its eggs on leaf surfaces.

Further study of the chromosome number and morphology in nine species within the three main genera of Bombinae (Apidae) confirmed the general karyotype to be $n = 18$ with short rod-like chromosomes; exceptions were *Megabombus borealis* (Kby.) with $n = 14$ and *Pyrobombus perplexus* (Cr.) with $n = 12$.

The chromosomes and spermathecae were described in more than 30 species of tabanids representing all the major genera of the family. The chromosome numbers in the subfamily Tabaninae range from $2n = 10$ to $2n = 18$, whereas in the subfamily Chrysopinae they range from $2n = 8$ to $2n = 12$. Intrageneric differences in chromosome numbers occur commonly in *Tabanus* and rarely in *Chrysops*. Esterase zymograms of the thoracic muscle are being used to extend descriptions of intrageneric and intraspecific differences.

Light and electron microscope studies were completed on the morphology and fine structure of the neuroendocrine organs in

three species of sawflies in the family Diprionidae; no differences of taxonomic importance were noted. A paper describing these structures was prepared.

The final draft of a monograph on the morphology and evolution of the insect abdomen was begun.

Hymenoptera

Parasitic wasps. A world revision of the two tribes of the Scelionidae was completed; six new genera and 10 new species were described. In collaboration with two Russian entomologists, a paper describing a new genus and species belonging to a new subfamily of Mymaridae was completed. A new species of a primitive encyrtid and a soft scale eulophid parasite were described. Three new species of *Apanteles* reared from spruce budworm were described. A new European euphorine wasp, used in biological control of alfalfa weevil, was described. The braconid genus *Peristenus* Forster was removed from *Leiothron* Nees and both genera were reviewed and keyed.

New technique for Hymenoptera. To provide better illustrations for research papers, the scanning electron microscopy technique was applied to the microsculpture of scelionid, braconid, and eulophid wasps and to the antennal segments of braconid wasps.

Biosystematics. The cytotaxonomy (karyotypes) of 10 species of bumblebee was analyzed. The study showed that genera can be easily separated but that the technique is of limited use at the species level.

Collaboration with other agencies. Research projects on the chalcid parasite of the birch leafminer and birch casebearer and on a scelionid wasp were undertaken in cooperation with the Commonwealth Institute of Entomology, British Museum (Nat. Hist.), London, and the Commonwealth Institute of Biological Control, European Station,

Delémont, Switzerland. The study and curation of Provancher types of Hymenoptera, a joint project with Laval University, is well advanced; research on the ichneumonid types is nearly completed.

Lepidoptera and Trichoptera

Handbooks. Two handbooks were started in 1972, one devoted to the cutworm moths of Ontario and Quebec, and the other to the lepidopterous leaf miners of North America. Both works are well advanced and will be submitted for publication before the end of 1973.

Part II of a *Guide to the Geometridae of Canada* was published in 1972, and Part III, which deals with an additional three tribes of the Ennominae, is in preparation.

Descriptions, drawings, and keys have been prepared for the 60 species of the genus *Rhyacophila*, to form part of the handbook of Canadian Trichoptera.

Faunal monographs. Comprehensive studies on the North American Pyraloidea are being reported in the fascicle series, *Moths of America North of Mexico*. The first three fascicles deal with the species and genera in a number of subfamilies of the Pyralidae; one of these was published in 1972, and the other two will appear in early 1973. Remaining sections of the monograph are in preparation.

Taxonomy. A revision of world species of the pyralid genus *Nomophila* (the celery webworm and its allies) has been submitted for publication. In continuing studies of North American *Dioryctria*, a report on the fourth of the seven species groups comprising the genus has been completed.

Structural characters of several hundred specimens of the homogeneous *declarata* group of the genus *Euxoa* were analyzed statistically in an attempt to segregate the components of the group. Only a discriminant analysis was effective, and results from this analysis suggest that there are three species comprising the group.

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Food Research Institute Ottawa, Ontario

PROFESSIONAL STAFF

R. P. A. SIMS, B.Sc., Ph.D., F.C.I.C.
J. JOANISSE

Director
Administrative Officer

Food Research Liaison

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

Liaison Officer

Food Carbohydrates

I. R. SIDDIQUI, B.Sc., M.Sc., Ph.D., D.Sc., F.R.I.C.
P. J. WOOD, B.Sc., Ph.D.

Section Head; Rape carbohydrates
Rape carbohydrates

Food Chemistry

W. A. MCGUGAN, B.S.A., Ph.D.

Section Head; Cheddar cheese
aroma

A. B. DURKEE,¹ B.Sc., M.Sc.

Chemistry of phenolics

M. E. MCKILLICAN (Miss), B.Sc., M.S., Ph.D.

Lipid chemistry

Food Microbiology

J. A. ELLIOTT, B.S.A., M.Sc., Ph.D.

Section Head; Bacteriophage

R. P. SINHA, B.Sc., M.S., Ph.D.

Microbial genetics

A. R. YATES,² B.S.A., Ph.D.

Dairy organisms

Food Processing

G. W. HOPE,³ B.Sc., M.A.

Acting Section Head; Rape protein
technology

D. B. EMMONS, B.S.A., M.S., Ph.D.

Milk protein technology

D. H. LEES,⁴ B.S.A., M.Sc., Ph.D.

Oilseed technology

A. C. NUNES, B.Sc.

Dairy technology

D. PATON, B.Sc., Ph.D.
C. J. RANDALL, B.Sc., M.Sc., Ph.D.

Cereal technology
Meat technology

Food Protein

J. R. QUINN, B.S.A., M.S., Ph.D.

Section Head; Protein functional
properties

V. R. HARWALKAR B.Sc., M.Sc., Ph.D.

Milk protein

J. D. JONES, B.Sc., M.Sc., Ph.D., F.R.I.C.

Rapeseed protein

M. KALAB, M.Sc., Ph.D.

Milk gelation

C. G. ZARKADAS, B.S.A., M.Sc., Ph.D.

Beef muscle

Research Services

R. P. A. SIMS, B.Sc., Ph.D., F.C.I.C.

Section Head

ELIZABETH LARMOND (Mrs.), B.Sc.

Sensory evaluation

Departure

F. B. JOHNSTON, B.A., M.A., Ph.D., F.C.I.C.
Retired March 1972

Plant and analytical chemistry

VISITING SCIENTISTS

F. BENDER, D. Ingr. Chem.
Research Associate

Chemistry of sulfur compounds,
Oilseed Program

A. HOSONO, B.A., M.A., Ph.D.

Microbial physiology, Dairy

National Research Council postdoctorate fellow,
1972-73

Program

¹On transfer of work at Reading, England, August 1971 to August 1972.

²On 1 year loan to FAO, Malaysia, from May 1, 1972.

³On 1 year loan to FAO, Brazil, from June 15, 1972.

⁴Seconded to Grains Marketing Office, Department of Industry, Trade and Commerce from January 1972.
Resigned August 1, 1972.

INTRODUCTION

During 1972, a meat technologist joined the staff to study emulsification and other unit processes. Research on milk replacers for calves and lambs, carried out in cooperation with animal nutritionists, was expanded through the addition of research scientists with expertise in dairy and vegetable protein, milk-coagulating enzymes, lipids, and sensory evaluation of carcass quality.

Research on Cheddar cheese flavor and its defects now involves studies of the genetics and physiology of the microorganisms and studies of new and conventional milk-clotting enzymes.

The Institute and the Engineering Research Service cooperated in the development of a process to produce "Cryogran eggs," which won the "Prix Techniques" at the Fifth International Food Products Exhibition in Paris. The product is granules of frozen egg melange.

Cooperation with the Canadian food industry has been further developed. Contracts were signed with private industry for confidential research in areas compatible with the Institute program. A Food Research Liaison Officer was appointed to improve communication with the Canadian food industry.

The mailing address of this establishment is: Food Research Institute, Research Branch, Canada Department of Agriculture, Central Experimental Farm, Ottawa, Ont. K1A 0C6.

R. P. A. Sims
Director

OILSEED PROGRAM

Rapeseed and Mustard Seed Preparations

Preparations of flours, hulls, lyophilized water extracts, and crude oil have been continued to meet our own research requirements. Material is also provided for nutritional evaluation and for chemical and biological investigations at universities and interested commercial enterprises.

Improvements have been made in the denaturation of protein during solvent extraction by increasing the efficiency of cooling the solvent. Dehulling of rapeseed posed problems because of the small size of the seed. The Palyi Pneumatic Mill did not function well for Span; the Crippen-Model-S was found most suitable for dehulling without pulverization; the Bauer Attrition Mill yielded the best preparation for our purpose.

Purified hull fractions of rapeseed were analyzed for fiber (58-60%), crude protein (13%), and in vitro digestibility (33%).

Immature, dried, dehulled green seed (Bronowski) yielded an excellent quality of yellow oil that contained less than 2 ppm S. Frost-damaged seed (Zephyr) yielded a green oil similar to the one obtained from immature green seed boiled in water for 2 min before drying and extraction. This

finding suggests that glucosinolates are hydrolyzed to isothiocyanates, which are extracted in oil to give it a high sulfur content.

A flour preparation of yellow mustard showed a Protein Efficiency Ratio (PER) of 2.06; longer boiling-water treatments improved the PER value to 2.50, equal to that of casein and rapeseed flour.

Mustard flour contains 75% crude protein and has only one glucosinolate (sinalbin). Purified yellow mustard hulls contain 45% fiber, and 14% crude protein, and have an in vitro digestibility of 75%. Purified hulls of brown mustard have 50% fiber, 14% crude protein, and an in vitro digestibility of 50%.

Rapeseed Carbohydrates

Ten low molecular weight carbohydrates were characterized either in the crystalline form or by the isolation of crystalline derivatives from the deionized 80% ethanol-soluble fraction of rapeseed meal. Their average percentage composition in an oligosaccharide fraction (approximately 48% of the deionized 80% ethanol-soluble solids) as determined by gas-liquid chromatography (GLC) was D-fructose 1.5, D-glucose 2.8, D-galactose trace (about 0.03% by weight), myo-inositol 0.31, sucrose 23, galactinol 0.39,

raffinose 3.2, stachyose 15, digalactosyl-glycerol 0.97, and digalactosyl-myo-inositol trace (about 0.03% by weight).

A series of extractions of water-insoluble rapeseed meal residue (4,300 g) with 0.5% ammonium oxalate yielded a total of 612 g of oxalate-soluble material precipitated with ethanol and 1,414 g of insoluble residue. Fractionation of the oxalate-soluble material is in progress.

Sodium chloride (0.9%) soluble fractions of hexane-extracted, dehulled rapeseed meal showed weak hemagglutination activity against rabbit red blood cells. No activity was detected with cow's red blood cells, or with rabbit red blood cells variously treated with trypsin. However, human red blood cells (Group A, Rh negative) showed a weak response. Heating for 10 min at 63°C destroyed the hemagglutination activity. Dialysis of the extract from rapeseed did not change its activity. The hemagglutination activity was not inhibited by 2-deoxy-2-acetamido-D-glucose, mannose, galactose, glucose, lactose, maltose, raffinose, or melibiose.

It has been demonstrated that butane boronic acid can eliminate the multiple-peak formation observed in the GLC of trimethyl silyl ethers of some carbohydrates. Reaction yield of butane boronate derivatives (as indicated by GLC) showed a maximum at a 3 to 4:1 molar ratio of butane boronic acid to sugar for D-mannose, D-galactose, D-fructose, D-xylose, L-arabinose, and L-fucose. The peak area of D-mannose decreased 20% for a tenfold molar excess of butane boronic acid. A similar decrease of about 9% was observed for D-glucose. However, D-galactose, D-fructose, D-xylose, L-arabinose, and L-fucose maintained a constant response up to a tenfold molar excess of butane boronic acid. The GLC area responses relative to methyl arachidate of each sugar at a 1:4 molar ratio to butane boronic acid were: L-fucose 1.12; L-arabinose 1.12; D-xylose 1.08; D-fructose 1.15; D-galactose 0.64; D-mannose 0.99; and D-glucose 1.25.

The butane boronates of L-fucose, L-arabinose, and D-xylose, and the phenyl boronates of L-arabinose and D-glucose have been prepared in gram quantities.

Brassica spp. Seed Phenolics and Other Physiologically Active Compounds

Phenolics. Kaempferol 7-glucoside, Kaempferol 3,7-diglucoside, and Kaempferol 7-glucoside-3-sophoroside were isolated and identified in most common *Brassica* and *Sinapis* species. The same glycosides of isorhamnetin and to a lesser extent quercetin were also characterized. The 7-rhamnoside of 3-glucosides of these aglycons were also tentatively identified. A survey of 25 species indicated that the 7-glucose-3-sophorosides were the major components and the Kaempferol derivative was isolated from *B. campestris* seed meal. Some wild species contained 3-monosides and biosides of isorhamnetin rather than 7-monosides. One of these, present in *S. flexuosa*, was isorhamnetin 3-galactoside. Rutin and Kaempferol 3-glucoside were not detected.

Flavones, catechins, and leucoanthocyanidines were absent in seedlings. Seedlings of yellow-coated varieties of *B. campestris* contained 7-glucosides, whereas those of dark-coated varieties did not.

The total phenolics content of flour preparations (with and without water treatment) and lyophilized water extracts were examined semiquantitatively; *D* + Catechin was used as a standard. Dehulled, direct solvent extracted prepared flours showed the following typical values (w/w %): Echo 1.7%, Bronowski 2.1%, Oro 2.4%, Target 2.3%, Yellow Sarson 1.0%, brown mustard 1.1%, and yellow mustard 7.0%.

Flours from dehulled, water-extracted, and solvent-extracted seed showed the following typical values: Echo 0.6%, Oro 0.7%, and Bronowski 0.8%. Washing removed approximately 60% of the phenolics present in the seed. Lyophilized, dried water extracts contained up to 6.0% phenolics.

Phytic acid. Rapeseed flours prepared from dehulled seeds were extracted under varying conditions and examined for phytic acid content. The results with direct solvent extraction were: Echo 8.5%, Oro 7.0%, Bronowski 5.5%, Target 7.4%, Yellow Sarson 6.9%, and brown mustard 6.5%. Water-washed flours gave the following values: Echo 5.3%, Oro 4.3%, Bronowski 6.3%, and yellow mustard 6.0%. Most of the phytic acid present was apparently in an insoluble form and was probably responsible for the high ash content of rapeseed flours (about 8.0%), in the form of Ca and Mg as phytates.

Rapeseed and Mustard Seed Protein

The solubility of rapeseed protein as a function of pH in aqueous systems has been examined. The pattern of soluble N exhibited two regions of decreased solubility, one at pH 3.5–3.8 and a second at pH 7.5–8.0. Minimum solubility was observed at pH 3.7 (43% soluble N) and maximum solubility at pH 11.0 (90% soluble N). Addition of 5.0% NaCl increased the N solubility, especially between pH 6.0 and 8.5. Addition of 5.0% CaCl₂ increased the solubility below pH 8.0 and significantly reduced it above pH 9.5.

The preparation of myrosinase extracts for glucosinolate assay has been improved. The solubilization of myrosinase from yellow mustard seed by low concentrations of acetone followed by precipitation of the clear supernatant by acetone yielded a myrosinase precipitate of high activity. Acetone dehydration of the precipitate was preferable and easier to handle than lyophilization.

The addition of sulfite to the solubilization medium increased the final protein precipitated threefold, accompanied by a corresponding reduction in the myrosinase activity of the preparation. The preparation has some interesting whipping properties.

DAIRY PROGRAM

Cheddar Cheese Flavor

Volatile flavor components. A technique has been developed for the silylation of microgram quantities ($\geq 0.5 \mu\text{g}$) of volatile flavor compounds in a closed GLC system. The components that produce a GLC peak are trapped from the column effluent in a small loop of 1/16-in. OD tubing filled with a packing. The silylation reagent (2,4-pentanedione) is introduced into the loop by way of an auxiliary injection port and a micro-volume valve; the loop is then heated by an electric current and the reaction products flushed onto a second GLC column. The method appears to be efficient for simple fatty acids and alcohols. It produces only the mono-silylated derivative, whereas conventional silylation in a vial produces a mixture of mono- and di-silylated derivatives.

Bacteriophage-resistant Cultures

Of 19 starter cultures studied, only two failed to yield phage-resistant cultures of good acid-producing activity. The cultures

were challenged with phage and the survivors were grown by serial transfers with 1% inoculum in sterile reconstituted skim milk. Probably a scheme can be established to protect a cheese factory from serious phage attack by systematically challenging the starter cultures used in the factory with the phages that appear in the factory.

Bacteriophage Antisera

As part of a program to evaluate serology as a method of typing phages, antisera against four more phage races have been prepared and tested for their ability to neutralize the races in our phage collection. Eight antisera have been prepared that neutralize or partially neutralize a total of 34 phage races at 1/50 dilution. The neutralization patterns are different from the host-range patterns of the phage races.

Milk-coagulating Enzymes

A further modification was made to the Shovers and Kornowski procedure for quantitatively determining pepsins and rennin in mixtures. Swine pepsin is determined by rate of inactivation of milk-coagulating activity at pH 6.3 at 30°C; rennin activity is determined from activity remaining after 30 min at pH 7.25 at 37°C; and bovine pepsin is determined by difference. By use of Douillard's procedure, most of the bovine pepsin in rennet was found to be bovine pepsin II.

Milk-coagulating activity was measured with a modified Berridge's substrate (0.1 M CaCl₂, reconstituted skim milk powder 10.5%) at an alkali-adjusted pH of 6.5–0.02 to simulate conditions in a cheese vat. The relative activity of pepsins was twice that of rennin in an unmodified Berridge's substrate (pH 6.3) and about three times that of rennin in the same substrate adjusted to pH 6.0.

Rennin comprised 10–20% of the milk-coagulating activity of two extracts of adult stomachs. The presence of rennin in these extracts was confirmed by the Douillard procedure.

Antisera against crystalline rennin completely inactivated milk-coagulating activity in extracts of adult stomachs. The nature of the reaction in gel diffusion indicated antigenic cross-reactions between rennin and bovine pepsin II.

UTILIZATION PROGRAM

Thermal Gelation of Skim Milk

Milk protein and other food gels were tested for the effect of temperature on firmness. Gels formed by heat from reconstituted skim milk powder typically decreased in firmness by 70–80% when temperature was increased from 10°C to 60°C. Various additives, including oxidizing and reducing agents, divalent cations, SH-compounds, starches, celluloses, gluten, and gelatin, had no effect on the decrease. The firmness of gels made from partly de-lactosed whey decreased by only 40%. The firmness of cheese decreased by more than 80%. Coagulated egg white, weiners, tofu (soybean curd), and hamburgers did not decrease in firmness as much as the milk gels. Polyacrylamide gel increased in firmness.

Milk gels were examined by scanning electron microscopy. Heat-induced milk gels from concentrated skim milk consisted of casein micelles that were slightly expanded from their size in the original milk; the micelles were connected by thin short fibers. Gels induced by heat from acidified milk were formed of structural units several times the size of casein micelles. Renneted gels had a distinct chain-like structure. Three-dimensional stereo pictures were successfully obtained at magnifications to 20,000 times. Milk gels were similar structurally to commercial cheese and gels of gluten, egg white, gelatin, and meat. Washing with water instead of fixing with glutaraldehyde produced fibrous material in all milk gels; the washing technique was considered to produce artifacts.

Gels formed by compressing precipitates produced when acidified skim milk was heated differed considerably in texture, elasticity, and firmness from gels formed by heating concentrated skim milk. A penetrometric procedure to measure the properties of the acid-heat gels was developed. These gels were six times firmer than the heat-only-induced gels and twice as firm as cooked hamburger. A soft, pudding-like gel was formed by quiescently holding milk at 100°C in the presence of gluconolactone.

Evaluation of Spaghetti

Eight varieties of spaghetti made from different durum wheats by Italian and Canadian processes were evaluated by a trained laboratory panel. Rating scales were established for firmness, gumminess, chewing quality, adhesiveness, starchiness, and flavor. When the results were compared with those of a consumer panel survey, it was clear that the laboratory panel could determine the quality required for consumer acceptance. Flavor plays a minor role in the acceptance of spaghetti and did not vary greatly among the varieties studied. Consumer preference is based on low scores for gumminess, adhesiveness, and starchiness and on high scores for firmness.

Oat Flour and Protein

Oat flour was fractionated by selective alkaline extraction into protein, starch, fat, and gum. Starch and gum were obtained as separate entities, whereas protein and fat were not separated. The protein-fat complex had the capacity to emulsify at least 20% its weight of oil with a minimum efficiency of 83.5% and a stability of 80%. A 5% aqueous dispersion of the complex can be whipped to give a high overrun. The resulting product is unstable, but can be stabilized by adding sugar to a level of 60% in the mix.

Whole oat flour was modified by chemical derivatization to carboxymethyl and hydroxypropyl ethers. A 5% aqueous dispersion exhibited good whipping characteristics applicable to meringue confections, icings, and toppings.

MEAT PROGRAM

Analytical Techniques

During polyacrylamide isoelectric focusing of the charge isomers of beef myoglobin in the presence of Ampholine buffers, the reduction of metmyoglobin was observed. The protein resolution was unimpaired, but the existence of a reducing environment in the Ampholine buffer – polyacrylamide gel system, which otherwise has oxidizing power due to residual persulfate catalyst, was totally unexpected. Proteins capable of undergoing oxidation-reduction reactions should therefore be monitored when being separated under these conditions.

A method was developed for identifying and quantitatively determining methylated lysines, histidines, and basic amino acids in meat and meat products. After hydrolysis under vacuum in 6 N HCl at 110°C, samples representing 0.01 μ M protein were analyzed on a Beckman 120B amino acid analyzer by use of Spinco and Durrum resins and a 0.35 N sodium acetate buffer of pH 5.84 at a flow rate of 35 ml/h.

Effects of Rigor Mortis on Beef Muscle

In preparation for studies to relate post-mortem changes in beef muscle to manufacturing properties, myofibrillar (myosin, actin, and actomyosin) and sarcoplasmic (creatine kinase) proteins were prepared in high purity from beef animals at death and during the onset and resolution of rigor mortis.

Milk Replacers for Lambs

By the use of a heavy-duty colloid mill, excellent soybean milks were prepared from dehulled soybeans. These products proved to be highly acceptable to both humans and lambs. The tough hilum of the soybean, however, prevented the preparation of soybean milk from the whole bean.

Lambs were fed milk replacers containing lard plus soybean oil or lard plus coconut oil as the fat source and skim milk powder or soybean flour as the protein source. The control animals either nursed on the ewe or were fed an expensive but good commercial lamb milk replacer. Roasted meat from the control animals possessed good lamb flavor, but the meat from the experimental animals did not.

Nutrition Practices and Carcass Quality

Sensory evaluation, objective measurement of meat texture, and assessment of the physical and chemical properties of the fat were applied to several substrates. The study of the effects on turkey carcass quality of dietary rapeseed oil, soybean oil, and tallow was continued this year. Carcasses from turkeys fed each of these diets were examined after 14 mo storage at -12°C and -23°C. After that time, tallow-fed turkeys

received low flavor ratings regardless of storage temperature. The carcasses of turkeys fed soybean oil and stored at -23°C had the best flavor, whereas those stored at -12°C had the poorest flavor of all treatments. Turkeys fed rapeseed oil had flavor scores between these extremes. Extent of fat oxidation, as measured by Thiobarbituric Acid (TBA) Value, was affected by diet as well as by storage temperature. TBA Values agreed fairly well with sensory data.

A trained sensory evaluation panel examined the eating quality of veal from calves fed various high-fat milk replacers containing protein supplied by herring meal or fish protein concentrate (FPC) from France or FPC prepared by the Fisheries Research Board in Halifax, N.S. Veal from the calves fed the two FPC diets and from those fed whole milk compared favorably. The use of herring meal in the diet resulted in tougher meat with an objectionable odor.

Beef from steers fed diets high in potatoes with various levels of added protein was evaluated by an experienced panel to determine whether a high-potato, low-protein diet lowered the eating quality of the meat. The incorporation of 75%, 100%, or 125% of the NRC (USA) recommended levels of protein in these high-potato diets produced no appreciable changes in the odor, flavor, tenderness, or juiciness of the meat.

As part of the experiment sponsored by the Canadian Committee on Animal Nutrition, an experienced sensory evaluation panel examined the quality of loin roasts from swine (barrows) fed diets containing 0, 125, and 200 ppm added Cu. The meat was examined after 4 and 8 mo frozen storage. The panel found that the addition of Cu to the diet had no effect on the flavor or texture of the fat portion nor on the flavor, tenderness, or juiciness of the cooked meat. All treatments were acceptable. The fat portion of the uncooked roasts from the added-Cu treatments, however, tended to be softer and greenish in color. The TBA and Peroxide values of the fat were not affected. In contrast to the control animals, the adipose tissue from barrows fed diets containing 200 ppm Cu contained less fat and this fat had a lower melting point.

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Plant Research Institute Ottawa, Ontario

PROFESSIONAL STAFF

A. CHAN, B.Sc., M.Sc., Ph.D. Director

Administration

R. ROY Administrative Officer
B. W. JABLONSKI, B.L.A. Landscape Architect
D. HALL (Miss), B.A., B.L.S. Librarian

Agrometeorology Section

W. BAIER, Diplomlandwirt, Dr. agr., M.Sc. Chief of Section; Agrometeorology
R. L. DESJARDINS, B.Sc., M.A. Micrometeorology
S. N. EDEY, B.Sc. Climatology
H. N. HAYHOE, B.Sc., M.S., Ph.D. Biomathematics
C. E. OUELLET, B.Sc., M.Sc. Ecoclimatology and plant survival
W. K. SLY, B.A. Applications
G. D. V. WILLIAMS, B.S.A., M.A. Agroclimatology

Mycology Section

R. A. SHOEMAKER, B.S.A., M.S.A., Ph.D. Chief of Section; Pyrenomycetes
J. A. PARMELEE, B.Sc., M.A., Ph.D. Curator of Mycological Herbarium;
Uredinales and other parasitic
fungi
R. ARNOLD (Mrs.), B.A., M.Sc. Pyrenomycetes on woody plants
D. J. S. BARR, B.Sc., M.Sc., Ph.D. Phycomycetes
M. P. CORLETT, B.A., M.A., Ph.D. Pyrenomycetes
M. E. ELLIOTT (Miss), B.A. Discomycetes
J. H. GINNS, B.S., M.S., Ph.D. Wood-inhabiting Hymenomycetes
S. J. HUGHES, B.Sc., M.Sc., D.Sc. Fungi Imperfecti, Hyphomycetes
D. W. MALLOCH, B.A., M.A., Ph.D. Agaricales
K. A. PIROZYNSKI, B.Sc., M.Sc., D.P.P., M.I.B.,
Ph.D. Pyrenomycetes including Fungi
Imperfecti
D. B. O. SAVILE, B.S.A., M.Sc., Ph.D., F.R.S.C. Uredinales

Ornamental Plant Section

- | | |
|---------------------------------|---|
| W. E. CORDUKES, B.Sc., M.Sc. | Chief of Section; Turfgrass |
| A. R. BUCKLEY | Ornamental horticulture |
| J. MOLNAR, B.Sc., M.Sc., Ph.D. | Floriculture |
| E. V. PARUPS, M.S.A., Ph.D. | Physiology of ornamental plants |
| F. J. SVEJDA (Miss), Ph.D. | Ornamental plant breeding |
| J. WILNER, B.S.A., M.Sc., Ph.D. | Frost hardiness and nursery
research |

Vascular Plant Taxonomy Section

- | | |
|---|---|
| J. MCNEILL, B.Sc., Ph.D. | Chief of Section; Numerical
taxonomy, Caryophyllaceae |
| W. J. CODY, B.A. | Curator of Vascular Plant
Herbarium; Pteridophyta, flora of
the Northwest Territories |
| I. J. BASSETT, B.A. | Chenopodiaceae, Plantaginaceae,
Urticaceae, palynology |
| B. R. BAUM, M.Sc., Ph.D. | Aveneae, Tamaricaceae |
| B. BOIVIN, L.Sc., B.A., Ph.D., F.R.S.C. | Canadian floristics |
| R. J. MOORE, B.A., M.A., Ph.D. | Cardueae, cytogenetics |
| T. MOSQUIN, B.Sc., Ph.D. | Reproductive biology |
| G. A. MULLIGAN, B.Sc. | Cruciferae, weeds |
| E. SMALL, B.A., B.Sc., M.Sc., Ph.D. | Ecophysiological biosystematics,
<i>Cannabis</i> |

Departure

- | | |
|--|-------------|
| J. M. GILLET, B.A., Ph.D.
Resigned May 1972 | Leguminosae |
|--|-------------|

VISITING SCIENTISTS

- | | |
|--|---------------------------------|
| P. G. KEVAN, B.Sc., Ph.D.
Postdoctoral fellow to September 1972 | Taxonomy (reproductive biology) |
| J. SUGIYAMA, B.Sc., M.Sc., D.Sc.
University of Tokyo | Mycology |

INTRODUCTION

The Versatile Soil Moisture Budget developed in the Agrometeorology Section has been accepted by scientists in Canada and abroad as the most practical technique for estimating the daily soil moisture contents under crops from standard climatic data.

Biosystematics research has been very productive and requests for identification services have increased by another 25%. A reference work, *Material for an International Oat Register*, which lists and fully cross-references 4,200 oat cultivar names and commercial synonyms, including pedigree charts for nearly every cultivar, has been completed and is being used internationally by oat workers. The computer system that was developed is being used by breeders, commercial seed growers, taxonomists, and scientists to provide a similar register for other cultivated crops.

A patent for a preservative for cut flowers has been filed and processed; the manufacturing rights will be awarded in 1973. A new grandiflora rose, which was obtained by mutation breeding, was introduced and will be widely available in 1973.

Reprints of the research publications are available from the authors. Correspondence should be addressed to: Plant Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Allan Chan
Director

AGROMETEOROLOGY

Agroclimatic Data

Verification and processing of data obtained from the National Agroclimatic Data Program have been streamlined through new quality control and collating procedures. The testing of a low-cost automated system for routine collecting of agrometeorological data was continued, but further improvements and field tests will be necessary before such a system can be recommended for use in the field.

Micrometeorology

Progress has been made in the development of a system for measuring the complete energy balance of a crop continuously. Carbon dioxide flux as an index of plant growth was measured under field conditions with an estimated accuracy of 15%. Light fluctuations, in time and space, in corn canopies were separated by spectral analysis.

Agrometeorological Computer Services

Services have increased and become more diversified with the development of new computer applications. These services were provided to many scientists in the Department and to user agencies such as the Canada Transportation Commission and the Water Survey of Canada for national and regional resource assessments.

Model Development

Several agrometeorological models for the interpretation of the effect of weather and climate on soils and crops have been completed.

The crop-weather analysis model, which evaluates the response of crops to any three environmental parameters, is now operational. It can be used with climatic data for crop-yield analysis or with forecast data for short-term prediction.

Background work has been done on the relationships between weather data and forage drying rates. An index was developed that expresses daily moisture loss as a function of soil and atmospheric conditions. The yield-weather analysis of the 1961-70 data for crop districts in the Prairie Provinces was extended to account for weather and soil influences on yields of wheat, barley, and oats.

Applications

Maps of derived agroclimatic data, prepared by improved computer techniques and new cartographic procedures, have created considerable interest through national and international displays and are being used by several agencies. Seasonal water requirements for irrigation, based on practices developed in British Columbia through field experience, were computed from climatic

data. The results were compared with those obtained if a budgeting technique were employed involving the assumption that the entire crop could be irrigated in one day. Data showed that substantial water savings would result if the above system could be used.

The Versatile Soil Moisture Budget has been accepted by scientists in many countries as the best technique for estimating daily soil moisture contents from standard climatic data. The technique was employed to analyze probabilities of field-work days on the basis of estimated daily soil moisture and to provide a climatology of field-work days for 10 selected stations across Canada. The economics of fallow-seeded and continuous spring wheat in southern Saskatchewan has been analyzed by using climatic data, production costs provided by the Economics Branch, and results of research conducted at the Research Station, Swift Current. Results of this agroclimatic analysis showed that annual yields for continuous wheat were 71% of those from fallow-seeded wheat. When wheat was valued at 61 c/kg, net returns per hectare were 39% higher for continuous than for fallow-seeded wheat, which had been seeded over half the area under cultivation and was under a 2-yr rotation. Beyond an initial 15.2 cm of available water, each additional centimetre yielded \$1 in terms of additional returns from fallow-seeded wheat and \$2 from continuous wheat.

By using earlier-developed agroclimatological techniques and corn heat units as criteria for classification of farmland, it was shown that nearly half the 80,000 ha diverted to urban use between 1961 and 1966 came from the best 1/20th of Canada's farmland. Such agroclimatic analyses can have important implications in regional and national planning.

ORNAMENTAL PLANTS

Evaluation and Identification of Ornamental Plants

Evaluations of 1,013 woody plants; 468 herbaceous perennials; 346 alpine and rock garden plants; 262 bulbous, cormous, and tuberous plants; 368 garden annuals and related plants; and 56 outdoor chrysanthemums were made in 1972.

Marigolds have changed considerably since the 1968 survey was made; the trend is

now toward larger blooming dwarf types and more prolific blooming tall types. The mound type, *Tagetes signata* group, now includes bronze and reddish types in addition to yellow, orange, and lemon colors.

A method of propagating the disease-resistant Quebec elm that involved the bruising and slashing of the cuttings prior to treatment with indolebutyric acid and insertion in the mist beds gave a rooting count of 80%.

Development of Hedge Shrubs with Colored Foliage

Variation of foliage color was studied in taxa from *Prunus*, *Euonymus*, and *Weigela* to find the most suitable taxon from which a hedge plant with purple foliage could be developed to replace the banned Japanese barberry, *Berberis thunbergii* DC. Seedlings from open pollination of the *Prunus virginiana* L. cultivar Shubert showed considerable variation in the color and size of leaves; the desired plant type may be obtained from such populations. Some seedlings from open pollination of *Euonymus europaeus* L. produced bright crimson foliage in the fall, similar to that produced by *E. alatus* (Thunb.) Sieb. Because *E. alatus* grows slowly, a mutant of the faster growing *E. europaeus* would be useful to the nursery industry.

Histochemical Changes During Senescence in Rose Flowers

Histochemical tests indicated that the accumulated starch in the cortex and in the phloem and xylem ray cells of freshly harvested roses was depleted completely within 3 days from harvest. The carbohydrates in the cell walls did not appear to change during senescence. There was a reduction in lipid and protein content 4 days after harvest. There were also reductions in both succinic dehydrogenase and cytochrome oxidase activity with the advance of senescence; at the same time peroxidase activity increased.

Photoperiodic Response of Rieger Elatior Begonias

Experiments confirmed that vegetative plants need a 12-h photoperiod for 3 wk to induce maximum flowering. The short-day treatment should begin 6 wk before the plants are required to be in full bloom. Plants under a 10-h photoperiod for 3 wk flowered

earlier and more abundantly than those grown under 14, 16, 18, and 24 h of light per day. Rieger begonias grown without shading may develop scorch of the leaf margins. Tests showed that a reduction of 20–30% in light intensity (equivalent to about 26,910 lx) in the summer was optimum. Plants that received more than 30% shading became elongated and brittle. Plants grown under 55% and 73% shading produced 30% fewer buds and flowers than plants under optimal light conditions.

Inhibition of Ethylene Production in Plant Tissues by 8-hydroxyquinoline

The effectiveness of 8-hydroxyquinoline, a component of flower preservative mixtures, has been ascribed to its bacteriostatic and fungistatic action and its phytoalexin and other activities. Using apple and rose flower tissues as ethylene-producing model systems, it was shown that 8-hydroxyquinoline suppresses the growth of ethylene-producing microorganisms but that its direct effect on ethylene synthesis was greater than its indirect effect as an antimicrobial agent. The ability of 8-hydroxyquinoline to inhibit the synthesis of ethylene may explain how it delays senescence in plants and affects cut flowers.

Inhibition of Ethylene Action in Plants

The chemical 5-methyl-7-chloro-4-ethoxycarbonylmethoxy-1,2,3-benzothiazole was found to prevent the “shattering” of snapdragons, to delay the senescence of cut flowers, and to prevent the epinastic responses of plants exposed to ethylene or other plant growth regulators that promote the synthesis of this gas.

Container-grown Nursery Stock

Bioelectric tests of cold-hardened plants have established an impedance shoot-to-root ratio of about 1.5:2.0 as the best condition for the overwintering of container stock. Studies also indicated that, in addition to cold hardening of plants, biological and cultural factors are important.

Single applications of the slow-release N fertilizers Osmocote and I.B.D.U. early in the spring were as effective on the growth of container stock as soluble fertilizers, such as 20-20-20, applied every 10 days during the growing season. Ethrel at 1%, 2%, 3%, and 4% concentrations increased the earliness of

autumn maturity of container stock from 10% to 85%.

Turfgrass

The first tiller of a single plant of each of 10 Kentucky bluegrass cultivars was grown enclosed in aluminum foil for 6 mo in a greenhouse. After this growth period, the enclosed tiller exhibited all the characteristics of a true rhizome. Such cultivars as Nugget and Fylking, strains of northern latitudes, had many buds that produced side shoots that grew almost as long as the initial tiller. Belturf and Geary, cultivars from southern latitudes, had significantly fewer tiller buds and none of them developed into side shoots. The cultivars Windsor, Merion, Cougar, and Sydsport produced more buds than Belturf and Geary but fewer than Nugget and Fylking. Only a few buds of these cultivars developed side shoots. The tolerance of these cultivars for frequent and close clipping is in the same order as their bud production herein described. Thus plant breeders in search of bluegrass selections tolerant of close, frequent clipping will find their best sources in northern latitudes. These findings may also be relevant to the selection and breeding of other rhizomatous grasses.

MYCOLOGY

Taxonomic Research

Phycomycetes. Preliminary studies on the fine structure of some Chytridiales indicated a need for reassessment of taxonomic criteria used in current classification. Biochemical analysis of cell wall material of two species of chytrids disclosed the same carbohydrates as those in cell walls of the “higher” Basidiomycetes and Ascomycetes. Four zoosporic fungi, suspected vectors of wheat spindle streak mosaic virus, were found to be endemic in southern Ontario soils.

Basidiomycetes: rusts and smuts. Further research was done on the rusts of *Scirpus* and allied genera, and on North American autoecious species of *Puccinia* on Heliantheae. One hundred and fifty-two rust entities, parasitic on members of Poaceae, Cyperaceae, and Juncaceae, were reexamined and interpreted in the light of criteria provided by the hitherto neglected aeciospore morphology. This study corrected several misconceptions about economically important grass

rusts. An investigation of cytology and nuclear conditions of *Roestelia brucensis* Parmelee, a rust of juniper, was carried out.

Basidiomycetes: Hymenomycetes. Monographic studies of *Merulius* and *Coniophora*, involving more than 500 names, are being completed. Some 70 isolates of sclerotium-producing Basidiomycetes, including members of *Rhizoctonia* and *Typhula*, are under comparative study to determine the method of ontogeny and the taxonomic significance of sclerotia. Because of the growing concern over poisonous and halucinogenic fungi, a study of lawn-inhabiting mushrooms was undertaken and a preliminary report was prepared.

Ascomycetes: Discomycetes. Two previously ill-defined species of *Peziza*, *P. badia* Pers. ex. Mérat, and *P. badio-confusa* Korf, were investigated and shown to be allochronic. A *Botrytis* species attacking *Erythronium*, and presumed to be the imperfect state of a member of Sclerotiniaceae, is under investigation.

Ascomycetes: Pyrenomycetes. Several new species of cleistothecial fungi were described including perfect states of species of *Aspergillus* and *Penicillium*, for which five new genera were proposed. Chalkbrood disease of honey bee larvae was reported from British Columbia, Ontario, and Quebec. Type studies in the Pleosporales continued with the description and illustration of 65 species of *Massaria* and allied genera, a revision of Canadian species of *Ophiobolus*, and a survey of pleosporaceous fungi occurring on brome grass. A new species of *Didymosphaeria* hyperparasitic on a rhododendron leaf-spotting fungus was discovered and described. *Fusicoccum* canker and die-back of Russian olive, and *Hypoxylon mammatum* (Wahl.) Miller canker of beech were investigated. Developmental studies involving members of sooty molds were continued and resulted in redefinition of the families Euantennariaceae and Metacapnodiaceae. The electron microscope was used to elucidate centrum structure of a species of *Chaetomium* and fine structure of the apple scab fungus.

Fungi Imperfecti: Hyphomycetes. Continuing reassessment of asexual reproductive structures formed by cryptogams generally resulted in the discovery of several nomenclatural abnormalities. Corrective proposals

were made. A survey of the hyphomycete flora of red bay leaf litter in the Carolinas (undertaken jointly with the USDA Forest Service) yielded several new species and a member of a new genus. A monograph of *Dicoccum* was published.

Fungi Imperfecti: Coelomycetes. A study of diseased specimens of *Koeleria* from the Prairie Provinces led to the discovery of a new physiological form of *Septoria andropogonis* J. J. Davis. A new genus *Cornutispora* was proposed to accommodate a recently discovered hyperparasite of *Therrya fuckellii* (Rehm) Kujala, the red pine canker organism.

Identification Service and Cultures

There was a 25% increase in the number of specimens that were identified to bring the total to 1,411 for 1972. The requests came from scientific and government agencies, and the general public. A total of 190 cultures, 65 more than in 1971, were requested from various agencies.

VASCULAR PLANT TAXONOMY

Taxonomic Studies

In the continued macro- and micro-morphological studies on oats, directed toward the production of a taxonomic monograph of the genus *Avena*, two new species have been discovered and named: *A. damascena* Rajhathy & Baum and *A. canariensis* Baum et al. Both are diploid and the discovery of the latter is a breakthrough in our understanding of the evolution of cultivated oats. *Avena septentrionalis* Malzew has been distinguished from its close allies and its potential as a source of genes useful in oat breeding has been emphasized. Electron microscopy has revealed new features that allow *A. sterilis* L., *A. murphyi* Ladizinsky, and *A. magna* Murphy & Terrell to be distinguished; hitherto this was very difficult.

Material for an International Oat Register, a reference work that lists and fully cross-references 4,200 oat cultivar names with all types of synonyms, translations, and pedigree charts, has been completed. A new approach to the classification and identification of oat cultivars has been developed. From 21 nonagronomic characters that generated 14 cultivar groupings, four characters of primary importance in discrimination were

derived and used in a Bayesian identification scheme.

Cytotaxonomic studies have been conducted on two closely related species of *Draba*, *D. oligosperma* Hooker ($2n = 64$) and *D. incerta* Payson ($2n = 112$). Both species are mainly confined to the mountains of western North America, but *D. incerta* is also disjunct nearly 3,000 miles eastward to the tip of the Gaspé Peninsula in Quebec. *Draba oligosperma* is an octoploid, which reproduces mostly by agamospermy, and *D. incerta* is a 14-ploid, which produces seed by autogamy.

On the basis of pollen morphology, an identification key has been provided for all species of the genus *Tamarix*. In this genus, evolutionary trends in pollen morphology appear to be: reduction in size of the luminae and of the whole grain, and an increase in wall thickness and of the polar area. These trends, supported by previously assessed trends in the morphology of floral parts, suggest the development of anemophily from entomophily in the evolution of the group.

A survey was made of the species of knapweed (*Centaurea*, family Compositae) reported to occur in Canada and the USA. After revising the identification of numerous specimens upon which these reports were based, we concluded that 26 introduced species and two native species occur in this area. Eleven of the introduced species are widespread and five of these are sufficiently common to be classed as weeds.

Cannabis studies on the "cannabinoids" (the class of chemicals responsible for the psychoactive effects of marijuana) were started. It was found that F_1 hybrids between "drug strains" (those in which the resin is composed chiefly of tetrahydrocannabinol) and "nondrug strains" (those in which the resin is chiefly cannabidiol) were generally intermediate between their parents; significant heterosis occurred in about one-third of the cases. Extreme deficiencies of N, P, or K have little effect on the content of drug constituents. Seasonal development of cannabinoids was also studied. It was found that the cannabinoid content in *Cannabis* increases gradually at first, drops sharply immediately before flowering, and then rises sharply during flowering.

A natural hybrid between the apogamous triploid fern *Phegopteris polypodioides* Fée ($2n = 90$) and the sexual diploid *P. hexagonoptera* (Michx) Fée ($2n = 60$) was

discovered and its cytology elucidated. This is only the second time such a hybridization between a sexual and apogamous species has been reported and it is concluded on cytological and morphological evidence that the natural hybrid ($2n=120$) was produced by the fusion of a 90-chromosome motile gamete from *P. polypodioides* with a 30-chromosome female gamete from *P. hexagonoptera*.

Taxonomic and biosystematic studies have also continued on a variety of groups, such as the Caryophyllaceae, Chenopodiaceae, Gramineae, and Urticaceae, which include weedy or economic species. Investigations of populations of weedy white cockle in Canada showed, contrary to claims in the literature, that these are similar to European white cockle, *Silene alba* (Miller) E.H.L. Krause, and are not the result of hybridization with red cockle, *S. dioica* (L.) Clairv. Artificial hybrids have been produced between the diploid and tetraploid chromosome races of the native *Urtica dioica* L. subsp. *gracilis* (Aiton) Solander, but these triploid hybrids have not been found in nature. A new species of spring beauty, *Claytonia ogilviensis* McNeill, found in the Ogilvie Mountains, Yukon Territory, has been described.

Floristic Studies

Volume 3 of the four-volume *Flora of the Prairie Provinces*, which completes the account of the dicotyledons, has been published. As part of the International Biological Program (CCIBP-CT), 10 more sites in the District of Mackenzie were evaluated for possible preservation, and much valuable material was collected and is being used in the preparation of the *Flora of the Continental Northwest Territories*.

Weed Biology

A study of the insects that visit the flowers of Canadian weeds showed that both self-pollinating (autogamous) and cross-pollinating (allogamous) weeds are visited during the flowering period. Self-incompatible species are visited by insects frequently, whereas self-compatible weeds are not visited or are rarely visited. Most of the insect visitors, to both the autogamous and allogamous species of weeds, are native species, whereas the weeds themselves are mostly introduced species. The amount of reflectance from the flowers, at various wavelengths within the insect visual spectrum, has been evaluated

for nearly all common weeds in Eastern Canada.

Ecophysiology

Clarification of the adaptive physiology of peat bog plants in relation to the very low levels of nutrient elements in the bog substrate, and several aspects of nutrient and photosynthetic relations of peat bog plants and a variety of other plants were studied. Preceding leaf fall, bog species were found to reabsorb significantly more N from their foliage than nonbog species. Estimates were made of the potential photosynthate that bog and nonbog species could manufacture during the time a given unit of N remained in the plant before being lost through leaf fall. The amounts are high for the bog plants, particularly the evergreens. Apparently the increased time available to photosynthetically utilize N before it is recycled is adaptive in bog plants because of the difficulty of

acquiring N from the extremely nutrient deficient bog substrate.

Herbarium, Index Seminum, and Plant Identification.

The vascular plant collection now contains 593,866 mounted herbarium specimens, an increase of 11,360 during the past year. Loans of 4,208 specimens were made to institutions in North America and Europe; 5,965 specimens were borrowed from cooperating institutions for study by our research staff.

Over 6,500 packets of seeds of native and adventive plants were sent to more than 300 research centers in various parts of the world through the Index Seminum program, and in return approximately 6,700 samples were received for Canadian scientists.

As a service to scientific and government agencies and to the general public, approximately 5,500 plant identifications were made by the research staff of the Vascular Plant Taxonomy Section during the year.

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Ottawa, Ontario

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Prince Edward Island Soil Survey Unit (Charlottetown)

J. I. McDOUGALL, B.Sc., B.Sc. (Agr.)	Head of Unit
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Nova Scotia Soil Survey Unit (Truro)

J. NOWLAND, B.A., M.Sc.	Head of Unit
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New Brunswick Soil Survey Unit (Fredericton)

K. K. LANGMAID, B.Sc., M.Sc.	Head of Unit
C. WANG, B.Sc., M.Sc., Ph.D.	Party leader

Ontario Soil Survey Unit (Guelph)

C. J. ACTON, B.S.A., M.Sc., Ph.D.	Head of Unit
B. H. CAMERON, B.Sc. (Agr.)	Party leader
J. E. GILLESPIE, B.S.A., M.S.A.	Party leader
S. E. HUMPHREY, B.Sc. (Agr.), M.Sc.	Party leader
E. W. PRESANT, B.S.A., M.Sc.	Party leader
G. J. WALL, B.S.A.	Party leader

Manitoba Soil Survey Unit (Winnipeg)

R. E. SMITH, B.S.A., M.Sc.	Head of Unit
G. J. BEKE, B.S.A., M.Sc., Ph.D.	Party leader
W. MICHALYNA, B.S.A., M.Sc.	Party leader
C. TARNOCAL, B.S.F., M.S.	Party leader

Saskatchewan Soil Survey Unit (Saskatoon)

D. F. ACTON, B.S.A., M.Sc.	Head of Unit
K. W. AYRES, B.S.A.	Party leader
A. K. BALLANTYNE, B.S.A., M.Sc.	Party leader
L. S. CROSSON, B.S.A., M.Sc.	Party leader
W. K. JANZEN, B.S.A., M.Sc.	Party leader
H. P. W. ROSTAD, B.S.A., M.Sc.	Party leader

H. B. STONEHOUSE, B.S.A., M.Sc. Party leader

Alberta Soil Survey Unit (Edmonton)

T. W. PETERS, B.Sc., M.Sc. Head of Unit
G. M. COEN, B.Sc., M.Sc., Ph.D. Party leader
P. H. CROWN, B.S.A., M.Sc. Party leader
A. A. KJEARSGAARD, B.Sc. Party leader
S. S. KOCAOGLU, B.S. Party leader
W. W. PETTAPIECE, B.S.A., M.Sc., Ph.D. Party leader

British Columbia Soil Survey Unit (Vancouver)

L. FARSTAD, B.S.A., M.Sc. Head of Unit
T. BEDWANY, B.S.A. Party leader
P. CHRISTIE, B.S.A. Party leader
A. J. GREEN, B.S.A., M.Sc. Party leader
L. A. LESKIW, B.S.A., M.Sc. Party leader
T. M. LORD, B.S.A. Party leader
J. I. SNEDDON, B.S.A., M.Sc. Party leader
K. VALENTINE, B.S.A., M.Sc. Party leader
W. WATT, B.S.A. Party leader

Cartography

J. G. ROBERTS Chief Cartographer

Departures

J. S. CLAYTON, B.S.A., M.Sc. Soil correlation
Retired August 31, 1972
R. L. HALSTEAD, B.S.A., Ph.D. Soil phosphates
Acting Research Coordinator, July 1, 1972

VISITING SCIENTISTS

MARIA ORTIZ DE SERRA, Lic. Humic acid chemistry
Comision Especial de Ciencias Agricolas
(Argentina) fellow
R. RIFFALDI, Ph.D. Humic acid chemistry
Italian National Research Council fellow
B. KLOOSTERMAN, B.S.A., Ph.D. Soil data bank
National Research Council postdoctorate fellow

B. G. VOLK, B.Sc., M.Sc., Ph.D.
Transfer from University of Florida at Belle
Glade
L. M. COSTESCU (Mrs.), B.Sc., M.Sc.
Transfer from University of Toronto

Humic acid chemistry

Humic acid chemistry

¹On Career Assignment Program with the Department of the Environment.

INTRODUCTION

During the past two years the activities of the Soil Research Institute have been directed toward two new program areas: soil resources and soil quality and related environmental studies. In the Soil Resource program, work has been expanded on soil correlation, interpretations and applications of soil information, and remote sensing; also, a soil data bank (Canada Soil Information System) has been started as an aid to correlation and interpretations. The Soil Conservation Research program has included studies on urban and animal waste disposal, metal reactions, nutrient accumulation and transmission, reclamation of mine tailing areas, and other activities related to the maintenance of soil quality.

Regional programs have been maintained through the regional Soil Survey units, which have continued work in regular soil survey programs but have extended studies to northern transportation corridors and other wildland areas where northern land management is a concern. To provide more effective correlation and coordination, the Canada Soil Survey program is operated through the Institute.

Reprints are available from the authors. Correspondence should be addressed: Soil Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. S. Clark
Director

SOIL RESOURCE RESEARCH

Soil Water Movement

A computer program was developed and tested to combine an implicit solution of the diffusion equation with the concept of independent domains for soil moisture tension. The program made it possible to vary nodal spacing with depth, and to use different conductivity data for crusted or mulched layers near the surface. This program was about six times faster than the one previously used for computing sequences of infiltration, redistribution, and evaporation.

Work completed in 1972 showed that evaporation rates after wetting could be explained adequately in terms of soil conditions. Similar tests are being carried out for conditions in which moderate rewetting (involving hysteretic effects) is preceded by redistribution alone, or by redistribution and surface evaporation.

Studies of soil-water hysteresis and of models for predicting hysteretic effects from limited soil data have shown that the nature, but not the magnitude, of hysteresis in sieved soil materials is independent of texture. The most promising model for predicting hysteresis in the relationships between water content and pressure head is not adequate, and probably gives no more accurate results than educated guesses. Further refinements that appear to improve the prediction model are very complex to apply, and they probably

will not be widely used at present. No hysteresis was measured in the relationship between hydraulic conductivity and water content.

Another phase of the program involved measuring soil-water hysteresis in relation to the natural layering in soil. Laboratory studies were performed on an undisturbed core of Castor very fine sandy loam, to map the soil-water hysteresis and to study the response of the core to simulated infiltration and evaporation effects. The results showed that the natural layering in this soil could mask hysteresis in most field measurements. This work on soil-water hysteresis has been discontinued, and attempts are being made to develop methods of physically characterizing soil in the field.

Aluminum - Organic Matter Interaction in Acid Soils

A greenhouse experiment of Dr. P. B. Hoyt at the Research Station at Beaverlodge, Alta., showed that the application of organic materials, such as alfalfa meal, to acid soils increased the pH, decreased exchangeable Al, and increased yields. However, the beneficial effects of the addition of organic matter were only temporary.

Experiments designed to elucidate the role of alfalfa meal in complexing Al showed that a number of Al - organic matter complexes, some water-soluble and some insoluble, were formed. Fresh alfalfa meal was a more

efficient complexer of Al than the incubated material, and much of the Al complexed with the fresh alfalfa meal was soluble in water. These results were consistent with some of those obtained in experiments with alfalfa meal in the presence of acid soils, but were inconsistent with others. It was found that many of the components of fresh alfalfa meal that complexed Al were removed from solution both by an acid soil from which exchangeable Al had been removed, and by Al or ferric hydroxide precipitated on clay. Apparently, the application of large amounts of alfalfa meal benefits an acid soil mainly because of complexing between components of the organic material and Al.

Selenium Distribution and Some Selenium-Sulfur Relationships in Various Canadian Soils

The distribution of Se in 54 soils was examined according to horizon and to soil properties. Apart from the organic surface layers, the Podzolic B horizons gave the highest Se values (0.52 ppm) and showed a marked accumulation; the Luvisolic and Gleysolic B horizons also showed some accumulation. The Se content of parent materials was generally low (0.10 ppm). Simple correlation analyses of the combined data (irrespective of horizon) indicated that Se distribution was closely associated with both organic C and NH_4 -oxalate-extractable Fe and Al. When the data were arranged according to genetic grouping, this association remained true only for Podzolic B horizons. Multiple regression analyses showed that the predominant factors involved in Se distribution were the Se content of parent materials and the C content of the upper horizons; the former factor was more important, except in Podzolic soils.

The distribution of Se was closely related to that of S, probably because both elements were associated with organic matter. Some differences were found in the distribution of Se and S through the profile; S seems to be more strongly held in the organic surface layers, whereas Se apparently moves more readily down the profile.

Effect of Temperature on Fungal Flora and Decomposition of Leaves

The rate of decomposition, changes in fungal flora, and amino acid content of a mixture of coniferous and deciduous leaves

incubating at different temperatures were studied over a 4-yr period. For each 1°C drop in temperature, the rate of decomposition decreased approximately 1.8%. Estimations were based on a decomposition period of 5 mo and a leaf fall of 7,400 kg/ha (6,600 lb/ac), which is approximately the average annual rate in the cool-temperature forests of Canada; they showed that at soil temperatures of 10, 4, and 1°C, the annual loss of leaf litter would be 1,620, 1,030, and 660 kg/ha (1,450, 920, and 590 lb/ac) respectively. Thus, at cold soil temperatures the organic matter would accumulate, and the rate of accumulation would increase as the temperature became lower. At low soil temperatures (10, 4, and 1°C) half of all fungal isolates belonged to the genus *Chrysosporium*. The next most abundant genera were *Mucor*, 22%, and *Penicillium*, 15%. At higher temperatures (21 and 27°C), species of *Trichoderma*, *Aspergillus*, and *Penicillium* predominated.

Three species of fungi were used to prepare fungal humic acids. These substances were similar in surface functional groups, but were more aliphatic than soil and peat humic acids.

Gas Chromatography - Mass Spectrometry of Phenolic Compounds

The use of gas chromatography - mass spectrometry (GC-MS) to identify microgram amounts of phenolic substances in soil humus showed that some compounds with identical retention times in the GC can be differentiated readily by their mass spectra. The application of GC-MS enabled us to identify phenolic esters of fatty acids in organic soils for the first time.

Silylation of certain phenolic compounds yielded two derivatives that produced two distinct peaks in the gas chromatograms. GC-MS analyses showed that the first peak, which had the lower retention time, was caused by the expected silyl derivative. The second peak was probably a result of an intermolecular transfer reaction that incorporated a second silyl group into the phenolic compound. The appearance of the second peak depended upon the silylating agent, the reaction time, and the phenolic compound. The fact that only certain phenols were observed to display this behavior could be of diagnostic value, but it is also apparent that GC-MS analysis of silyl derivatives cannot

be used indiscriminately for positive identification.

Chemical Structure and Reactions of Humic Substances

In a search for methods that would provide meaningful information on the chemical structure of humic material, we investigated a number of procedures for oxidation and degradation. A humic acid extracted from an Argentinian Brunizem soil was degraded in the unmethylated and methylated forms by sequential oxidation, with reagents of increasing strength. These reagents were: CuO-NaOH, CuO-NaOH + KMnO_4 , CuO-NaOH + KMnO_4 + H_2O_2 , KMnO_4 , and KMnO_4 - H_2O . The humic acid was also reduced by Na-amalgam. The degradation products were extracted into organic solvents, separated by preparative gas chromatography, and identified by mass spectrometry and micro-infrared spectrophotometry. The results showed that the humic acid contained a fairly easily degradable part (about 10% of the total weight), which comprised guaiacyl and syringyl monomers and which could have been derived from lignin. Most of the humic acid structure, however, consisted of a more condensed, chemically complex core, which degraded with stronger oxidation into phenolic and benzenecarboxylic acids.

Acid Dissociation and Metal Ion Binding Equilibria of Fulvic Acid

Potentiometric and conductometric titration methods have been considered in detail for equivalence point determinations. When three to six values were averaged, the potentiometric titration method was found to give excellent agreement for the second equivalence points of two different batches of fulvic acid. The potentiometric titration method has therefore been adopted.

The binding equilibria of N^+ and Ca^{++} with fulvic acid have been measured potentiometrically, as functions of the degree of ionization. For Na^+ , the binding is assumed to be totally electrostatic, and the differential equilibrium function and electrostatic binding free energy have been deduced from the weighted averages of experimental results.

The 3 meq/g of most strongly acidic functional groups appear to bind little or none of the metal ion Na^+ or Ca^{++} . Because the heavy metal ions such as Cu^{++} and

Fe^{++} , which can chelate by covalent bonding, react with the most strongly acidic 3 meq/g of carboxyl groups, at least two distinct types of reactions between fulvic acid and metal ions are indicated.

Clay - Organic Matter Interactions

When water-soluble fulvic acid (FA) reacted with Cu^{++} -montmorillonite at pH 2.5, the interlamellar spacing increased from 1.00 to 1.50 nm under extremely dry conditions. The extent of interlayer adsorption decreased as pH increased. Examinations by differential thermal and thermogravimetric analyses showed interlamellar adsorption and also retention of FA on external clay surfaces. The FA was held so tightly by the Cu^{++} -clay that, unlike the FA-Na montmorillonite complex, three-quarters of the total amount adsorbed resisted decomposition even when heated to 1,000°C. Infrared spectra revealed that β -diketone groups in FA reacted with Cu^{++} in or on the clay to form acetylacetonate-type chelates. This type of reaction may also occur with other di- and tri-valent metal ions in the presence of clays. Montmorillonite appears to affect the conformation of the FA polymer in a way that favors reactions between C=O groups and metal ions, a type of reaction that has so far not been observed in aqueous solutions in the absence of clays.

The external adsorption of FA by nonexpandable clay minerals, such as kaolinite, muscovite, and sepiolite, decreased with an increase in pH, increased with an increase in the amount of FA in the system, and was proportional to the surface area of the clay.

Characteristics of Hydroxy Aluminum Sulfate - Montmorillonite Complexes

The chemical composition and the structure of the interlayer material formed in Wyoming bentonite depends upon the kinds and concentrations of anions present when the reactions are taking place. When Al was titrated in the presence of Wyoming bentonite to an OH:Al molar ratio of 2.25, and when the anions Cl and SO_4 were present in the same equivalent concentrations, the cation exchange capacity of the montmorillonite was reduced to 0.15 meq/g clay from the original capacity of 0.85 meq/g clay. The chemical composition of the system revealed that the net Al precipitated was 20 meq/g clay and that the amounts of OH and SO_4 precipitated were 16.50 meq and 2.38 meq

respectively; thus, the 20 meq Al combined with 2.38 meq SO_4 , 16.50 meq OH, and 0.70 meq negative charge of the clay. Probably the net negative charge of 0.42 meq was satisfied by chloride ions, which on washing with water were replaced by OH ions, indicating mild hydration as a result of washing. The atomic ratio Al:OH: SO_4 of the precipitate was 1.00:2.53:0.18.

X-ray data showed that the complex had spacings of 1.97 nm under extremely dry conditions, 2.19 nm under moist conditions, and 2.44 nm in solution with glycerol. During heat treatments between 100 and 200°C, the d_{001} spacing was sharply reduced to 1.60 nm and the newly developed phase was an interstratified structure consisting of a 1.43-nm unit (chloritelike structure) and a 1.77-nm unit (dehydrated basaluminite plus silicate layer of montmorillonite). The d_{001} spacing observed for the unheated material was larger than that expected for the amount of Al precipitated in the montmorillonite, but it was interpreted in terms of voluminous $\text{Al}_{13}\text{O}_{40}$ polyhedra, which are fundamental structural units of a basic aluminum sulfate.

Artificial Weathering of Chlorites and Micaceous

The hydroxide sheet in chlorite was removed by heating to effect dehydroxylation, and the material was then treated with dilute HCl. The product appeared similar to vermiculite, and it is inferred that chlorites under some natural conditions may weather to vermiculite.

Replacement of K from muscovite by Ba increased both the *b* and *c* dimensions of the mineral. X-ray and electron diffraction analysis of K-resaturated product showed that the structure of the original muscovite could not be reconstituted. Apparently, replacement of K by Ba caused structural disturbances in muscovite.

Results of work with Dr. C. I. Rich at the Virginia Polytechnic Institute supported the hypothesis that the increasing degree of completeness of K exchange with particle size and thickness of micas is mainly caused by the greater bending and deformation of elementary mica layers during K release from larger and thicker particles.

SOIL RESOURCE CONSERVATION Analytical Methods

Procedures were investigated for determining orthophosphate, ammonium, and nitrate in water samples by automated methods with the Technicon Autoanalyzer. The methods adopted for ammonium and nitrate determination presented no serious problems. Much more difficulty was encountered with orthophosphate determination, because the amounts in our samples were in the parts-per-billion (ppb) range. The relatively high concentration of silica in the samples interfered with determination at this low concentration, and difficulties were encountered if the samples were colored or turbid. The turbidity could be removed by high-speed centrifugation and the silica interference eliminated by the use of an automated isobutanol extraction method. This usually reduced, but did not completely eliminate, the color interference. However, the isobutanol extraction procedure is slow (10 samples/h) and difficult to maintain in running order. Serial samples of tile drain effluent are very uniform in silica content, and if the orthophosphate standards are prepared in silica solutions at this concentration, the standard automated method can be used.

A study was made of possible interference in atomic absorption measurements of Al in plant digests and neutral salt extracts of soils. A new Techtron lamp designed by Westinghouse and a 5× scale of expansion measured Al at 1.0 ± 0.08 ppm. Addition of lanthanum (2,000 ppm) prevented high readings caused by Na, K, Sr, Fe, and a mixture of many constituents. The measurements in plant digests were independent of dilution, gave complete recovery of added Al, and showed excellent agreement with 8-quinolinolate colorimetric values. It was concluded that the new lamp provides adequate sensitivity, stability, and freedom from interference, so that atomic absorption can be used for routine measurements of Al in plant digests and neutral salt extracts of soils.

Soil Pollution

From manure. The effect of two manure storage areas more than 30 yr old at the Central Experimental Farm, Ottawa, on the pollution of groundwater by plant nutrients was investigated for 3 yr. One storage area was on a concrete base and the other was located on a gravel base. The water table was usually above the 275-cm depth at both sites.

Two unused shallow wells less than 250 m from the storage areas were not contaminated by nitrate, ammonium, or phosphate. Water from piezometers installed at 275- and 425-cm depths near the gravel-based storage area was always low in nitrate and ammonium, but significant levels of nitrate were sometimes found in water from a piezometer 122 cm deep. Water from piezometers installed at 122- and 275-cm depths near the concrete-based storage area usually contained nitrate and ammonium. Water from piezometers installed 200–250 m from the storage area in the direction of groundwater flow contained little nitrate or ammonium. The conditions in the area and the seasonal variation in the nitrate content of the groundwater suggested that much of the nitrate originating from the storage areas was denitrified at or near the water table. No evidence of serious contamination of groundwater by the storage areas could be found.

From mercury. Composite soil samples were collected in the fall of 1970 from the 0 to 5-cm layer of some greens of three golf courses in the Ottawa region; they contained an average of 54 ppm Hg. Samples of the 0- to 15-cm layer were collected in the fall of 1971 at the edge of a green of each of three courses that varied in soil texture from sand to clay loam. The samples were found to contain 57.4 ppm Hg in the sand, 7.3 ppm in the loam, and 123.8 ppm in the clay loam. The corresponding amounts in samples on the slope of the fairway at a distance of 30.8 m from the green were 0.30 ppm Hg in the sand, 0.57 ppm in the loam, and 21.2 ppm in the clay loam.

The amounts of Hg in the sand decreased abruptly below the 15-cm depth, whereas the zone of Hg retention extended slightly deeper in the loam. The clay loam soil contained much the highest amounts of Hg, and there was evidence that it had leached to a depth of 90 cm at the edge of the green and to at least 120 cm at 30.8 m from the green.

Of 10 different plant species grown in an Hg-treated loam soil (5.25 ppm Hg as phenyl mercury acetate), 98.3% of the Hg was retained by the soil at the end of the cropping period.

From organic additives. Incubation experiments are in progress to determine the capacity of soils to assimilate polyaromatic hydrocarbons (PAH); these substances are of

serious concern in the field of air pollution. Two oilseed crops have been grown in pot culture, with and without added benzanthracene, in soils collected from regions that have various degrees of air pollution, to determine if higher levels of PAH in soils could lead to hazardous PAH levels in vegetable oils.

Measurement of Plant-available Aluminum and Manganese in Canadian Acid Soils

Laboratory techniques for estimating plant-available Al and Mn in soils were compared in 33 soils that had a wide range of acidity. Barley, rape, and buckwheat were grown on the soils in the greenhouse and the laboratory soil measurements were correlated with the percentage yields of barley and rape (yield unlimed \times 100/yield limed), the Al content of rape, and the Mn contents of rape and buckwheat.

The soil Al and Mn soluble in dilute CaCl_2 were highly correlated with the Al content of rape and the Mn contents of rape and buckwheat, respectively. The percentage yields of barley were highly correlated with Al, and the percentage yield of rape with Al and Mn combined. The CaCl_2 -soluble, 0.1 N H_3PO_4 -soluble, and exchangeable Mn gave equal correlations with the crop data, but reducible and H_2O -soluble Mn were less well correlated. The CaCl_2 -soluble Al was better correlated with the crop data than was exchangeable Al.

The recommended diagnostic technique for plant-available Al and Mn in soils is to shake soils at a 1:2 ratio with 0.01 M CaCl_2 for 5 min, and measure Al and Mn in the supernatants by atomic absorption spectrophotometry.

Spartan Apple Breakdown

Work at the Research Station at Summerland, B.C., indicated that the breakdown of Spartan apples was associated with a low Ca content of the fruit. Tomatoes were grown in the greenhouse on three topsoil and subsoil samples from Spartan apple orchards, in order to study the Ca nutrition of plants grown on these soils with various amendments. The yields of tomato plants grown in the subsoils were lower than those obtained from topsoils for control, CaCO_3 , KCl, and $\text{CaCO}_3 + \text{KCl}$ treatments. The treatment with KCl alone resulted in yields about 25% lower than those of the control, in all soils except one subsoil.

The addition of either CaCO_3 + $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ or $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ alone eliminated the difference in yield between a topsoil and a subsoil, and resulted in much higher yields than those obtained by any of the other treatments. The evidence indicates that the soils were deficient in S, which may contribute to the Spartan apple problem.

SOIL RESOURCE INVENTORY

Soil Correlation

The Soil Map and the Soil Climatic Map of Canada were prepared for cartographic reproduction. The two-volume report on the Soils of Canada, in which these maps will be included, was completed for publication. Soil correlations were conducted in Ontario, Quebec, and Newfoundland in Eastern Canada, and in Saskatchewan, Alberta, and British Columbia in Western Canada. A special sampling program related to classification of Podzolic and Brunisolic soils was conducted.

Canada Soil Information System

The Canada soil information system (CanSIS) was started in January 1972. At that time it was decided that: CanSIS was to be a collection of cooperative national and provincial data banks; it would include basic data derivable from soil survey operations and from studies dealing with the productivity or performance, or both, of soil under specified levels of management; most of the input would be compiled at the provincial level; and a pilot project area would be selected to evaluate the scheme. The area selected covered about 1.8 million ha (4.5 million ac) in west-central Alberta.

Four basic data files were defined for the CanSIS scheme: soil data, soil cartography, administrative or geographic boundaries, and performance or management. A coding scheme and file management system have been defined for the soil data file, but much more work is needed on the file to solve problems of data compatibility. Three soil maps have been digitized for the soil cartographic file, and a file management system is being prepared. A system of subfiles is being planned for the performance and management file, and a coding scheme for the first of these, the agricultural small-plot subfile for cereal variety trials, has been compiled.

Small-scale Maps

A project was started to prepare and publish individual maps for each province, or group of provinces in the case of the Atlantic region, showing the agricultural capability of the soils as identified by the Canada Land Inventory. These maps, at a scale of 1:1,000,000, have a uniform legend for the whole of Canada, and are prepared by generalizing the information published or to be published on maps at 1:250,000. Information matches perfectly along provincial boundaries, and maps can be used individually or with adjoining sheets.

The preliminary maps for Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island have been completed. They have been checked by the provincial authorities and are now ready for drafting by Cartography. Maps for Saskatchewan and Alberta will be completed in 1973. Information from British Columbia and Newfoundland is so fragmental that the preparation of the maps has had to be postponed.

Soil Classification

A study of micromorphological, physical, chemical, and mineralogical properties of a four-member catena of soils from Prince Edward Island was completed. All of the soils were developed in dense, reddish-brown till of low hydraulic conductivity. The four soils had well-developed, acid, weathered eluvial horizons and weakly developed, acid horizons of clay accumulation. The two better-drained soils had podzolic B horizons and the clay mineralogy characteristic of Podzolic soils of the area. Although the soils of Prince Edward Island are generally considered to be Podzols, the classification of the four soils according to present criteria was: Orthic Humo-Ferric Podzol, Bisequa Gray Luvisol, Gleyed Gray Luvisol, and Low Humic Eluviated Gleysol. This work contributes toward the maintenance of a uniform classification of soils in Canada, and provides basic soil data that may be interpreted for various uses of the soils. Work continued on the refinement of criteria for the classification of Podzolic soils.

Remote Sensing

The satellite launched by NASA on July 23, 1972, for experimental land resource studies is providing imagery in four spectral

bands. Ten reference sites were established for calibrating the imagery in selected agricultural regions in Canada. Estimation from airborne and satellite imagery of changes in the amount of land under cultivated crops was begun in two areas for corn and fall-seeded wheat. A study was begun on changes in the spectral characteristics of a crop (beans) under various controlled conditions of the soil environment in the field, to provide information on the spectral regions most suitable for use by photographic or scanner equipment.

Soil Surveys

In Canada, soil surveys are conducted through cooperative agreements between Agriculture Canada and the provincial departments of agriculture or research councils and universities. In the following summaries of activities, no distinction is made between the activity and the affiliation of the personnel involved.

British Columbia Soil Survey. The soil survey program in British Columbia is being conducted in several locations: Seymour Arm, Nelson, Lardeau, Ashcroft, and Penticton map sheet areas, and in McBride and Nimpkish areas. A report on the soils in the Smithers-Hazelton area was published.

Alberta Soil Survey. In Alberta, surveys were conducted in the Oyen map area, Suffield Military Reserve, Waterton Lakes National Park, Edmonton urban areas, Wapiti map area, and Two Hills area. To assist in urban planning, detailed surveys were conducted on 1,100 ha (2,800 ac) adjacent to Edmonton. Reports were published on an area near Edmonton and on the Tawatinaw area.

Saskatchewan Soil Survey. In Saskatchewan, surveys were conducted in the Swift Current map area. Preliminary field work was started in the Weyburn map area. From surveys of the seven northern forested map areas, soil and soil capability maps have been completed in manuscript form. A report on one of these northern areas, St. Walberg, was published.

Manitoba Soil Survey. In Manitoba, a detailed soil survey project in the Portage la Prairie area was completed and the soil report published. This report is the first of its kind in Manitoba, and was produced on a detailed scale of 1:20,000, with soil maps

published on aerial photomosaic bases. The unit is currently engaged in 12 mapping projects at various stages of progress. Compilation of reports and maps are nearing completion for the map areas of Morden-Winkler, St. Rose du Lac, Red Rose - Washow Bay, Waterhen, and Virden. Field surveys have been completed and additional soil sampling, soil correlation, and compilation of reports and maps are in progress for the areas of Grand Rapids, The Pas, Swan Lake, Cormorant Lake, and Wekusko, and western halves of the Cross Lake - Norway House and Pointe du Bois areas. The unit also became involved in an organic-soil study of approximately 40,000 ha (100,000 ac) in the Canadian section of the Roseau River Basin, and in a study of the region of Lake Winnipeg, Churchill River, and Nelson River, an area of 3.6 million ha (9 million ac). The latter provides soil resource data needed to determine the impact on natural resources of flooding caused by diversion of the Churchill River into the Nelson River for hydroelectric development. This project ends on June 1, 1973.

Ontario Soil Survey. In Ontario, soil surveys were conducted in Brant and Middlesex counties. A study for a soil site — forest site productivity index was conducted at 63 sites under red pine. Organic soils over a 600,000-ha area (1.5 million ac) were surveyed in northern Ontario.

Quebec Soil Survey. In Quebec, surveys were conducted on Ile d'Orleans and in Charlevoix and Portneuf counties.

Maritime Soil Survey. In New Brunswick, soil surveys were conducted in Lepeau Provincial Park. In Prince Edward Island the detailed resurvey program was continued. In Nova Scotia, a survey was conducted in Colchester County, and ratings of some soils for susceptibility to erosion and for waste disposal were prepared.

Newfoundland Soil Survey. In Newfoundland, surveys were conducted in the Codroy Valley area, Deer Lake area, and Bonavista Peninsula.

Northwest Territories Soil Survey. In the Northwest Territories, an extensive terrain study was undertaken in cooperation with the Geological Survey of Canada (GSC). The objectives were to identify and characterize soils according to GSC mapping units, and to

AREAS SURVEYED IN 1972, BY PROVINCE AND BY OBJECTIVE

	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	N.S.	P.E.I.	Nfld.	NWT + YT	Total
Soil surveys — Thousands of hectares												
New surveys*												
Reconn.	1972	6,264.7	295.4	—	242.8	—	38.9	—	—	63.9	—	6,905.7
	Total	34,780.7	52,399.8	27,835.7	18,967.2	14,967.6	7,323.4	4,389.7	5,372.3	1,265.9	3,707.0	171,575.1
Detailed	1972	0.2	12.7	—	—	4.5	0.1	—	—	—	17.0	34.5
	Total	37.8	1,706.2	—	—	5.3	19.1	—	—	—	17.0	1,785.4
Explor.	1972	—	—	—	3,733.3	—	—	—	—	—	17,118.6	20,851.9
	Total	2,630.5	41,387.3	10,926.8	4,469.9	5,683.9	89.0	—	—	—	17,118.6	82,306.0
Resurveys*												
Reconn.	1972	28.3	421.7	647.5	—	708.2	—	28.3	9.7	—	—	1,843.7
	Total	2,802.1	630.9	18,315.7	410.4	1,500.2	333.9	28.3	554.8	—	—	24,576.3
Detailed	1972	32.4	—	—	—	—	—	—	—	121.4	—	153.8
	Total	365.8	0.1	2,078.5	756.0	230.7	0.1	—	34.4	204.4	—	3,670.0
Canada Land Inventory — Thousands of hectares												
Agriculture	1972	6,264.7	—	—	1,011.7	—	—	—	—	63.9	—	7,340.3
— new	Total	30,470.3	43,302.3	35,988.3	20,542.3	21,917.4	30,237.2	7,115.7	5,372.3	1,265.9	3,528.7	200,306.4
— reassess.	1972	28.3	—	828.8	—	331.8	—	—	—	—	—	1,188.9
	Total	1,994.7	—	1,756.4	227.4	331.8	—	—	—	—	—	4,310.3
Forestry	1972	6,264.7	—	—	—	—	—	—	—	—	—	6,264.7
	Total	29,549.2	—	—	20,542.3	331.8	—	7,115.7	5,372.3	565.8	—	63,477.1
Wildlife	Total	—	—	—	20,542.3	—	—	7,115.7	5,372.3	565.8	—	63,477.1
Recreation	Total	—	—	—	20,542.3	—	—	7,115.7	5,372.3	565.8	—	33,596.1

* Reconnaissance at scale 1:50,000 to 1:126,720. Detailed at scale of less than 1:50,000. Exploratory at scale greater than 1:125,000.

describe ecologically sensitive features that should be included in a terrain sensitivity rating for the area. A detailed soil survey was conducted in the Truelove Lowlands of Devon Island. A report of the soils of the Slave River Lowland was published.

In 1972, the Cartography Section published 13 Soil Survey maps and nine miscellaneous maps for the Branch and Department. The Section also prepared and published 84 capability maps for the Canada Land Inventory, and 231 other maps were prepared and are awaiting publication.

Cartographic and Photo Mechanical services were provided to Soil Survey units in the provinces, CanSIS, Remote Sensing, and the Economics Branch.

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Research Institute London, Ontario

PROFESSIONAL STAFF

Administration

E. Y. SPENCER, B.Sc., Ph.D., F.C.I.C.	Director
M. VAN YSSELSTEIN, B.Sc.	Administrative Officer
V. NATHAN (MRS.), B.Sc., M.L.S.	Librarian

Herbicides and Growth Regulators

T. T. LEE, B.Sc., Ph.D.	Plant biochemistry and tissue culture
W. H. MINSHALL, B.S.A., M.Sc., Ph.D.	Plant physiology
E. B. ROSLYCKY, B.Sc., M.Sc., Ph.D.	Microbiology

Mode of Action of Selected and Potential Insect Control Agents

W. CHEFURKA, B.Sc., M.Sc., Ph.D.	Biochemistry
E. J. BOND, B.S.A., M.Sc., Ph.D.	Fumigation: toxicology
B. E. BROWN, B.Sc., M.Sc., Ph.D.	Neurochemistry
T. DUMAS, D.C.E., M.Sc.	Analytical chemistry
C. L. HANNAY, B.S.A., Ph.D.	Electron microscopy: cytology
R. M. KRUPKA, B.A., M.A., Ph.D.	Biochemistry
D. G. R. MCLEOD, B.S.A., M.S., Ph.D.	Physiology
T. NAGAI, M.E., M.Sc., D.Sc.	Neurophysiology
J. R. ROBINSON, B.S.A., M.S.A., Ph.D., F.C.I.C.	Radioactive tracers
A. N. STARRATT, B.Sc., Ph.D., F.C.I.C.	Chemistry: attractants and repellents
A. VARDANIS, B.Sc., M.Sc., Ph.D.	Biochemistry

Soil Insecticide Behavior

C. R. HARRIS, B.A., M.A., Ph.D.	Insect toxicology
B. T. BOWMAN, B.S.A., Ph.D.	Soil physical chemistry
R. A. CHAPMAN, B.Sc., M.Sc., Ph.D.	Analytical organic chemistry

J. R. W. MILES, B.Sc.
H. H. SVEC
A. D. TOMLIN, B.A., M.Sc., Ph.D.
C. M. TU, B.Sc., M.Sc., Ph.D.

Analytical chemistry
Applied entomology
Pesticide ecology
Microbiology

Mode of Action of Selected and Potential Plant Pathogen Control Agents

E. W. B. WARD, B.A., M.Sc., Ph.D.

Plant pathology: phytoalexins and toxins

D. M. MILLER, B.Sc., M.Sc., Ph.D.

Biophysical chemistry: fungicide selectivity

L. T. RICHARDSON, B.A., M.A., Ph.D.

Plant pathology: fungicides

A. STOESSL, B.Sc., Ph.D., F.C.I.C.

Organic chemistry: phytoalexins and toxins

G. D. THORN, B.Sc., M.A., Ph.D., F.C.I.C.

Organic chemistry: fungicides

G. A. WHITE, B.A., M.Sc., Ph.D.

Biochemistry: fungicides

VISITING SCIENTISTS

T. KAJIWARA, B.S., M.S., Ph.D.

Organic chemistry: phytoalexins

National Research Council postdoctorate fellow,
1971-72

K. P. KASHI, B.Sc., M.Sc.

Fumigation

Graduate student, 1970-

INTRODUCTION

The highlights of the Institute's research activities for 1972 are summarized here. The activities include studies on the mode of action and use of toxicants (fungicides, herbicides, and insecticides); search for new target sites; and isolation and characterization of biologically active material such as toxins associated with plant pathogens, phytoalexins, and insect attractants and repellents that may have potential in crop protection. The study of these materials and sites and their utilization often requires a multidisciplinary approach and cooperation with other establishments in the Branch and elsewhere. The current pressure to replace persistent pesticides has made it even more important to discover alternative pesticidal materials, to determine any deleterious side effects of these substances and to reduce their effect on the environment to a minimum.

This report and reprints of publications are available on request from the Research Institute, Research Branch, Agriculture Canada, University Sub Post Office, London, Ont. N6A 3K0.

E. Y. Spencer
Director

PLANT PESTS

Mode of Action of Selected and Potential Insect Control Agents

Much effort was devoted to a search for physiological sites that might support an insect control program, and to a continuation of studies on the mode of action of different classes of insecticides. Biologically active materials that occur naturally were also examined as possible insect control agents.

The study of the differential toxicity of the carbamate insecticide carbofuran to two species of nontarget organisms, the earthworms *Lumbricus terrestris* and *Eisenia faetida*, led to an examination of the ability of each species to absorb, metabolize, and excrete the toxicant. It was concluded that the resistance of *E. faetida* is probably due to a rapid excretion of toxicant and little metabolism and absorption.

Although the neuromuscular system of insect visceral muscle has an important function, insecticidal action on its neurophysiological components has never been studied. During the past year basic information necessary for further study of possible insecticide action was published. This information has now been used to show the specific activity of a fumigant oxidation product from phosphine.

The neuromuscular junction in insects is also being studied. A highly purified peptide has been identified as a new transmitter substance at the junction. Large quantities of insects have been processed and sufficient

material purified for final chemical identification. The substance has been shown to be present in eight insects representing six orders. This finding suggests that it may be a transmitter substance associated exclusively with insects.

Chitin synthesis is another target being studied. However, attempts so far to establish an in vitro synthesis have been unsuccessful.

Progress has been made in understanding the role of specific and nonspecific bonding forces in complexes formed between biologically active proteins and their specific ligands. These ideas are being applied to explain the specificity of pesticides, development of resistance to them, the action of neurotransmitter agents, and detailed differences in acetylcholinesterase from insects and mammals.

An attempt to determine the mode of action of organochlorine insecticides has shown that DDT inhibits the respiratory chain of fly mitochondria only in the nonenergized state. The membrane may be the target site, and some of the membrane-linked enzymes are inhibited at concentrations approaching toxic levels. Addition of certain membrane components from fly mitochondria relieves these inhibited systems but those from mammalian sources do not; these results suggest a possible partial basis for toxicological selectivity.

As part of the studies on the mode of action and selective toxicity of organophosphorus insecticides, the geometrical isomers

of some vinyl phosphates were synthesized and purified. At the same time, as part of a project to determine the selective action and active component, toxic crystal inclusions of *Bacillus thuringiensis* have been produced and purified, and attempts made to disperse the proteinaceous material.

To assist in pinpointing changes in the life cycle of the European corn borer so that the application of insecticides can be timed more effectively, physiological studies have shown a correlation between the hemolymph $\text{Na}^+:\text{K}^+$ ratio and rate of diapause termination. Electron microscope studies carried out at the same time have established that during the fifth instar there are cyclical changes in the visible contents of the cells that indicate changes in biochemical pathways and systems. These changes have been followed in both laboratory and field insects.

Work continued on the isolation and chemical characterization of substances that influence insect behavior and that may be useful for their control. In this area, the oviposition pheromone from extracts of egg rafts of *Culex tarsalis* was shown to contain a mixture of hydroxy fatty acids of 1,3-diglycerides. The composition of the pheromone contained in similar extracts from two related species showed differences in only the hydroxy fatty acid. Two estrolide diglycerides have been synthesized. Both the natural and the synthetic materials are being supplied so that laboratory and field assay can be carried out at the Research Station, Winnipeg, Man.

Soil Insecticides—Ecological and Chemical Behavior

One of the responsibilities of this section is the maintenance of insect cultures and the establishment of conditions and diets to maintain new cultures. Nine species of economic importance have been maintained and four new ones established, including the common armyworm, the bertha armyworm, and the sandhill and white cutworms, a total of 20 including susceptible and resistant strains. From primary laboratory screening of 14 experimental soil insecticides, four showed promise. Of these, three have been dropped from development by the companies concerned because of the anticipated high costs. Screening was extended to include five other insect species. In-depth laboratory studies were started on the behavior and persistence of DDT, its metabolites, and

methoxychlor in soil. Similar studies were extended to include the field tests of some new organophosphorus and carbamate insecticides.

Studies on the development of resistance by soil insects have indicated that two strains of the onion maggot are tolerant of parathion. Laboratory and field studies were undertaken to study the biology of several crop pests and to develop control measures. Subjects included cutworms attacking tobacco in Ontario and Quebec; the carrot weevil attacking carrots, celery, and parsnips in these provinces; and the cabbage maggot in rutabagas and the European corn borer in peppers and sweet corn in southwestern Ontario. Excellent results were obtained in both microplot and large-scale field trials. As part of the general program for insect control in cooperation with the University of Guelph, a project was started to assess the feasibility of the sterile-male technique for control of the onion maggot in isolated muckland areas in Ontario.

In studies on the behavior of insecticides in soil, on clays the saturating cation was shown to be the single most important factor affecting adsorption of the organophosphorus insecticide fensulfothion (Dasanit). The adsorption mechanism was deduced from infrared and X-ray studies. Preliminary results show, as might have been predicted from the adsorption studies with montmorillonite clay, that iron significantly reduces the bioactivity of fensulfothion in sandy soil.

The study of the interaction of insecticides and microflora was extended to lindane in three soil types. Plate counts indicated a temporary inhibition of nitrifier bacteria and fungus populations, but an increase in oxygen consumption in proportion to lindane concentration suggests microbial degradation of the insecticide. In a joint study with the research stations at Delhi and Vineland Station, no permanent deleterious effect was observed on nitrifier bacteria and fungus populations after a fumigant, or an organophosphorus or carbamate nematocide, was applied.

The model being studied for development of more precise timing of organochlorine insecticide replacements for corn borer control was developed further. Differences were found in the time of pupation of the overwintered population in different areas of southwestern Ontario, and the timing is

therefore of importance in providing information for prediction. The gathering of critical information from the appropriate department for the experimental areas has been coordinated.

In the study of the ecosystem to define indicator species that reflect the impact of insecticides on nontarget soil animals, current study shows that springtails and larvae of predatory beetles are good candidates, in addition to earthworms. These insects are being used in an attempt to quantify and compare effect of various insecticides on the ecosystem so that insecticides that have the fewest environmental side effects can be selected for testing.

In the new program on insecticide metabolism in the soil, known metabolites of the insecticide carbofuran have been synthesized in preparation for developing improved methods of metabolite assay.

Fumigation—Mode of Action, Use, and Residue Analysis

Phosphine, a fumigant gaining in use, is under intensive study. Its toxicity was increased threefold by adding carbon dioxide to the atmosphere, and sublethal doses increased susceptibility of insects to subsequent treatments. Ongoing studies of mode of action have narrowed down the target-site enzymes involved in respiration inhibition. A nonvolatile residue from air oxidation showed none of the typical toxic effects of phosphine, but it exerted a powerful contractive effect on isolated roach-gut muscle similar to the effect of DDT. Treatment in the larval stage resulted in delayed mortality or deformed development. To date, a threefold tolerance has been developed in the study for resistance under continual selection pressure.

In experiments on selection for resistance to methyl bromide, tolerance declined very slowly in the absence of selection pressure. A field population of red flour beetles that survived spot treatment with ethylene dibromide - methyl bromide was shown to have a twofold tolerance for ethylene dibromide but no appreciable cross-tolerance for methyl bromide.

For control of the European red mite and the McDaniel spider mite on apples for export, conditions for ethylene dibromide

fumigation have been established in collaboration with the Research Station at Vineland Station. Improved analytical methods have been developed and adapted to determine both organic and inorganic bromide that remains after treatment. These methods have been used to determine the influence of temperature on the rate of desorption, since this information is critical in the recommendation of holding times for specific residue levels.

Concentration and time of exposure to ethylene oxide for eradication of mites have also been established.

Because fumigation is often required during periods of low temperature in winter, the lowest temperature at which methyl bromide effectively controls three insect species has been determined.

PLANT DISEASES

Mode of Action of Selected Fungicides

In an attempt to explain the synergistic antifungal effect observed with a mixture of thiram and chloroneb in controlling *Pythium ultimum*, the uptake and metabolism were studied. No explanation of this effect was found from the identity and quantity of the metabolites.

In the appraisal of systemic fungicides for seed dressings, phytotoxicity was exhibited by one, Dexon [(*p*-dimethylamino)benzenediazo sodium sulfonate], in the absence of inoculum, but it disappeared when a damping-off organism such as *P. ultimum* was present.

Differences in sensitivity to benzimidazole systemic fungicides were found within the genus *Fusarium*, the species *F. solani* alone acquiring resistance by a single exposure in vitro. Cross-tolerance for all benzimidazoles could be induced by previous exposure to any derivative.

In an attempt to explain selective systemic fungicidal activity by a study of the uptake of one by a number of fungi, no correlation was found between susceptibility and uptake. Attention is now being focused on selective uptake and translocation by the plant.

To determine the basis for the relatively high selectivity of systemic fungicides, detailed studies were made of the interaction of the fungicide carboxin (Vitavax) and a number of closely related derivatives with the enzyme succinic dehydrogenase from the

corn smut fungus, *Ustilago maydis*. This same enzyme isolated from various strains of yeast was found to be insensitive from some, sensitive from others.

Mechanism of Disease Development and Resistance

In the program for the isolation of naturally occurring compounds with potential fungicidal activity and the study of their significance in disease resistance, the pepper model system was used further to determine factors that induce formation of the antifungal factor, capsidiol, and conditions for its degradation and detoxification. Capsidiol is also produced in the field. Antifungal compounds (phytoalexins) induced in disease-resistant reactions have also been isolated from several members of the Solanaceae, including potato and tomato, and from sunflowers. In the meantime, intermediates have been synthesized for a study of the biosynthesis of pisatin, the phytoalexin from peas.

WEEDS

Herbicides and Plant Growth Regulators (Including Some Insecticides)

Because transpiration is one of the factors influencing the uptake of herbicides from the soil, the effect of different nutrients has been studied. Of the ones used, only those with a nitrogen component increased the rate of transpiration; this rate was in proportion to the nitrogen content.

Long-term effects of herbicide applications revealed substantial changes in the physiological profile of bacteria. All herbicides increased the numbers of acid producers. In addition, paraquat-diuron and paraquat-simazine-diuron combinations increased the number of cellulose hydrolyzers. The same treatment encouraged urea decomposers but suppressed nitrate utilizers and reducers. The paraquat component of herbicide treatments suppressed nitrifiers.

Further work on the mode of action of herbicides confirmed the finding that the auxin type of herbicide like picloram has a dual effect on plant growth through differential stimulation of indoleacetic acid (IAA)

oxidase and peroxidase isoenzymes. The fastest-migrating IAA oxidase was shown to produce at least four IAA derivatives possessing growth-promoting activity and thus contributing to the complexity of herbicidal action.

Evidence was found that some of the new organophosphorus and carbamate insecticides affected plant growth. Of the former, chlorfenvinphos was shown to inhibit growth, the primary site of action being the cellular membrane and inhibition of active transport. Reaction varied with the plant species used. From the test systems established for this study these plants should prove useful in screening new insecticides and herbicides for phytotoxicity. A carbamate insecticide, carbofuran, which by contrast led to increased yields in field trials, was found in laboratory plant physiological studies to affect plant growth only in the presence of 2,4-D or IAA.

ENVIRONMENTAL QUALITY

Management of Pesticides

The relative contribution to pollution of water systems by three areas of Ontario with differing insecticide patterns was examined. Average "total-DDT" transported (April–Oct. 1971) in pounds per week per 100 square miles of drainage area was as follows: Muskoka River (resort area) 0.11; Big Creek, Norfolk County (agricultural) 0.05; and Thames River (urban-agricultural) 0.03. Insecticides detected in the study were *p,p'*-DDT, *o,p'*-DDT, *p,p'*-TDE, *o,p'*-TDE, *p,p'*-DDE, γ -chlordane, dieldrin, endrin, endosulfan, heptachlor, heptachlor epoxide, lindane, and aldrin. Concentrations in water were in pp 10^{12} (US ppt) and in mud pp 10^9 (US ppb). Fish from the resort area contained up to 19 ppm total DDT compared with 1.3 ppm from the agricultural stream. A method was developed for analysis of DDT and its metabolites in the presence of polychlorinated biphenyls, by use of chemical conversion, liquid–solid fractionation, and gas-liquid chromatography. In 1972, studies were continued on insecticide concentrations in Big Creek, and were started in the Holland Marsh water systems.

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Engineering Research Service Ottawa, Ontario

PROFESSIONAL STAFF

C. G. E. DOWNING, B.E., M.Sc., F.A.S.A.E., F.E.I.C. Director
K. B. MITCHELL Administration

Development and Advisory Section

J. E. TURNBULL, B.S.A., M.S.A.	Head of Section; Livestock structures
M. FELDMAN, B.E., M.Sc.	Field mechanization
F. R. HORE, B.S.A., M.S.	Water resources
H. A. JACKSON, B.Sc. (Eng.), M.Sc.	Storage structures
K. W. LIEVERS, B.Sc. (Agr.), M.Sc.	Systems analysis
P. A. PHILLIPS, B.Sc. (Agr.), M.Sc.	Waste management

Research Service Section

P. W. VOISEY, M.I., Mech.E.	Head of Section; Instrumentation
E. J. BRACH, D.E.E., Dip.Mil.Electronics	Electronics
D. J. BUCKLEY, B.E., M.Sc.	Electronics
W. S. REID, B.Sc. (Agr.), M.Sc.	Mechanical
G. E. TIMBERS, B.S.A., M.S.A., Ph.D.	Food process engineering

Technical and Scientific Information Section

D. J. COOPER, B.Sc. (Agr.)	Head of Section
G. F. MONTGOMERY, B.Sc. (Agr.)	Information officer

INTRODUCTION

The Department was awarded a prize at the Fifth International Food Products Exhibition in Paris for the process used to produce "Cryogran eggs." The process was the work of G. E. Timbers in cooperation with the staff of the Food Research Institute, who developed a small unit that used liquid nitrogen to freeze-dry egg melange into a granular form. It is an efficient method of marketing eggs in bulk for commercial and institutional use.

Several machines were developed to improve the efficiency of experimental work in the field and laboratory. The need for increased accuracy and resolution and improved measurement and control of various parameters in research called for special instrumentation and measurement devices. Radiotelemetry is finding new uses in biological research. Remote sensing by means of infrared spectrophotometry is bringing useful results in the study of plant characteristics. In studies of animal shelter ventilation in cold northern climates, a porous ceiling proved to be successful as a fresh-air inlet. Increased emphasis is being placed on forage harvesting and preservation and in animal waste management systems and equipment.

The Canada Farm Building Plan Service and ERDA are effectively implementing and communicating new technology both nationally and internationally, as indicated by increased requests for the services. There has been a real increase in staff participation in seminars, symposia, short courses for provincial extension engineers, farm organizations, industry groups, university groups, and special research planning committees.

For more information, correspondence should be addressed: Director, Engineering Research Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

C. G. E. Downing
Director

DEVELOPMENT AND ADVISORY SECTION

Developmental Research Program

Research on forage systems continued in cooperation with the Research Station at Melfort, where laboratory tests and feeding trials with cattle and sheep were used to evaluate the methods for handling and storing forage in 1971. New methods included the use of chemical preservatives with packed and unpacked silage, as well as mechanically formed loose haystacks. A rotary drum mower and a second mechanical stacker (loaded by blower but not mechanically compressed) were added to the haying treatments. A hay tower (used previously) was modified and filled successfully to capacity. The information from this research is filling gaps in existing engineering data being used to synthesize mathematical models for examining forage-making systems. Weather at Melfort is included in the models, for predicting rates of field curing.

PTO-driven reciprocating harrows were evaluated for seedbed preparation in Manitoba; they produced a good seedbed, but were less effective as the amount of trash cover increased.

Systems engineering techniques were also applied to western cereal harvesting and to eastern beef production (cow-calf and finishing operations).

For winter ventilation a fresh-air inlet in the form of a porous perforated ceiling was compared with the conventional perimeter slot inlet system in a free-stall dairy barn at the Animal Research Institute's Greenbelt Farm. Inside air temperatures were less uniform with the perforated ceiling, but relative humidity was significantly lower, probably because less heat was lost through the ceiling. A porous ceiling of fiber glass insulation supported on wire netting was built into a free-stall dairy barn at the Experimental Farm, Normandin, Que., to evaluate this ventilation principle in a colder winter environment.

A computer program was prepared and recommendations were developed for the sizing and spacing of wood studs and the

design of sill and plate connections for bulk potato storages having vertical walls 3–7 m (10–22 ft) high. Corn silage densities and storage losses were measured in a 9 × 24-m (30 × 80-ft) tower silo; with corn stored at 72% moisture, storage losses for the 1971 crop were 18% of total or 9.2% of dry matter. The 1972 crop was stored at lower moisture (68%) in an attempt to reduce the seepage component of the losses.

Instrumentation was completed to measure groundwater levels and nutrient content, plus runoff rate and quality, from the Greenbelt Farm watershed. A test plot drainage system to evaluate soil and water pollution was installed at the Central Experimental Farm, Ottawa, in cooperation with the Soil Research Institute. Polluted runoff from an open-slab manure storage was collected and measured, and several innovative designs were developed for low-cost farm manure storages.

Canada Farm Building Plan Service (CFBPS)

The Design Center, in cooperation with provincial subcommittees and the Information Division, prepared and distributed 24 plan sets and 29 catalog leaflets. These include free-stall and tie-stall dairy systems; milk houses; herringbone milking centers; storages for solid, semisolid, and liquid manures; implement storages with attached repair shops; and others.

A commercial drafting service was contracted for preparation of 67 single-sheet plans for farm building roof trusses; this was required to update the CFBPS standard truss drawings to the new CSA lumber sizes and grades. Three quick-release plans prepared by provincial drawing offices were distributed.

The first of a series of 3-day training courses was offered to provincial draftsmen; the objective is to improve drafting presentation and techniques so that more provincial design offices will be able to prepare plans to CFBPS standards of quality.

RESEARCH SERVICE

Equipment for Mechanization of Field and Laboratory Experiments

A self-propelled forage harvester equipped with a sickle-bar cutter was developed and an existing design improved. A

two-row cereal harvester was further developed to increase its efficiency. A six-row harvester was developed for nursery tree seedlings and evaluated for harvesting carrots. A plot seeder was improved to increase seeding accuracy. A self-propelled sprayer for horticultural test plots was developed. A technique for enveloping oat spikelets in plastic to prevent cross-pollination was arranged.

Other apparatus designed and constructed included a silage cutter for animal feeding trials, an oat panicle thresher, an oat micro-scutter, an oat dehuller, and a corn picker-sheller husk remover. A survey of Canadian-developed equipment for test plots was published.

Mechanisms such as an automatic watering system for humidifying tobacco curing chambers and an improved tobacco sample press were developed to reduce labor requirements or open new areas of research. A veterinary operating table and animal handling system were constructed for animals weighing up to 1,000 kg. A portable freezer was developed to study the winterhardiness of grasses and legumes in the field.

Improved traps for grain beetles were manufactured. An electric mouse was made to install plug-gauge towlines in field drainage conduits. A commutator was fabricated to transmit power to an experimental silo loader motor.

Instrumentation

Automatic data acquisition systems were designed for Branch establishments to record experimental variables. An electronic seed counter with a laser detector was developed to accurately count seeds of plants ranging from tobacco to corn.

An electronic temperature integrator was developed to record the accumulated degree-days in the soil to indicate when to apply short-life insecticides for optimum effect. A general-purpose data integrator was designed for agrometeorological applications. A wind velocity detection system was arranged for the isokinetic sampling of air to study wind-borne materials.

A radiotelemetry system was developed to detect copulation between a ram and up to 15 ewes for a study of estrus in sheep.

A new temperature control was assembled for an air drier used for plant materials. A temperature recording system was installed

in the Food Advisory Services test kitchen. A method of measuring eggshell color was evaluated. A semiautomatic digital instrument was developed to measure the ratio of length to diameter of eggs.

Remote sensing by means of infrared spectrophotometry continued. Special optical and scanning attachments were developed so that reflectance of various kinds of experimental material could be measured. New and more sensitive sensors were developed and evaluated. It appears feasible to estimate the yield of apple trees by remote sensing. Disease development in soybean plants at different soil temperatures was detected within 24 h of inoculation. Differences in the spectral signature of wheat heads, stems, and leaves and the surrounding soil were established.

Processing and Quality Measurement

A pilot plant was developed for the recovery and 30,000-fold concentration of apple juice aroma to scale up a new process developed by the Research Station at Summerland. A survey was made of the tomato industry to determine the best method for peeling whole-pack tomatoes, so that advice can be given to Canadian processors.

A study of methods of measuring the moisture content of milk powder under Canadian standards showed that errors caused by spatial temperature variations in the drying oven were too large to apply the standard. Oven designs to overcome this have been recommended. An instrument was developed to measure the ease of scooping of ice cream so that this quality factor can be determined mechanically. The firmness of milk puddings was measured by a new electronic instrument that measures curd cutting forces (5 to 200 g). A milk heat exchanger was instrumented to record temperatures in milk processing. A unit was developed for aseptic handling of egg products so that samples can be shipped for bacteriological testing. A machine was made to cut cheese samples of precise dimensions for rheological testing.

A new tensile tester was developed for measuring the extensibility of doughs. Techniques were developed and evaluated for measuring the firmness and chewiness of spaghetti to compare products made from different varieties of durum wheat. A shearing test was correlated with sensory evaluations.

Instruments and methods were developed for measuring the texture of poultry and fowl products. It was found that under field conditions the puncture test was not suitable for determining the optimum maturity of sweet corn for processing. A comparison of the Food Machinery Corporation pea tenderometer, Food Technology Corporation tenderometer system, and Ottawa pea tenderometer showed that the relationships among readings from these instruments were affected by pea variety.

Methods of drying tobacco in bulk and drying laboratory samples were investigated and optimum laboratory conditions established. It was found that sample size in the previously developed Delhi method for measuring the filling value of shredded tobacco affected the result.

TECHNICAL AND SCIENTIFIC INFORMATION

The section has obtained many new items relating to agricultural engineering, including research papers, journal articles, conference proceedings, product literature, extension bulletins, and slides. Many items of current interest were disseminated throughout the country through publication in the section's periodical ERDA. A supplement to ERDA supplied an updated list of current agricultural engineering research and development work in Canada.

A computer-aided information retrieval and cataloging system has been established. This system is capable of providing bibliographic and abstract lists by subject matter, author, title, or other criteria. Special searches can be made for specific key words.

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Statistical Research Service Ottawa, Ontario

PROFESSIONAL STAFF

L. P. LEFKOVITCH, B.Sc.	Director
C. S. SHIH, B.Sc., Ph.D.	Head of Biometrics Section; Design of experiments, crop-loss studies
M. R. BINNS, M.A., Dip. Stat.	Design of experiments, sampling
D. J. CLARK, ¹ B.S.A.	Systems and programming
L. M. A. GRAHAM (Ms.), ¹ B.A.	Systems and programming
B. J. HACHE, ¹ B.Sc.	Systems and programming
C. S. LIN, B.Sc., M.S., Ph.D.	Quantitative genetics
J. KWOK (Ms.), ¹ B.Sc.	Programming
P. M. MORSE (Ms.), M.A.	Bioassay, design of experiments
D. L. PAULHUS, ¹ B.Sc.	Programming
K. R. PRICE, B.Sc., M.Math.	Systems and programming
S. PURI, ² B.A., M.A., M.Sc.	Quality control
B. REISER, B.Sc., M.Math., Ph.D.	Time series; multivariate analysis
D. T. SPURR, B.Sc., M.Sc., Ph.D.	Quantitative genetics, design and analysis
B. K. THOMPSON, ³ B.Sc., M.Math.	Genetics, systems, and programming

Departures

P. ROBINSON, B.A., Dip.Math.Stat., Ph.D.	Director
Transferred to Department of Communications, June 1972	
A. BICKLE, B.Sc.	Systems and programming
Transferred to Environment Canada, October 1972	
M. G. BICKIS, B.Sc.	Quantitative ecology
Transferred to Research Station, Winnipeg, Man.	

¹Seconded from Finance and Administration Branch, Data Processing Division.

²Seconded from Production and Marketing Branch.

³On educational leave.

INTRODUCTION

In 1972, the Statistical Research Service provided advice and assistance on some 160 problems, concerned not only with the design and analysis of experiments and their interpretation but also with nonstatistical mathematics.

Cooperation with other scientists in the Research Branch has been close in the areas of animal breeding and nutrition, crop losses attributable to disease, numerical taxonomy, and ecology. The appointment of a Production and Marketing Branch statistician to the Service late in the year has substantially improved the solution of day-to-day problems arising from quality control and produce inspection.

The library of computer programs has been enlarged by the addition of programs to perform multivariate linear multiple regression, nonlinear regression, analysis of multiple contingency tables, the probit hyperplane, factor analysis, numerical procedures for finding overlapping clusters in numerical taxonomy and for producing keys to taxa, mathematical programming, the analysis of nonfactorial paired-comparison experiments with or without ties, and special procedures for evaluating inverse distribution functions.

For more information, correspondence should be addressed: Director, Statistical Research Service, Room E-265, Sir John Carling Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C5.

L. P. Lefkovitch
Director

Statistical Science

Methods suggested in the literature of obtaining an interval estimate for the overall mean of estimates of different precision, computed from different experiments, are hard to assess because an analytical approach is difficult in small-sample situations. An incomplete Monte Carlo study, which includes such factors as the number of experiments, the range of within-experiment variance estimates, the number of degrees of freedom on which these are based, the number of observations contributing to each mean, and the ratio of between-experiment variance to the mean within-experiment variance, has provided some guidance on approaches to be explored. It appears unwise to neglect the component of variance among experiments, even when this value is small. When the within-experiment variances were approximately equal, an unweighted analysis of the means agreed well with that of the simulation; however, when there are few experiments this procedure may overestimate the length of the interval. This special case presents no great difficulty, because combined analysis of variance is possible. In other situations, a weighted analysis using a variance estimate modified empirically from the maximum likelihood estimate was best, but this procedure underestimated the confidence interval calculated assuming normality. As noted by others in more limited

investigations, the tails of the distribution are too long to agree with a t-distribution.

Bioassay

Assistance has been given on specific problems in the design, analysis, and interpretation of bioassays. Much use has been made of the general quantal assay program (S104), which permits easy formulation and comparison of different models including those appropriate to dilution assays. This completed program can handle virtually any design constraints. A long series of assays of insecticides used against grasshoppers has been reanalyzed, and maximum likelihood estimates have been obtained for large, replicated assays with data for individual insects. The value of using individual records rather than grouped data was assessed more reliably than before. The results give a consistent picture of the influence of the method of application of insecticides.

A special type of assay, in which the number of individuals at risk is not known (Wadley's problem), arose from work at the Animal Diseases Research Institute to characterize strains of the bluetongue virus. For this assay a new computer program (S112) has been developed that has the same facilities for model-specification as S104. The analysis needed for the submitted data

involves replicates, several independent variables, and natural immunity, which are situations not considered in the literature.

Statistical Ecology and Population Dynamics

Predator-prey relationships between a spider mite and a predatory mite have been studied. The field variability was too large and infestation levels were often too low for sufficiently precise estimates of these relationships to be obtained by standard techniques. Diffusion of predators in the absence of prey and under controlled conditions has also been studied. Research on certain fundamental problems, such as sampling techniques on the dynamics of single species populations, and the comparison of different representations of a population, has resulted in a clearer understanding of the problems.

Two ecological models are under construction, one for grain and one for the dynamics of species in two areas of grassland. With grain, elimination of environmental factors does not appreciably alter the numerical interrelationships among the species, which indicates that there may be fundamental biological interrelationships largely unaffected by time, position, and other factors. But with grassland the numerical interrelationships are altered. These different results may reflect either a different biological structure or merely differences between the sampling procedures and the available data.

Consulting and advisory work in statistical ecology has included critiques of various indices of diversity, which suggest that these indices rarely aid in the interpretation of data; sampling plans to obtain life-table data for the apple maggot fly; studies of the effect of the adult fly population density on the number of eggs hatched; determining adequate sample sizes for collecting moths and alfalfa weevils; the relationships between mite density and cropping on apple trees; the distribution of McDaniel mites along spurs in apple trees; a design for an orchard to examine certain hypotheses about maggot fly attraction and repulsion; the effect of temperature on mean developmental time of red mites; the association between numbers of moths caught in light or pheromone traps with certain meteorological data; and detailed analyses of possible acceptance sampling schemes for potato fields suspected to have golden nematodes.

Plant Science

A new compact design for spacing experiments, which was applied to several crops, allows the layout and field practice to be simpler than that for systematic designs; the land required is less than with randomized block designs. Statistical techniques were also developed for investigating a second-order response surface, allowing for the design restrictions. The inclusion of additional factors into the present design will deal with the situation where the number of seeds per sowing point, the distance between rows, and the distance between the sowing points within rows need to be investigated simultaneously.

A rotation experiment with potatoes as a test crop had been terminated in mid-cycle; analysis of the results from the consequently unbalanced design was effected with little special programming by using general programs for multiple weighted and unweighted regression, analysis of covariance with dummy variables, and suitable transformations, and making use of such symmetry and orthogonality as remained in the design. The procedure would be applicable in other cases of this kind.

Model building and curve fitting have been carried out for several situations: an autoregressive model for the absorption of infrared light by different varieties of oats, an asymptotic regression model for growth curves for raspberries, a sine curve of flower temperature fitted for angles of incidence of light; a multiple regression model of yield and size of strawberries on soil and leaf nutrition; and a mathematical model accounting for the herbicidal effects of spray techniques.

Other investigations included studies of the effects of fertilizer treatments on yield and quality of rutabagas; residual effects of P and K on yield of strawberries for successive years; stability measures of varieties for grain corn and cereal crops; the effects of gaps in the rows on potato yield; a test of normality for coverage data in a spray experiment; and estimation of sampling errors with respect to operators, machines, and the test position for an apple pressure test.

Crop Losses

Studies have continued on late blight of potatoes. A model was developed to estimate the loss in marketable tuber yield due to

disease, and surveys were conducted in Prince Edward Island and New Brunswick to gather information on the timing and frequency of the application of fungicides. A computer program was developed to simulate natural epidemics of late blight as affected by climatic factors including temperature, relative humidity, and precipitation. The progress of the disease was expressed in terms of the percentage of foliage affected by the disease. The program was successful in simulating several epidemics recorded in the past.

A study of the interplot interference that occurs in field experiments when the plots have different disease severity showed that the spread of spores by air movement results in a net gain of spores in plots with low disease severity and a net loss of spores in plots with high disease severity. Such interference complicates the interpretation of experimental results not only for experiments on late blight, but also in experiments involving other diseases caused by airborne pathogens.

In a study of the effect of an antibiotic on the incubation time of leafhopper-borne mycoplasmic plant diseases, it was found that the level of this antibiotic exponentially decreased the growth rate of the pathogen.

Animal Science

Much agricultural work, particularly in the field of animal science, gives rise to qualitative rather than quantitative data. To meet the need for their analysis, work has continued to develop a suitable computer program. This program has been successfully applied to results from various experiments, including mortality data under different treatments in sheep breeding. Current work on this program is directed toward making it easier to set up a hierarchical series of models and to provide tests of hypotheses.

Advisory work and statistical analyses were carried out on a number of animal nutrition studies. Experiments on swine were carried out at 10 locations across Canada to determine the effects of high levels of Cu on the growth rate, feed conversion efficiency, fatty acid distribution in the subcutaneous region, and on the deposition of Cu in the tissues of swine. Assistance was given in experiments to study the etiology of nutritional muscular dystrophy in ruminants and the effects of levels of Se and tocopherol on

the incidence of this disease. Other experiments were conducted to compare different levels and sources of protein and of energy in swine rations.

Assistance was given to poultry researchers at various stations; this included the analysis of two large experiments, one to investigate the effects of bird density and number of birds per cage on egg production, feed efficiency, mortality, body size, and egg production, and the other to study the effects of artificial lighting, bird density, feeder space and waterer space per bird on mortality, feed cost, body weight, and carcass quality of broilers.

Special emphasis was placed on finding the effects of selection on estimates of genetic parameters and on genetic-environmental interaction in a long-term poultry study. Expressions for the genetic correlations between performance in good and poor environments are being developed.

Data from some experiments in reproductive physiology were analyzed. One study involved finding the effect of the stage of the estrus cycle on nitrogen retention and on the free fatty acid levels in the blood of gilts.

Numerical Taxonomy

Two studies were made of difficult species groups of the genus *Euxoa*. On the basis of prior assignation of individuals to supposedly distinct taxa, discriminant analyses were performed. As a result, certain taxa were synonymized, whereas others appeared to be heterogeneous.

A comparison of some different methods of numerical taxonomy was made using morphological and genetic data for 17 varieties of oats whose known pedigrees are interlinked. The most important findings were that genetic and "phylogenetic" relationships need bear little resemblance to each other, and that it is virtually impossible to represent the phylogeny of a group of organisms as a dendrogram without discarding a great deal of relevant information.

Regression analysis was used to study the variability in Ichneumonidae. The data were found to be too scattered to allow for definite conclusions.

A study on the family Chironomidae of the order Diptera was begun. Tabulation of the data in relation to different measured characters was carried out. The study is

proceeding with an analysis of geographical differences.

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Research Station Brandon, Manitoba

PROFESSIONAL STAFF

W. N. MACNAUGHTON, B.Sc., M.Sc., Ph.D. Director

Animal Science

J. H. STRAIN, B.S.A. M.Sc., Ph.D.	Head of Section; Poultry genetics
R. L. CLIPLEF, B.Sc., M.Sc., Ph.D.	Meats physiology
G. W. DYCK, B.S.A., M.Sc., Ph.D.	Reproductive physiology
A. P. PILOSKI, B.S.A.	Poultry production
G. W. RAHNEFELD, B.Sc., M.Sc., Ph.D.	Animal genetics
E. E. SWIERSTRA, B.S.A., M.S.A., Ph.D.	Reproductive physiology

Plant Science

E. D. SPRATT, B.S.A., M.Sc., Ph.D.	Head of Section; Plant nutrition
L. D. BAILEY, B.S.A., M.Sc., Ph.D.	Soil-plant relationships
P. N. P. CHOW, B.S.A., M.A., Ph.D.	Weed physiology
R. D. DRYDEN, B.S.A., M.Sc.	Crop culture
A. T. H. GROSS, B.S.A., M.Sc.	Forage crops
R. I. HAMILTON, B.Sc., M.S.A., Ph.D.	Forage physiology and management
R. I. WOLFE, B.S.A., B.D.	Barley breeding

Departure

B. J. GORBY, B.S.A. Retired May 1972	Agronomy
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INTRODUCTION

This report describes the progress in long-term experiments and the main research findings for 1972. Research emphasizes animal breeding and physiology; and plant breeding, physiology and management, soil-plant relationships, cultural practice, crop rotations, and weed control.

Highlights for the year were the completion of the first phase of evaluating foreign breeds of beef cattle (topcrossing with sires of foreign breeds), and the start of the second phase (evaluation of hybrid females for beef production); progress in the development of a new barley variety with high yield potential and malting quality; and continued high yields of silage and grain corn in field experiments.

Enquiries concerning details of the work discussed in this report, or related subjects, should be directed to: Research Station, Agriculture Canada, Box 610, Brandon, Man.

W. N. MacNaughton
Director

ANIMAL SCIENCE

Beef Cattle

Factors affecting preweaning traits in Shorthorn calves. In studying birth (456) and weaning (429) records of Shorthorn calves in the selection control herd for 9 yr, sex of calf was the most important source of variation in birth weight, preweaning daily gain, and weaning weight. Age of dam did not have significant effects on preweaning traits, although calves from cows 5 to 7 yr old were heaviest at birth, grew more rapidly, and were heaviest at weaning. Heavy cows tended to produce heavier calves, but the differences were not significant. Cows that lost weight during gestation produced heavier calves at birth than cows that gained in body weight during this period. Paternal half-sib heritability estimates for birth weight, preweaning daily gain, and weaning weight were 0.25 ± 0.17 , 0.38 ± 0.26 , and 0.31 ± 0.22 . Repeatability estimates were 0.11 ± 0.05 , 0.27 ± 0.05 , and 0.27 ± 0.05 for birth weight, preweaning daily gain, and weaning weight.

Semen characteristics of purebred and crossbred Limousin bulls. Single ejaculates collected at 48-h intervals for 22 days from four Limousin and eight Limousin \times Hereford bulls were evaluated for semen characteristics. The bulls averaged 15 mo of age and represented four groups of half-sibs. On a per ejaculate basis, purebred and crossbred bulls produced: semen volume 3.1 vs. 3.2 ml, with progressive motility 74% and 73%; sperm per ml 1.49 vs. 1.26×10^9 ; total sperm 4.5 vs. 4.0×10^9 ; and motile sperm

3.3 vs. 2.9×10^9 . These differences were not significant.

Sperm production and epididymal sperm reserves. Daily sperm production of eight 16-mo-old Limousin \times Hereford bulls was 5.0×10^9 , as determined by quantitative testicular histology. Sperm output previously determined by collection on a 48-h schedule was 4.4×10^9 sperm per ejaculate. Thus sperm output represented 2.2×10^9 sperm per day or about 44% of the sperm produced by the testes. Twenty-four hours after the last semen collection the head, body, and tail of the epididymides contained 5.3 , 1.7 , and 8.4×10^9 sperm. The average weights of the testes and epididymides were 228 and 25 g.

Evaluation of bovine germ plasm. Limousin, Simmental, and Charolais bulls mated to Shorthorn, Hereford, and Aberdeen Angus cows produced 2,093 crossbred calves from 1970 to 1972. Of these, 1,116 were Limousin crosses, whereas 614 represented Simmental- and 363 Charolais-sired calves. Birth weights averaged 36.0, 38.8, and 40.5 kg for Limousin, Simmental, and Charolais crossbreds. Gestations producing calves sired by Limousin bulls averaged 287 days, whereas those for calves sired by the other two breeds averaged 285 days. Difficult calvings where a jack or calf puller was required were 4.2%, 4.7%, and 8.8% for Limousin-, Simmental-, and Charolais-sired calves. Based on 1,069 Limousin, 585 Simmental, and 339 Charolais records, weaning weights adjusted to 205 days of age were 206, 220, and 222 kg for the three breeds of sire. Feedlot performance for a 140-day

feeding period in 1970 and 1971 favored bulls and steers sired by Simmental bulls over bulls and steers sired by Limousin bulls. Averaged across sexes, Limousin crossbreds gained 1.17 kg/day and required 6.50 kg feed/kg gain, compared with a gain of 1.29 kg/day and 6.48 kg feed/kg gain for the Simmental crossbreds.

Carcass characteristics of crossbred cattle. Carcass data were obtained from 450 crossbred animals and physical separation of fat, lean, and bone was performed on 144 carcasses. Limousin crossbreds had a higher dressing percentage than Simmental (60.2% vs. 58.4%) and lighter heads, hides, and feet; but they produced less weight of live animal per day of age. Limousin crossbreds had larger areas of rib eye (71.7 vs. 61.3 cm²) and greater fat cover (1.35 vs. 0.99 cm) than Simmental crosses. Crossbreds sired by Limousin and Simmental bulls were equal in percentage yield of defatted retail cuts from chuck, rib, loin, and hip (50.9%). There was no difference between breeds in the chemical analysis of lean tissue, but carcasses from steers contained 1% more fat than those from bulls. Similarly, carcasses from 545-kg animals contained 1% less moisture than those from 454-kg animals at market.

Evaluation of crossbred cows for beef production. The second phase of evaluation of bovine germ plasm emphasizes reproductive performance of hybrid females sired by bulls of the recently introduced European breeds out of cows of the three common British breeds of beef cattle. The first matings were made in 1971 when 180 heifers representing 10 breed combinations [Limousin (L) with Shorthorn (Sh), Hereford (H), and Aberdeen Angus (AA); Simmental (S) with Sh, H, and AA; Charolais (C) with Sh, H, and AA; and a H × AA control cross] were designated for breeding by artificial insemination. In the first 21 days of the breeding period, 170 (94.4%) were detected in heat and bred. In the 42-day breeding season, 176 (97.8%) were detected and bred. Pregnancy tests by palpation in November identified 142 (78.9%) in calf, and 137 (76.1%) of the 180 assigned for breeding calved in 1972.

Beefmaster and Red Angus sires were used for breeding in 1971; the calves sired by Beefmaster bulls had heavier birth weights and longer gestations. Weaning weights also

tended to favor the calves sired by Beefmaster bulls, but numbers were too small to establish the significance of the difference.

Swine

Correlated response to selection for postweaning gain. Recurrent selection for postweaning daily gain was continued in a population of Lacombe swine. After eight generations the genetic correlation between postweaning average daily gain and weaning weight was high and positive (> 1), and the response to selection for postweaning average daily gain in terms of improved weaning weight was 0.030 ± 0.072 kg/generation. The genetic correlation between postweaning average daily gain and feed efficiency was -0.35 and the response to selection in terms of feed efficiency was -0.583 ± 0.582 kg feed/100 kg gain per generation.

Cold stress and reproductive performance. In December–January breeding seasons, matings on cold days resulted in significantly higher conception rates. With four temperature ranges: below -25°C , -25 to -18°C , -17 to -10°C , and higher than -10°C , conception rates for gilts bred once were 81%, 73%, 58%, and 56%. Corresponding rates for gilts bred on consecutive days to the same boar were 88%, 81%, 73%, and 65%. Litter size was not affected by cold stress at mating.

Semen characteristics in young Yorkshire boars. By 6 mo of age, approximately 50% of Yorkshire boars produced sufficient numbers of motile sperm to settle females. This would facilitate progeny testing of boars before 18 mo of age. Seven semen characteristics were studied by collecting single ejaculates, on two consecutive days, from 49 boars 21–26 wk of age and 56 boars 27–31 wk of age. The younger boars had a lower sperm concentration, a lower percentage of motile sperm, and fewer total and motile sperm per ejaculate than the older boars. In general, values for the different semen characteristics were significantly lower for second ejaculates. However, the percentage of progressively motile sperm was similar for first and second ejaculates. The total number of sperm in the first and second ejaculate was 19.6 and 12.2×10^9 for the younger boars, and 36.8 and 22.2×10^9 for the older boars.

Conception rate and embryonic survival as affected by frequency of ejaculation. Semen from Yorkshire boars previously on 24- and

72-h collection schedules was used for the artificial insemination of 59 primiparous Yorkshire sows on their first or second postweaning estrus. The semen was diluted with an egg yolk-citrate diluent and each insemination used 100 ml of semen containing 2.5×10^9 progressively motile sperm. Insemination took place within 4 h of collection, and the sows were slaughtered 24–26 days later to determine conception rates and early embryonic mortality. Boars differed significantly in fertility levels, but frequency of ejaculation did not affect conception rates or embryonic mortality. Conception rates were 91% and 82%, with semen from boars collected at 24- and 72-h intervals, and 81% and 86% of the embryos survived.

Poultry

Differences in feeding value of barley and wheat cultivars for chicks. Body weight, feed efficiency, and mortality to 10 wk of age in White Leghorn cockerels were not affected by differences in the feeding value of five barley and three wheat cultivars. Differences owing to barley cultivars were significant for shank length but not for average daily gain, although the ranking was identical for both traits ($r = 0.997$). No differences attributable to cultivars were found in the wheat-fed cockerels.

Low-protein grower diets for laying hens. Six strains of White Leghorns were reared from 8 to 21 wk of age on a regular grower ration (14.5% protein) and a low protein (10%) ration. Age at maturity, livability, and egg numbers were unaffected by the protein level in the ration. Feed efficiency and returns over feed costs favored the regular ration, but one strain displayed superior performance when reared on a low-protein ration.

PLANT SCIENCE

Cereal Crops

Malting barley. Improved yield, malting quality, and disease resistance continued to receive emphasis in barley breeding. The most advanced selection has been in extensive evaluation tests for 3 yr. It ranked among the highest in yield and has desirable malting quality, which is of intense interest to breeders and the industry.

Among selections from crosses between Brandon lines with good malting quality and North Dakota lines carrying resistance to septoria leaf blotch, some lines combining the desirable characteristics of both parent lines continued to show a substantial yield improvement over Bonanza. The most advanced selection of this material and Bonanza were rated outstanding in resistance to root rot.

Feed barley. The most advanced line, a selection from a Keystone \times Dickson cross, again outyielded Bonanza in tests at the Station. Crosses of Galt with North Dakota and Brandon lines continued to show promise of combining resistance to disease (loose smut, stem rust, and septoria) with desirable agronomic characteristics and high yield potentials. Fourteen advanced selections outyielded the control varieties at Brandon in 1972. Some success was achieved in carrying the high lysine characteristics into the F_1 when Hiproly barley was crossed with Brandon lines. The most promising crosses are being backcrossed to the Brandon parent lines.

Corn production and management. There were only a few instances of damage from June frosts, which were irregular but widespread in Manitoba. Grain yields approximated 37 q/ha with normal heat unit (HU) accumulation and limited but well-distributed precipitation. In cooperation with public and private breeders, evaluation of existing lines and varieties in a relatively adverse environment (2,150 HU) revealed a wide range of breeding material. Some exceptionally early lines showed tasseling by June 26, silk emergence by July 10, and 25–30% kernel moisture by September 1. Field-scale tests identified early planting and available moisture as key factors in successful production. Yields were 36.0–48.5 hl/ha for grain and 15.1–25.1 t/ha for silage.

Effect of fertilizer nitrogen on protein content of bromegrass. The protein content of unfertilized bromegrass was 10.9%. Fertilizer that supplied N at the rate of 84, 168, and 252 kg/ha increased the protein content to 12.9%, 15.0%, and 16.1%. These levels were maintained by annual applications of fertilizer, but no residual effects were observed the year after application when protein levels for all treatments were 11.4–11.8%.

Effect of floret manipulation on seed set in sweetclover. Floret manipulation by rolling the floret gently between thumb and forefinger increased seed set by selfing from 66.6% to 78.2% in annual species of sweetclover and from 20.1% to 53.8% in biennial species. Among nine biennial species grown in the greenhouse, floret manipulation was essential with all but two species (*Melilotus dentata* (W. & K.) Pers. and *M. wolgica* Poir) to assure successful maintenance.

Western false gromwell. *Onosmodium occidentale* Mackenz. is a native perennial adapted to sandy soils, which could serve well as a stabilizing plant for sandy locations if the quality and quantity of oil in the seed should justify the economics of production. The oil content is 58% of the endosperm, which constitutes 31% of the seed, so that the oil content of the seed is approximately 18%. The average composition of the oil is: palmitic, 6.9%; stearic, 2.2%; oleic, 18.5%; linoleic, 17.0%; linolenic, 47.5%; and tetraene, 8.2%.

Sulfur for forage on Gray Luvisol soils. In pure stands of alfalfa and birdsfoot trefoil and in brome-grass-alfalfa and Russian wild ryegrass - birdsfoot trefoil mixtures, significant yield response occurred with S fertilization in the year of establishment. The addition of S at 22.4 kg/ha increased alfalfa yield by 50% and doubled the yield of other forages when compared with similar stands where N, P, and K were applied without S. Yield responses were obtained with rates of S up to 44.8 kg/ha.

Agronomy

Comparison of tests for soil sulfur. When soil S was related to the uptake of the sulfate (SO_4) ion by alfalfa and rapeseed, the methylene blue (colorimetric) test was superior to turbidimetric analysis. The reproducibility of results was poor on clay and clay loam soils with the turbidimetric analysis, and readings were significantly lower than those obtained by the colorimetric method. In coarse-textured soils, readings were similar with both methods, but the recovery of SO_4^{2-} S was greater with the colorimetric method.

Residual effect of phosphorus on flax. The residual effects of P at 100, 200, and 400 kg/ha broadcast on and worked into a P-deficient soil at the start of a continuous cropping experiment (alternating crops of wheat and

flax) resulted in flax yield responses on all P treatments after 6 yr of cropping. Differences between rates of P were not significant.

Solution nitrogen for wheat and barley. Spray applications of N solution at the two- and four-leaf stages of wheat and barley gave yields equal to those with the fertilizer placed above the seed with a seed drill prior to emergence. Rates of N up to 44.8 kg/ha for wheat on sandy loam and clay loam soils and up to 67.3 kg/ha for barley on sandy soil increased yields significantly. With severe weed infestations, the effectiveness of N solution was reduced as much as 50%. However, herbicides such as triallate (Avadex BW) for wild oats, trifluralin (Treflan) for wild oats and green foxtail, TCA for green foxtail, and 2,4-D for broadleaf weeds, applied in mixtures with N solution, gave satisfactory weed control and improved the utilization of N for crop production.

Source of nitrogen and time of application related to yield and protein content of wheat. Field and growth chamber experiments indicated that N metabolism in the wheat plant can be manipulated by the source of fertilizer N and by the time of application relative to the stage of growth. Ammonium (NH_4) and nitrate (NO_3) ions were used as sources of N. When the fertilizer was applied at seeding, NH_4 -N increased the yield of plant material (leaves and stems) more than NO_3 -N. When fertilizer N was applied at flowering, NO_3 -N increased the percentage of N in the grain more than NH_4 -N but did not necessarily increase the yield of grain. Splitting the application of fertilizer N to supply NH_4 -N at seeding and NO_3 -N at flowering may be a useful technique for increasing the yield of plant material and the protein content of grain at maturity.

Nitrogen for corn silage production. With various combinations of anhydrous ammonia applied in the fall and NH_4NO_3 applied in the spring or just prior to tasseling or both times, the highest yields of silage were obtained with anhydrous ammonia (9,325 kg/ha, oven-dry). Yields with a spring application of NH_4NO_3 were 10.5% less than from anhydrous ammonia treatments. The fastest rate of growth (116 kg/ha per day) occurred when N at 112 kg/ha was applied as a split application (one-half as anhydrous ammonia in fall and one-half as NH_4NO_3 at tasseling).

Control of wild oats. In wheat, benzoilprop ethyl (Endaven) at 1.26–1.40 kg/ha applied at the four-leaf stage increased yields by 32–39%. Control was comparable with that obtained with barban applied at the two-leaf stage. Trifluralin at 0.84 kg/ha incorporated prior to seeding improved yields by 47%. In flax, postemergence treatment with asulam at 1.12 kg/ha gave good control of wild oats. Treatment at the four- to five-leaf stage of wild oats was preferable, but timing for application was not as critical as for barban. For controlling broadleaf weeds mixing herbicides with asulam decreased the efficiency of wild oats control.

Herbicide mixtures for weed control. In wheat, linuron (0.28 kg/ha) mixed with MCPA (0.56 kg/ha) gave satisfactory control of green foxtail, but control was improved by increasing MCPA to 0.7 kg/ha and adding TCA at 0.28–0.56 kg/ha to the mixture. TCA at 0.56 kg/ha mixed with 2,4-D at 0.56 kg/ha gave satisfactory foxtail control and excellent broadleaf control without injury. Postemergence applications of TCA (2.24 kg/ha) mixed with dicamba (0.14 kg/ha), linuron (0.28 kg/ha), or MCPA (0.28 kg/ha), and alachlor (1.12 kg/ha) with MCPA (0.28 kg/ha) gave good control of broadleaf weeds in flax, resulting in yield increases of 42% compared with those from TCA alone.

Glyphosate for control of perennial weeds. Glyphosate at 2.24–4.48 kg/ha gave excellent control of perennials such as Kentucky blue grass, needle-and-thread, and smooth

brome. Leafy spurge and Canada thistle required 8.96 kg/ha for effective control. No injurious effects were observed on barley plants after preemergence spraying of glyphosate at rates up to 8.96 kg/ha.

Relationship of ATP and 2,4-D to TCA absorption. ATP at 10^{-6} and 10^{-4} M, added to an incubating solution in which wheat root segments were immersed, increased TCA absorption by 5% and 57% in a 21.5-h incubation period. Increased absorption by ATP was completely eliminated in the presence of 2,4-D at equimolar concentrations. Apparently, 2,4-D is a strong inhibitor of TCA absorption by wheat roots.

Distribution of TCA residue in mature plants. Wheat, barley, and oats in decreasing order varied in the amount of TCA absorbed and retained as TCA residue. In each crop the amount of residue decreased with the stage of growth. At maturity, the main portion of the residue was in the straw and the small amount in the head was equally distributed in the grain and the chaff.

Preemergence weed control in corn. S-6176 (cyprazine + carbamate) at 5.3 kg/ha gave good control of wild oats, green foxtail, and broadleaf weeds. Dry matter (DM) yields of silage for sprayed, hand-weeded, and untreated plots were 6.2, 6.5, and 0.6 t/ha. EPTC at 3.8 kg/ha with or without a corn protectant gave satisfactory control of wild oats and green foxtail; the yield of DM was 4.4 t/ha.

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Research Station Morden, Manitoba

PROFESSIONAL STAFF

E. D. PUTT, B.S.A., M.Sc., Ph.D. Director

Special Crops Section

E. O. KENASCHUK, B.S.A., M.Sc., Ph.D.	Head of Section; Flax
S. T. ALI-KHAN, B.S.A., M.Sc., Ph.D.	Pea breeding
C. G. CAMPBELL, B.S.A., M.Sc., Ph.D.	Buckwheat breeding
W. O. CHUBB, B.Sc., D.Sc.	Herbicides
D. G. DORRELL, B.S.A., M.Sc., Ph.D.	Oilseed quality
H. ENNS, B.S.A., M.Sc., Ph.D.	Sunflower breeding
J. E. GIESBRECHT, B.S.A., M.Sc., Ph.D.	Corn and soybean breeding
G. H. GUBBELS, B.S.A., M.S.A., Ph.D.	Physiology and management
J. A. HOES, B.S.A., M.S.A., Ph.D.	Oilseed crop pathology
R. C. ZIMMER, B.Sc., Ph.D.	Pathology of peas

Vegetable Crops Section

B. B. CHUBEY, B.S.A., M.Sc., Ph.D.	Head of Section; Vegetable quality
W. A. RUSSELL, B.S.A.	Potato breeding
C. WALKOF, B.S.A., M.Sc., Ph.D.	New crops
E. D. P. WHELAN, B.S.A., M.S.A., Ph.D.	Sweet corn and cucumber breeding

Ornamentals and Fruit Section

W. A. CUMMING, B.S.A., D.Sc. (Hon.)	Head of Section; Ornamentals
W. G. RONALD, ¹ B.S.A., M.Sc.	Ornamentals breeding

Departure

H. DE JONG, B.A., M.Sc., Ph.D. Buckwheat breeding
Transferred to Research Station, Fredericton, N.B.,
August 4, 1972

¹On educational leave.

INTRODUCTION

This report summarizes research in special crops and horticulture at the Research Station, Morden, Man. Noteworthy items of 1972 include: a green pea that has performed well and will be recommended for licensing to become the first variety with green seed from Canadian work on this crop; interesting results, with practical application, from quality studies of the seed and oil in both flax and sunflowers; and naming of *Rosa* × 'Adelaide Hoodless' in honor of the founder of the Federated Women's Institutes of Canada.

The mailing address of the establishment is Research Station, Research Branch, Agriculture Canada, Box 3001, Morden, Man. R0G 1J0.

Eric D. Putt
Director

SPECIAL CROPS

Buckwheat

Breeding. A large-seeded selection that gives yields equivalent to Tokyo is being increased. The trade is interested in this material because of its large seed and satisfactory quality. Other selections with large seed are under test.

Management. Tests on date of seeding for 4 yr indicated that buckwheat yields are highest when the crop is seeded as soon as the danger of spring frost is past.

Disease. Large chlorotic lesions of unknown etiology appeared on the leaves of plants in station plots and in commercial fields.

Corn

Breeding. Some superior hybrids that mature early were released to corn companies, and 25 early maturing inbreds with good combining ability were released to public and private breeders. Inbreds of the Station are in the pedigrees of many early corn hybrids grown in North America and Europe. Among the 1,254 new hybrids tested, one outyielded Morden 67 by 28%, and had 2% less moisture at harvest, less lodging, and superior plant type.

Management. In fertilizer tests over 2 yr, both side-dressing with 27-14-0 and applying P₂O₅ with seed increased seedling vigor. The effect was greater with P₂O₅. It could give a competitive advantage to the crop when weed control is only partially effective. Only the treatment with 27-14-0 increased yield.

Field Peas

Breeding. A selection with large green seed, MP 766, from PI 206852 has out-yielded Delwiche Scotch Green by approximately 15% in 4 yr of cooperative testing. It will be recommended for licensing in 1973.

Disease. Further studies on epidemiology of *Ascochyta pinodes* L.K. Jones showed that diseased foliage buried for 3 yr was still infectious. Formation of the sexual stage on disease refuse correlated positively with the appearance of primary infection on the new crop.

Fifteen of 318 introductions exhibited a less severe reaction to *A. pinodes* than the control cultivar Century. Thirty-one of 96 introductions appeared to possess more resistance to bacterial blight than Century.

An isolate of *Ascochyta* sp. was pathogenic on both peas and fababean, *Vicia faba* L.

Management. In tests on date of seeding for 3 yr at two sites, early seeding produced higher yields, more uniform maturity, and larger seeds than late seeding.

A large-seeded cultivar, Century, and a small-seeded cultivar, Trapper, were each grown at three seeding rates at two locations in Manitoba. In 1971, no significant differences were recorded in yield or protein content. However, in 1972, higher yields were obtained for the highest seeding rates with both varieties. Peas at the lowest seeding rate matured last.

Flax

Breeding. Lines selected from the variety Noralta were superior in wilt tolerance, oil content, and seed yield. Yield increases were

4–23% for 23 lines in a preliminary test. Oil content of these lines was 41.9–43.2% compared with 40.7% for unselected Noralta and 42.7% for Redwood 65.

The random method of breeding produced one line from the cross Noralta × Redwood 65 that yielded 10% more than the higher parent in a test at nine sites.

Six introductions from Czechoslovakia will expand the genetic base of the program. The six ranged from 10% to 17% higher yielding than Redwood and carried combinations of other characteristics including early maturity and high oil content.

Quality. Some flax varieties mature abnormally under poor weather conditions and produce seed with the capsule septum adhering to the seed coat. This seed has a poor appearance, lower bushel weight, and lower germination than normal seed, but the oil has a higher iodine number. Protein and oil contents are not consistently affected. Therefore, this type of weathering does not lower the quality of the seed for crushing.

Swathing flax when the capsules start to turn yellow, or when there is approximately 38% moisture in the seed, accelerates ripening. The oil and protein contents, iodine number of the oil, and the weight, color, and germination of the seed are at least as good as in normally matured seed.

Seeds from varieties that mature late in the season, or that have been frozen, produce dark yellow oil. Although there is a significant difference among varieties, the northern growing locations usually produce darker oil.

Management. Alar (UniRoyal Chemical) applied in the seed furrow at seeding time, in an attempt to increase frost tolerance and reduce lodging, delayed emergence at the higher rates, but the plants soon outgrew the effects and yields were not reduced. Post-emergent frost or lodging did not occur in the test and, therefore, the potential of the chemical could not be evaluated.

Herbicide susceptibility. Bolls per plant, seeds per boll, and seed weight of three comparatively resistant cultivars were not significantly affected by MCPA, though the growth curve of one suggested it was more susceptible than the other two. In one year, the content of oleic, linoleic, and especially linolenic acids in the oil of two susceptible cultivars was affected by MCPA; the acid

composition of two resistant cultivars was not significantly changed.

Sunflowers

Breeding. Hybrids developed by means of the cytoplasmic male sterile-restorer system and tested in the Prairie Provinces showed the reliability of the system.

Sputnik, an open-pollinated variety, from the USSR produced 9.3% more oil per hectare than Peredovik in 2 yr at three Manitoba locations. It is similar to Peredovik in time to mature, rust reaction, and tolerance for verticillium wilt. Oil content over 13 tests was 47.5% in Sputnik and 44.1% in Peredovik.

Diseases. *Verticillium dahliae* Kleb. lowered the yield by reducing head size and yield per unit area of head, which is due primarily to smaller seed. It also reduced the oil content. Strains of *V. dahliae* from mint and sunflower caused severe disease in the original host and mild disease in the other; therefore the two crops should not occur in the same rotation.

Field observations on downy mildew, caused by *Plasmopara halstedii* (Farl.) Berl. & de Toni, suggest that only very young seedlings are susceptible, and that high moisture promotes the disease. *Sclerotinia sclerotiorum* (Lib.) can cause root rot, a result of invasion by vegetative growth from soil-borne sclerotia. Incidence of root rot was higher among closely spaced than among widely spaced plants, indicating that planting patterns offer prospects for reducing this disease.

Commercial cultivars contain a high proportion of plants susceptible to yellows, caused by *Phialophora* sp. In pathogenicity studies, *Phialophora* sp. was found to be highly pathogenic to sunflower but not to carnation, whereas the reverse was true for *P. cinerescens* (Wollenw.) Van Beyma from carnation.

Quality. Krasnodarets and Peredovik had the highest neutral or refinable oil content and the lowest chlorogenic acid content of six varieties tested at three locations in Manitoba. Location had no effect on these quality parameters; late seeding, however, significantly reduced the chlorogenic acid (May 15 = 2.3%, June 15 = 1.8%) but did not affect the neutral oil content.

Weed control. USB-3584 (Cobex), N^3, N^3 -diethyl-2,4-dinitro-6-trifluoromethyl-*m*-phenylenediamine, again showed promise for use in sunflowers. At rates that may be economically comparable to trifluralin, it gave equivalent selective control of green foxtail, barnyard grass, and some common broad-leaved weeds.

Results from herbicide tests and weed competition studies, where weeding was done by hand, support the competitive advantage of close row spacings; weeds reduced yields by 40% or more when the sunflower rows were 76 cm apart but only about half this when the rows were 30 cm apart. The sunflower population was constant at about 60,000/ha.

VEGETABLES

Potatoes

Breeding. The cultivar Norchip, which usually meets Manitoba chipping requirements, occasionally produces chips of poor color. Several seedlings with ability to chip well from cold storage from Morden breeding programs are being tested for other necessary characteristics. Successful crossings between Netted Gem \times diploid (*Solanum tuberosum* L. \times *S. phureja* Juz. & Buk. hybrids) and between $4n$ cultivars \times diploid (*S. tuberosum* \times *S. phureja* or *S. stenotomum* Juz. & Buk.) indicated potential for further $4n \times 2n$ breeding. Observation of diploid interspecific crosses with genetic markers and selection of promising seedlings has been made for further $4n \times 2n$ breeding.

Quality. Chip color was improved in 173 out of 222 new seedlings tested by preconditioning them at 21°C for 4 wk prior to 12 wk of cold storage at 5.5°C. Preconditioning appears to be more beneficial in cultivars such as Norchip that accumulate low amounts of reducing sugars in cold storage. Preconditioning seedlings prior to storage may be a good method of selecting for chipping quality.

A method was devised to measure texture of french fries with the Ottawa Texture Meter. Microwave cooking of french fries resulted in a gummy surface and was not a good method of preparing potato strips for determining textural differences. Holding the strips in hot water (50–70°C) for 30–90 min, prior to deep-fat frying, resulted in a firmer

texture. Hot-water blanching showed that varietal differences existed.

Correlations of $r = .866$, $r = -.604$, and $r = -.621$ were obtained in 22 cultivars between visual color ratings of boiled potatoes and respective L, a, and b values from a Hunter Color and Color Difference Meter.

There is a close association between dry matter and protein content in seven cultivars, which suggests that specific gravity and yield may be good parameters for selecting potatoes for high protein yields.

Cucumbers

Breeding. Four gynocious Morden hybrids resistant to scab and cucumber mosaic virus gave good to outstanding yields in Alberta, Manitoba, Ontario, and Wisconsin from both multiple and once-over harvests.

Single recessive genes control three new seedling mutants induced by gamma radiation of seed. Light sensitive, *ls*, was not linked with nonbitter cotyledon. Glabrate, *gl₂*, was not linked with glabrous, nonbitter cotyledon, light sensitive, yellow cotyledon, or crinkled leaf. Pale lethal, *pl*, was not linked with either glabrate or nonbitter cotyledon.

Sweet Corn

Breeding. Of 422 new Morden hybrids evaluated, 252 were as early as or earlier than the three standard hybrids. Yields based on cream style cut showed that 61 of the 252 early hybrids equaled or exceeded the standard hybrids.

New Crops

Fababeans, *Vicia faba* L., formerly designated horsebeans, continue as a potential commercial crop. Yields exceeded 4,500 kg/ha at the Station. Their performance must be judged in the light of abnormally cool midsummers in 1971 and 1972, which could have favored the crop. Good yields of 2,250 kg/ha were obtained with lentils, *Lens esculenta* Moench, but weed control is a major problem. Encouraging results were also obtained with white lupine, *Lupinus albus* L.; adzuki bean, *Phaseolus angularis* Wight; mung bean, *P. aureus* Roxb.; pinto bean, *P. vulgaris*, L.; and Holland brown bean, *P. vulgaris* L.

Chicory, *Cichorium intybus* L., and Jerusalem artichoke, *Helianthus tuberosus* L., may

have potential for producing industrial levulose. Inulin contents of up to 17% and 22% respectively have been obtained.

Tomatoes

The breeding terminated in a staking variety, Redstaker, and three indeterminate varieties, Booster, Melfort, and Pembina. The latter were selections in the Prairie Cooperative Program shared in by H. T. Allen, Research Station, Lacombe, Alta.; R. Anderson, Research Station, Melfort, Sask.; and T. A. Chesney, Special Crops Substation, Portage la Prairie, Man.

ORNAMENTALS

Breeding and Selection

One new cultivar, *Rosa* × 'Adelaide Hoodless', was named and officially described for introduction through the Canadian Ornamental Plant Foundation. The parentage of this new rose, developed by Henry H. Marshall of the Station staff, is *R.* 'Fire King' × (*R. arkansana* Porter 'J.W. Fargo' × *R.* 'Assiniboine'). The parentage of 'Assiniboine' is *R.* 'Donald Prior' × *R. arkansana*; both 'Donald Prior' and 'Fire King' are classified as floribunda roses. *R. arkansana* is the native prairie rose of which 'J.W. Fargo' is a double-flowered cultivar. It is a hardy rose most closely resembling the nonhardy, red-flowered cultivars of the floribunda class and is a vigorous, open-growing shrub up to 1.2 m in height. The individual semidouble to double flowers with about 25 petals are 6.5 cm in diameter when fully open and are borne in numerous clusters of up to 25 blooms each. The flowers are medium red (R.H.S. Color Chart 53A) in color, faintly fragrant, and long lasting as cut flowers. Foundation plants 'Adelaide Hoodless' were supplied to propagators designated by the Canadian Ornamental Plant Foundation.

In herbaceous ornamentals, seed of the Morden strain of *Lupinus polyphyllus* Ldl. was released. Garden chrysanthemums homozygous for the production of yellow flowers were identified. Also, one clone each of white and purple chrysanthemums was identified, which appear to produce progenies free from yellow segregates. Selection

for hardy herbaceous plants was accelerated by low temperatures and little snow cover in November and December 1971.

A chromatographic study of the anthocyanins responsible for petal color in *Rosa* revealed that peonin was present in 45 out of 67 different samples of *R. arkansana* Porter. Peonin was previously reported only in *R. rugosa* Thunb. and its derivatives. The other two anthocyanin pigments, cyanin and pelargonin, are also present in roses; cyanin may occur in combination with either peonin or pelargonin, but the combination of the latter two is unknown in *Rosa* except in four of the Morden hybrids. Because the breeding program is largely based on *R. arkansana*, and because pelargonin and peonin fluoresce brilliantly in sunlight, these discoveries open possibilities for colors yet unknown in roses.

Chromatography of 90 *Malus* taxa revealed that only one anthocyanin, cyanin, in varying amounts was responsible for petal color. This finding limits the breeding for new flower colors in *Malus*. Variation can only be obtained by varying the intensity of this pigment.

Evaluation

Some noteworthy cultivars among newer accessions of woody ornamentals are *Juniperus horizontalis* Moench 'Kleskun', *Malus* × 'Springsnow', *Potentilla fruticosa* L. 'Hurstbourne', *Rosa* × 'Cuthbert Grant' and 'Rita Bugnet', *Sambucus racemosa* L. 'Goldenlocks', *Spiraea arguta* Zab 'Grefsheim', *Spiraea* × 'Fairy Queen', *Syringa* × *hyacinthiflora* Lemoine 'Doctor Chadwick', *Syringa vulgaris* L. 'Agincourt Beauty', 'Flora', and 'Rochester', *Syringa* × 'Miss Canada', and *Viburnum trilobum* Marsh. 'Compactum'. Among newer herbaceous accessions that performed well were *Erigeron* 'Foersters Lieblig' and 'Rote Schoenheit', *Penstemon* 'Westlander', *Polemonium* 'Sapphire', and *Solidago* 'Golden Falls' and 'Mimosa'.

Arboretum and Herbarium

Generic blocks of *Betula*, *Cornus*, *Prunus*, and *Viburnum* totaling 117 taxa were established and 321 other taxa were added. Collections for the herbarium added 388 specimens of cultivated or native plants to bring the total taxa to 3,186. Duplicate sheets of many are available for exchange.

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Research Station Winnipeg, Manitoba

PROFESSIONAL STAFF

W. C. McDONALD, B.S.A., M.Sc., Ph.D.	Director
J. VANDERLEE, R.I.A.	Administrative Officer

Scientific Support

V. M. BENDELOW, B.Sc., M.Sc., Ph.D.	Cereal chemistry
K. D. OLIVER, B.A., B.L.S.	Librarian
W. ROMANOW, B.S.A., M.Sc.	Scientific Liaison Officer

Cereal Rusts Section

R. ROHRINGER, Dr. sc. agr.	Head of Section; Physiology
R. J. BAKER, B.S.A., M.Sc., Ph.D.	Population genetics
A. B. CAMPBELL, B.S.A., M.Sc., Ph.D.	Common wheat breeding and genetics
E. M. CZARNECKI, B.S.A.	Common wheat breeding
P. L. DYCK, B.S.A., M.Sc., Ph.D.	Wheat genetics
G. J. GREEN, B.S.A., M.Sc., Ph.D.	Wheat stem rust
E. R. KERBER, B.S.A., M.Sc., Ph.D.	Wheat cytogenetics
W. K. KIM, B.S., M.S., Ph.D.	Biochemistry of parasitism
D. LEISLE, B.S.A., M.Sc., Ph.D.	Durum wheat breeding and genetics
J. W. MARTENS, B.Sc., Ph.D.	Oat stem rust
R. I. H. MCKENZIE, B.S.A., M.Sc., Ph.D.	Oat breeding and genetics
D. J. SAMBORSKI, B.S.A., M.Sc., Ph.D.	Leaf rust of wheat; physiology

Crop Protection Section

F. L. WATTERS, B.Sc., M.Sc., Ph.D.	Head of Section; Insect biology and control
W. R. ALLEN, B.Sc., M.Sc., Ph.D.	Toxicology
P. S. BARKER, I.A., M.Sc., Ph.D.	Insect and mite control
B. BERCK, B.S.A., M.Sc., F.C.I.C.	Fumigant chemistry
S. R. LOSCHIAVO, B.Sc., M.Sc., Ph.D.	Grain insect biology
J. T. MILLS, B.Sc., Ph.D., D.I.C., F.L.S.	Ecology of seed-borne diseases

W. ROMANOW, B.S.A., M.Sc.
R. N. SINHA, B.Sc., Ph.D.
L. B. SMITH, B.Sc., M.S.A., Ph.D.

Grasshopper surveys
Mite and insect ecology
Population dynamics

Cereal Diseases Section

K. W. BUCHANNON, B.S.A., M.Sc., Ph.D.

Head of Section; Six-rowed barley
breeding and genetics

M. BICKIS, B.Sc.

Statistics

A. W. CHIKO, B.Sc., M.S., Ph.D.

Viruses

C. C. GILL,¹ B.Sc., Ph.D.

Viruses

W. A. F. HAGBORG, B.S.A., Ph.D.

Bacterial diseases; antibiotics

D. R. METCALFE, B.S.A., M.Sc., Ph.D.

Two-rowed barley breeding and
genetics

J. J. NIELSEN, Dr. sc. agr.

Smuts

P. L. THOMAS, B.S.A., M.Sc., Ph.D.

Microbial genetics

P. H. WESTDAL, B.Sc., M.Sc., Ph.D.

Virus vectors

Integrated Pest Control Section

W. J. TURNOCK, B.S.A., M.S., Ph.D.

Head of Section; Ecology and
population dynamics

G. L. AYRE, B.S.A., M.S.A.

Insect ecology

R. P. BODNARYK,² B.A., M.Sc., Ph.D.

Nutritional physiology, nutrition

G. K. BRACKEN, B.Sc., M.Sc., Ph.D.

Physiology and behavior

G. E. BUCHER, B.A., M.A., Ph.D.

Insect pathology

G. H. GERBER, B.S.A., Ph.D.

Reproductive physiology

B. M. HEGDEKAR, B.Sc., M.Sc., Ph.D.

Reproductive biochemistry and
behavior

C. E. OSGOOD, B.S., M.S., Ph.D.

Behavior and fecundity

H. G. WYLIE, B.A., Ph.D.

Host-parasite relations

Departures

G. FLEISCHMANN, B.A., M.A., Ph.D.

Crown rust

Appointed Director, Chemistry and Biology
Research Institute, Ottawa, July 1972

A. J. MCGINNIS, B.Sc., M.S., Ph.D.

Head of Section; Insect
biochemistry

Appointed Director, Research Station, Vineland
Station, February 1972

H. A. H. WALLACE, B.Sc., M.Sc.

Seed-borne diseases

Retired April 1972

PEDOLOGY SECTION

Transferred to the Soil Research Institute, Ottawa,
April 1972

VISITING SCIENTISTS

National Research Council postdoctorate fellows

N. K. HOWES, Ph.D.
R. A. SKIPP, Ph.D.

Physiology of parasitism
Plant pathology

Graduate students

P. A. BURNETT, B.Ag.Sci., M.Ag.Sci.
R. DE PAUW, B.A., M.Sc.
F. A. KIEHN, B.S.A.
F. G. KOSMOLAK, B.Sc.
G. J. MUDRYJ, B.S.A.
M. O. OSORO, M.Sc.

Entomology
Plant breeding
Plant breeding
Plant biochemistry
Entomology
Plant pathology

¹On transfer of work to the Waite Agricultural Research Institute, University of Adelaide, Glen Osmond, South Australia, October 1972 to October 1973.

²On transfer of work to Oxford University, Oxford, England, July 1972 to June 1973.

INTRODUCTION

Two main changes in the organization of the Station occurred in 1972. A section of Integrated Pest Control, staffed by scientists transferred from the former Research Institute, Belleville, Ont., was established to develop a program on the control of major insect pests of field crops in Western Canada. Research emphasis will be placed on developing pest management systems that optimize cost-benefit relations and minimize environmental degradation.

The program and financial administration of the Pedology Section was transferred to the Soil Research Institute, Ottawa, to facilitate the coordination of all soil survey activities in Canada. The section will continue in its present location and correspondence should be addressed to Canada-Manitoba Soil Survey, c/o Department of Soil Science, University of Manitoba, Winnipeg, Man. R3T 2N1.

The cooperative research of breeders, geneticists, pathologists, and cereal chemists resulted in the development of Napayo, an awned, hard red spring wheat variety, which was licensed in 1972. It is similar to Manitou in disease resistance and agronomic characteristics, but should prove to be more suitable in areas where weather conditions often make harvesting difficult.

Further information on the research summarized in this report can be obtained from: Research Station, Research Branch, Agriculture Canada, 25 Dafoe Road, Winnipeg, Man. R3T 2M9.

W. C. McDonald
Director

BREEDING, GENETICS, AND CYTOGENETICS

Common Wheat Breeding

Napayo, an awned, hard red spring wheat variety similar to Manitou, was licensed in 1972. It yielded more than Manitou but less than Neepawa in plot tests. However, the awns should be an advantage under certain harvesting conditions and it may perform better in the field.

Leaf rust continued to be an important factor limiting yield in Manitoba and eastern Saskatchewan. Both Manitou and Neepawa, which are grown on over 80% of the wheat acreage in this area, are susceptible. Potential new varieties with leaf rust resistance are in various stages of development in the breeding program and the goal of backcrossing four new genes for resistance into Neepawa should be attained.

The lack of postharvest dormancy is restricting progress toward the objective of producing a high-yielding, white-seed wheat. Kenya 321.BT.1.B1, which has a moderate level of postharvest dormancy, is being tested for its suitability as parental material.

A study to evaluate recurrent selection for yield in cereal crops indicated that selection for single plant yield of wheat in growth

chambers results in no response when selected lines were tested in small plots under field conditions. Failure to obtain response may be due to extreme environmental variation for single plant yield in growth chambers, or poor correlation between single plant and small plot yield under two different sets of conditions, or both.

Durum Wheat Breeding

Improvements in quality, yield, lodging resistance, and disease resistance continued to be the primary objectives of the breeding program. One line tested for 3 yr in the Co-operative Durum Wheat Test has been among the top-yielding entries. It is slightly taller and later than Hercules, has good disease resistance, has a high level of grain pigment, and has excellent gluten strength. A total of 172 lines from the program were tested in other comparative trials. A considerable number of these approach Hercules in maturity and height, have good disease resistance, and are equal or superior to Wascana in yield.

Genetics of Wheat

Genetic analysis of a group of wheat varieties indicated that Democrat and Sinvalocho have the *Lr3* gene for leaf rust

resistance; Bage and Klein Anniversario each have at least two genes for leaf rust resistance and each has an allele at the *Lr3* locus. The results suggested that the susceptible variety Prelude has a gene that suppresses a portion of the action of *Lr3*.

Preliminary results from genetic studies on leaf rust resistance suggested that PI 58548 has two genes for seedling resistance. The individual genes gave a type 1+ to 2+ level of resistance, but together the two genes appeared to produce a better level of resistance (fleck), similar to that of the parents. PI 197249 appeared to have a gene that gave a fleck type of resistance and one or two additional genes that gave an intermediate level of resistance. PI 64149 has the *Lr1* gene, whereas PI 181337 has at least two and possibly three genes for leaf rust resistance in the adult plant.

A system of two complementary recessive genes for leaf rust resistance as present in Lee was also found in Timstein and a Chinese Spring - Timstein 2B substitution line. Lee originated from a Hope × Timstein cross. The results suggested that the two genes are on chromosome 2B.

The inheritance of resistance to wheat leaf rust was studied in the hexaploid triticale cultivars 6A-190 Rosner, Armadillo, Bronco, and Toluca 160. Resistance in these triticales was monogenically inherited and each cultivar carried a single dominant gene. The results indicated that the genes governing resistance were derived from the tetraploid wheat parental species and that resistance to wheat leaf rust carried by the rye parent was not expressed in the triticale amphiploid.

Preliminary results of a genetic study of stem rust resistance in a number of wheat varieties indicated the following: Agent has a gene from *Agropyron elongatum* (Host) P. Beauv., *Sr10*, and a third unidentified gene; Bonnie has two genes, possibly *Sr6* and *Sr11*; ESP 578/9 has four genes, which may include *Sr6*, *Sr8*, and *Sr10*; Romany may also have four genes, of which three may be *Sr6*, *Sr9a*, and *Sr13*; and Tama has two or three genes, of which one appears to be *Sr8*.

An evaluation for rust resistance and general agronomic characteristics was made of approximately 1,000 wheat collections. Of these, 217 were from the FAO collection made in Afghanistan, 300 were obtained from Turkey, and 487 from an Ethiopian collection. Approximately 40 entries grown in 1971 that looked promising were further

tested in the rust nursery and greenhouse. Crosses are being made to study the genetics of these lines.

Cytogenetics of Wheat

When the Q factor on chromosome 5A of common hexaploid wheat ($2n = 42 = AABBDD$) is hemizygous or absent, the spike is nonfree-threshing owing to the tenacity of the glumes that enclose the florets of the spikelets. When several forms of *Triticum carthlicum* Nevski ($2n = 28 = AABB$) and Tetra Canthatch (the AABB component extracted from the free-threshing hexaploid cultivar Canthatch) were combined with several forms of *Aegilops squarrosa* L., the source of the D genome in hexaploid wheat, synthetic hexaploids were obtained that are nonfree-threshing despite the presence of the Q factor in the AABB component. Apparently the Q factor is unable to counteract the effects of glume tenacity introduced into the synthetic hexaploids from *squarrosa*. The genetic basis for glume tenacity in two synthetic hexaploids, each having Tetra Canthatch as the tetraploid parent, was found to be a gene on chromosome arm 2Da, 39.4 ± 4.9 crossover units from the centromere in one hexaploid and 42.9 ± 4.6 in the other. These results led to the conclusion that primitive hexaploid wheat probably was nonfree-threshing and that subsequently a mutation occurred at the tenacious glume locus on chromosome 2D to confer the free-threshing habit.

Barley Breeding and Genetics

Good progress was made in the development of two-rowed barleys adapted to the eastern prairies. Emphasis is being placed on high yield, resistance to prevalent diseases, strong straw, and malting properties similar to those of six-rowed types. A problem of multiple-seeded florets was encountered in some of the highest quality lines, but because this characteristic is apparently controlled by a single gene, only minor delays in the breeding program are anticipated.

Several six-rowed selections with resistance to prevalent diseases, higher yield than Conquest, and with promising malting quality in blue-aleuroned selections or high bushel weight in yellow-aleuroned selections, will be advanced to regional trials in 1973.

Results to date in the program to develop hullless barley as high-energy feed grain are

encouraging. One line, with a test weight of 79 kg/hl (63 lb/bu), exceeded Conquest and Herta in yield. Work is continuing to improve the yield, disease resistance, and straw strength, and to incorporate the gene for high lysine in both two-rowed and six-rowed hullless types.

Oat Breeding and Genetics

The main emphasis in the breeding program is to develop stem- and crown-rust-resistant varieties that have more than one gene for resistance. One line from this program yielded very well at four test locations on the eastern prairies. Visual appearance of this strain was good and if it proves to have the complete gene system for rust resistance it has a real potential as a variety.

Leaf tissue analysis indicated a severe deficiency of Mn in the soil of the test plots at Winnipeg. Yields of the more susceptible strains were as much as 40% below that of Random, a tolerant variety. The susceptibility to Mn deficiency appears to be coming from Pendek, which has been widely used in the Winnipeg program, whereas tolerance is coming from Glen, a variety well known for its tolerance. Glen is a parent of both Random and OT 618, a strain from the Melfort program.

The results from the hullless oat breeding program continued to be very encouraging. Yields of the best strain continued to equal the yield of groats from Random. Postmaturity studies indicated that hullless oats are far more resistant to shattering than ordinary oats.

CEREAL RUSTS

Stem Rust of Wheat

Five new races of wheat stem rust appeared in Canada in the last 2 yr. They were identified by a change in virulence on hosts with single genes for resistance. Despite increased variability in the rust, commercial varieties of wheat are highly resistant. There is a potential problem in the gradual appearance of new, more virulent races on Thatcher and its derivatives Manitou and Neepawa.

Axenic cultures of several Canadian races of stem rust were produced for the first time, but all cultures showed the staling characteristic and would not grow when transferred to fresh media.

A study on the histology of infected leaves showed that stomatal penetration by race 56 of stem rust was synchronized by transferring seedlings from dark to light conditions 12 h after inoculation. During early stages of infection, stem rust hyphae grew in a similar way within leaves of resistant and susceptible, near-isogenic lines of wheat. Between 24 and 84 h, infected host cells of the resistant line became necrotic. About 25% of infection hyphae failed to invade more than one mesophyll cell of the host. Other infection hyphae became much branched but were eventually contained within necrotic tissue. Electron microscopy showed that haustoria were collapsed and disorganized in necrotic cells, but adjacent intercellular hyphae were not affected. Ultrastructural changes occurred in uninvaded cells bordering necrotic host cells. Necrosis rarely occurred in susceptible leaves.

Leaf Rust of Wheat

Wheat leaf rust was widespread in 1972 and infections were heavy by the end of the growing season. Early-sown fields escaped with little damage, but late-sown fields suffered losses estimated at 10%. The average loss in Manitoba and southeastern Saskatchewan was estimated at less than 5%.

The 1972 leaf rust race survey showed no important changes in virulence on seedling genes for resistance. However, virulence on adult plant resistance in Manitou and Neepawa has increased steadily in the past few years.

Virulence patterns on Glenlea and Waldron were compared with those on known genes for resistance. Glenlea possesses only gene *Lr1* for seedling resistance, whereas Waldron has gene *Lr2* and two other seedling resistance genes, one of which is probably *Lr10*. Field reactions of these varieties indicated that they possess adult plant resistance in addition to genes for seedling resistance.

Selfed, F₁ and F₂ cultures of leaf rust races 9, 11, and 161 were used to study the genetics of virulence on the varieties Democrat, Sinalocho, Bage, and Klein Anniversario. In general, the data corresponded to that expected from the genetics of the host, complete with a gene(s) corresponding with the suppressor or inhibitor in Prelude.

Stem Rust of Oats

The 1972 physiologic race distribution in Western Canada was the simplest in several decades; the two races C10 and C23 comprised 99% of all isolates from Western Canada. The most surprising aspect of this development was the rapid rise of race C23, a race avirulent on most commercial cultivars. If there are no big changes in the race distribution, the base of resistance genes presently being used in the breeding program should provide effective resistance for some time to come.

In 1972 over 1,800 new accessions to the Canada *Avena* gene pool were collected in Ethiopia, Kenya, Tunisia, Algeria, and Morocco. Most of these are hexaploid, the easiest group to work with in terms of cultivar improvement. Screening of the collection for stem rust resistance is now under way. The North African group of hexaploid species represents great potential as a source of genes for stem rust resistance.

A 4-yr study on the competitive ability of simple and complex (virulence range) races in mixtures was completed. Under growth cabinet conditions, the simplest race maintained or improved its competitive position but under field conditions, the more complex races consistently outperformed it.

A 2-yr study of worldwide oat stem rust virulence was completed with 18 countries participating. Virulence patterns are quite similar around the world, with *pg* 9, 11, and 13 providing the only effective resistance.

Crown Rust of Oats

Crown rust of oats did not cause any significant damage in 1972. Races 295 and 326 were predominant in the crown rust population. Genes *Pc38* and *Pc39*, which were isolated from *Avena sterilis* L., conferred effective resistance to the local crown rust population. These genes are being used in the oat breeding program.

Physiology of Parasitism

Shikimate-derived aromatic compounds in the host-parasite complex. Work continued on the purification of unknown ferulate-containing wheat metabolites. Purification was much more difficult than anticipated because of the presence of numerous closely related impurities. The unknowns appeared to contain ferulate in amide-bound form and

may be structurally related to the 2-hydroxyputrescine amides that were first identified in extracts of rust-infected wheat leaves. Amide-bound ferulate was also detected in alcohol-insoluble material from resistant-reacting, rust-infected wheat leaves. It may be a normal constituent of cell wall material. Few amide-bound cinnamic acids are known to occur in nature and nothing is known about their biogenesis.

Bioassay of fractions extracted from the rust fungus and from the host-parasite complex. A bioassay, which uses rust-infected wheat plants, was developed further. Manipulation of temperature made it possible to synchronize formation of infection structures and haustoria. This increased the specificity of the assay. In plants containing the temperature-sensitive *Sr6* gene for resistance, it was possible to delay the resistant reaction for several days during growth at higher temperatures. During this time, parasitic growth of the normally avirulent race was indistinguishable from growth of a virulent race. A sudden drop in temperature several days after inoculation produced massive necrosis throughout the infected leaves of plants containing the *Sr6* gene. Apart from their use in the bioassay, these plants may be used for the isolation of increased amounts of biologically active factors responsible for expression of resistance or susceptibility.

Polyribonucleotides of wheat stem rust. RNA content of uredospores decreased by 50–60% during germination, depending on the degree of differentiation. Experiments with ³²P-labeled spores showed that this decrease was not due to excretion of RNA. RNA from the mycelium of an exenic Australian culture had a similar profile to that of race 56 spores or sporelings. This culture and differentiated sporelings contained an RNA fraction of intermediate molecular weight not present in ungerminated spores. It was detected by sucrose density gradient centrifugation. In pulse-chase experiments with radioactive precursors, no “rapidly labeled” RNA was detected, although most RNA species became labeled to some extent. This may indicate that the newly formed RNA of intermediate molecular weight is a degradation (scission) product of preformed RNA, rather than being synthesized *de novo* after germination.

Chemical Control

In a bioassay to determine the inhibition of stem rust of wheat in vivo, polyoxin D, obtained from Japan, showed 50% activity at 200 μ g/ml equal to the unpurified standard of antibiotic P-9. Nystatin was inactive at 2,000 μ g/ml. A number of other substances also proved inactive.

In a field plot experiment, a new carbox-anilido systemic chemical, BAS-3170-F (2-iodo-benzanilide; BASF Canada Ltd.), had an efficacy superior to Plantvax 75W (UniRoyal Chemical) and equal to Plantvax EC in the control of leaf and stem rusts of wheat.

OTHER CEREAL DISEASES

Smuts

Crosses involving five different proline-requiring mutants of barley covered smut, *Ustilago hordei* (Pers.) Lagerh., were subjected to tetrad analysis. All but one of the mutant genes appeared to be tightly linked to the mating type locus. Pantothenic acid requirement also appeared to be tightly linked to mating type; over 800 progeny from one cross failed to show segregation between the loci. Approximately 50 mutants with other biochemical requirements were analyzed by tetrad analysis. None appeared to be linked to mating type.

Virulence on the barley variety Himalaya required the presence of two genes in the pathogen, *Uhv-1* (virulent on Hannchen) and *Uhv-2* (virulent on Excelsior). Therefore, the *U. hordei* barley differentials that were used in the past probably contained resistance genes in common.

Blue Dwarf of Oats

In growth cabinet experiments, the yield of barley that was inoculated with oat blue dwarf virus (OBDV) at the two-leaf or early tillering stage was reduced by 39%. Fewer seeds were produced on both the main culm and tillers of infected plants than on healthy plants and there were fewer seed-bearing tillers. Kernel weight was not affected. When plants were infected at the boot stage, there was no significant reduction in yield. Disease symptoms were milder and yield losses smaller at 20°C during 16 h of simulated daylight and 15°C at night, than at corresponding temperatures of 25 and -15°C. This

confirmed field observations that OBDV was not as severe when the weather was cool during the growing season.

Aster Yellows

Over 4,000 entries from the world collection of barley varieties were screened for resistance to or tolerance for the aster yellows pathogen. No resistant material was found, but there was evidence of tolerance in some varieties.

Oat Necrotic Mottle

A cytological study using electron microscopy showed that two types of inclusion bodies occur in cells of oats and bluegrass infected with oat necrotic mottle virus. One was the cylindrical type ("pinwheels"), characteristic of many viruses in the potato virus Y group, and the other was a granular inclusion. Both inclusion bodies were usually present in cells where virus particles were also observed. The latter were usually low in concentration and were seen only in the cytoplasm. Of further interest was the presence of three types of deposits on the inside of walls of infected cells. One was a fibrous type not previously described. The other two were called localized and extensive deposits. The possible role of these deposits and their composition have yet to be determined.

Barley Stripe Mosaic

In Alberta, Saskatchewan, and southeastern Manitoba barley stripe mosaic virus (BSMV) was detected in 43%, 11%, and 15% of the two-rowed barley fields and in 17%, 5%, and none of the six-rowed barley fields surveyed in 1972. The incidence of affected plants in these fields varied from a trace to 10%. The disease was confined mainly to southern areas in Saskatchewan and Alberta.

The percentage of two-rowed barley fields in which BSMV was detected in southeastern Manitoba in 1972 declined markedly from the previous year. This was probably due to decreased planting of Herta barley, the variety most commonly infected with BSMV in this province, and increased planting of a newer two-rowed variety Fergus that in 1971 appeared to be free from virus. In 1972, however, a very low incidence of BSMV was detected in two fields of Fergus barley and thus even a complete changeover to this variety in Manitoba will probably result in

only temporary control of the disease in two-rowed barley.

Breeder seed of 18 barley varieties, including those grown most commonly in Canada, was sown in a field plot and plants were examined periodically for BSMV symptoms. The disease was detected only in plots of Compana barley, where about 1% of the plants were affected.

The reactions of five of the most popular barley varieties in Manitoba (Herta, Fergus, Conquest, Paragon, and Bonanza) to four isolates of BSMV were compared under greenhouse conditions to a resistant variety, Moreval. The susceptibility of the Manitoba varieties to each isolate generally decreased in the order listed above, but even Bonanza was moderately susceptible (i.e., each isolate infected over 50% of the inoculated plants). Two isolates failed to infect the variety Moreval, whereas one isolate infected 20% and other infected 51% of the inoculated plants. With the latter isolate, 75% of the infected plants were symptomless. Tests are being conducted to determine if some selections of Moreval are more resistant to this isolate than other selections.

Seed Treatment

Adhesion of seed-treatment fungicides to seeds of cereals, buckwheat, and oilseeds was investigated further by determining the minimal effective dosages, based on adhesion data, required for the control of seed-borne microflora. The location of fungi, damage to the seed coat, and distribution of fungicides on the seed at various dosages was recorded. The minimal effective dosages, derived experimentally, were 31–148 g/hl (0.4–1.9 oz/bu) less than the recommended dosages. However, before lowering the recommended rate, the control of smuts and of soil-borne fungi at the new levels must be carefully evaluated.

FIELD CROP INSECTS

Insecticides

Cutworm damage to sugar beets. Because of the early and active outbreak of cutworms, about 3.4% of the 12,349 ha (30,492 ac) of sugar beets grown in Manitoba were destroyed. This represented more than \$480,760 lost income. The area sprayed at a cost of \$4.18/kg (\$1.90/lb) active insecticides amounted to a cost of \$28,800. In two

districts 66% of the sugar beets were sprayed. Leptophos, used at higher than recommended rates, was effective in controlling cutworms when applied to dry soil after seedling emergence but was ineffective when applied before seedling emergence. However, activity decreased after 60 h.

Grasshopper Surveys

Surveys carried out during the summer indicated a further increase in grasshopper infestations. Favorable weather resulted in an early hatch, rapid development, and an extended egg-laying period.

Marginal damage to crops was common, but timely control measures prevented serious losses. Approximately 81,000 ha (200,000 ac) were sprayed for grasshopper control in 1972 compared with 2,146 ha (5,300 ac) in 1971.

The forecast of grasshopper infestations for Manitoba in 1973 shows an increase in the density of expected population numbers and about a 25% increase in areas infested.

There are 12,909 km² (4,984 sq miles) infested, of which 5,727 km² (2,211 sq miles) are light, 6,568 km² (2,536 sq miles) moderate, and 614 km² (237 sq miles) severe.

STORED PRODUCTS ENTOMOLOGY

Surveys

An improved model of a trapping device for detecting insects in stored grain proved highly successful in laboratory and field tests conducted in 1972. Traps used in a survey of farm storages and country elevators in Manitoba showed that farms can be important sources of grain insects. Half of the 157 farm granaries examined were infested. A modified version of the trap installed in grain-carrying boxcars trapped rusty grain beetles, *Cryptolestes ferrugineus* (Stephens), during trips between loading and unloading points, but the official grain sample taken from the car contained no insects.

Principal component and canonical correlation analyses were used to determine the basic patterns of multivariate interrelationships among climatic, microbial, and entomological variables associated with stored grain. Maps of 41 crop districts in the Prairie Provinces were then prepared to indicate areas with high or low potentials for future

outbreaks of storage pests. Crop districts were ranked according to their infestation potential and also classified according to their recognized geographic and climatic regions. The northerly, subboreal region is most vulnerable to outbreaks of fungus-induced hot spots.

Ecology

The patterns of population fluctuations of seven kinds of mites of stored grain were revealed from studies of up to 10 yr of wheat stored in four typical farm granaries in Winnipeg and Glenlea. The grain mite, *Acarus siro* (L.), had periodic outbreaks every 2–5 yr in small localized zones where the numbers exceeded 10,000/200-g sample. Population peaks of *A. siro*, *Cheyletus eruditus* (Schrank), *Glycyphagus destructor* (Schrank), and *Tarsonemus granarius* (Lindquist) occurred throughout the storage period, but *Aeroglyphus robustus* (Banks) did not develop large populations until after 5 yr.

Insect Resistance

Studies to determine the possible occurrence of insecticide resistance among stored-product insects collected from various regions in Canada showed that of seven species tested for susceptibility to malathion, *Oryzaephilus surinamensis* (L.) and *O. mercator* (Fauvel) were the most susceptible, followed by *C. ferrugineus*, *Sitophilus granarius* (L.), *Tribolium castaneum* (Herbst), *T. confusum* (Jacquelin du Val), and *T. madens* (Charp.). Specimens of *T. castaneum*, collected in 1969 from the port areas in Vancouver and Montreal where malathion is used on a regular basis, were 2.5 to 3 times more resistant than those from laboratory cultures collected from inland storage facilities where malathion is used less frequently. Though these resistance factors are much lower than those found in other countries, monitoring of populations across Canada will be continued to determine possible changes in susceptibility.

Control

Malathion was applied at 8 or 12 ppm to 108 t of Rodney oats, of which 86 were heating (31–35°C) and heavily infested (231 insects/kg) with *O. surinamensis*. The treatment was effective at 12 ppm but not at 8 ppm. Uninfested oats treated at 8 ppm and stored at 27°C did not become infested during a 10-wk period.

In laboratory tests, when Orthene (*O,S*-dimethyl *N*-acetyl phosphoramidothioate; Chevron Chemical Co., Orthic Div.), a new organic phosphate insecticide of moderate persistence, was applied at 32 ppm to wheat of 12% moisture content, it provided complete control of *C. ferrugineus* and *T. castaneum* for 35 days after treatment. Orthene was less effective (55–65% mortality) against both species when the wheat moisture content was 16% and was ineffective at 4, 8, or 16 ppm. By contrast, malathion at 8 ppm gave complete control of both species in wheat at 12% or 16% moisture content for 35 days after treatment.

Studies on the distribution and persistence of a commercial fumigant in farm-stored wheat showed that concentrations of ethylene dibromide (EDB) and ethylene dichloride (EDC) were highest at the headspace, followed by the top, middle, and bottom of the grain; carbon tetrachloride (CT) concentrations were in the reverse order.

Fumigant residues in wheat, flour, bran, and middlings were determined during a 7-wk exposure period and EDB and CT residues declined as follows: wheat, 3.26 to 0 ppm and 54.5 to 3.2 ppm; bran, 0.03 to 0 ppb (10^{-9}) and 3.53 to 0.34 ppb; middlings, 0.030 to 0 ppb and 1.65 to 0.20 ppb; and flour, 0.030 to 0.010 ppb and 0.93 to 0.2 ppb. Fumigation of the wheat did not cause any change in germination, wheat quality, or bread baked from the flour.

The effect of grain temperature on the penetration of fumigants through wheat was determined by bioassay with adults of *T. castaneum* and adults and eggs of *C. ferrugineus*. At 17–20°C the following fumigants were equally effective against *C. ferrugineus* adults: EDB + EDC + CT (7:30:63 vol:vol) 5 litres/27 t; chloropicrin (CP) + EDC (35:65 vol:vol) at 1.1 litres/27 t; CP + CT (35:65 vol:vol) at 1.1 litres/27 t; acrylonitrile (AC) + EDC (35:65 vol:vol) at 1.1 litres/27 t; hydrogen phosphide (HP) at 500 pellets of 0.6 g/27 t.

At 15–20°C, HP was more effective against *T. castaneum* adults than EDB + EDC + CT (7:30:63 vol:vol) at 5 litres/27 t; against *C. ferrugineus* eggs, the order of effectiveness was reversed.

At –2 to –10°C, EDB + EDC (18:32 vol:vol) at 1.3 litres/27 t was more effective against *C. ferrugineus* adults than EDB + EDC + CT (7:30:63 vol:vol) at 1.3 litres/27 t.

Integrated Control of Insect Pests

During the past year, several programs begun at the Research Institute, Belleville, Ont., were completed. The objective of these programs was to discover and investigate new ways of reducing pest damage. These included studies of the roles of specific organic compounds in physiological and behavioral processes of insects and the use of parasites and pathogens as control agents.

The scientists concerned in these programs are now developing new programs directed toward the discovery and application of integrated and nonchemical control approaches for pest management systems in agriculture.

Physiology and Behavior

Oviposition by the parasite *Itopectis conquisitor* (Say) was induced by a certain fraction of the hemolymph occurring in species of Lepidoptera, Hymenoptera, and Trichoptera. This fraction, as isolated from the hemolymph of *Galleria mellonella* (L.), consisted of hexoses and some 19 amino acids. These results led to the development of a synthetic oviposition medium for laboratory culturing of *I. conquisitor*.

The hardening and darkening of the puparium is an essential step in the life history of flies. Low molecular weight derivatives of phenylalanine and tyrosine play a significant role in this process. Studies of the last larval instar of 46 species representing several families of Diptera revealed the occurrence of β -alanyl-L-tyrosine in all the *Sarcophaga* species and one tachinid species; of γ -L-glutamyl-L-phenylalanine in all *Musca* species and *Stomoxys calcitrans* (L.); and of tyrosine-*o*-phosphate in all *Drosophila* species. In the house fly, *Musca domestica* (L.), γ -glutamyl-L-phenylalanine is metabolized specifically by γ -glutamyl cyclotransferase to pyrrolidone carboxylic acid and free phenylalanine. The phenylalanine is

further metabolized for the sclerotization of the puparium cuticle.

Pathogens of Tobacco Pests

Field plots of tobacco seedlings were planted by commercial planter containing the nematode-bacterial complex (DD136) to compare the protection given from root maggot damage with that given by diazinon and by several candidate insecticides under commercial planting conditions. A heavy frost in June killed many seedlings and consequently results were not obtained to confirm previous observations that the nematode complex gave good protection from root maggot injury. Further attempts to introduce nuclear virus disease into healthy populations of the dark-sided cutworm of tobacco were made by strip-planting rows of tobacco in the rye cover crop and spraying them with virus suspensions at timed intervals. Success of the introduction will not be known until sampling is done in 1973, but trap-plant collections of cutworm larvae from areas where virus was introduced in 1971 were heavily infected with virus. This indicated that a considerable level of virus survival occurred and that virus introduction is feasible.

Parasites of Flies

A lower percentage of female progeny was produced by each of three house fly parasites, *Nasonia vitripennis* (Walk.), *Muscidifurax zaraptor* K. & L., and *Eupteromalus dubius* (Ashm.), when the parent females were crowded during oviposition than when they were uncrowded. The sex ratio shift in *E. dubius* at high ratios of parasites to hosts was caused by superparasitism of pupae of the host followed by differential mortality of female larvae. In two other parasite species, crowding reduced the rate of oviposition, which in turn lowered the proportion of eggs that were fertilized; this resulted in fewer female larvae because unfertilized eggs produce males.

PUBLICATIONS

Research

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Experimental Farm Indian Head, Saskatchewan

PROFESSIONAL STAFF

E. BUGLASS, B.S.A.

Acting Director

Agronomy

R. N. McIVER, B.S.A.

Field husbandry and experimental
project farms

Departures

J. ROE FOSTER, B.S.A.

Retired May 4, 1972

Director

E. V. McCURDY, B.S.A.

Retired April 28, 1972

Field husbandry and weed control

INTRODUCTION

During the year J. Roe Foster, Director, and E. V. McCurdy, research scientist concerned with field husbandry and weed control, retired. The long-time programs and projects were carried on by the remaining staff. The research is not described in detail; only the most significant items are reported. Data from our cooperative and evaluation tests are either reported by coordinators of the main project or incorporated in guides to Saskatchewan farmers on management practices for the production of cereal and forage crops.

In cooperation with the Research Station, Regina, Sask., we grew 81 ha of seed increases and distributed Breeder, Select, and Foundation seed of cereal, oilseed, and forage crops.

During 1972 we became an active member of the South Saskatchewan Wheat Breeding Project (SSWBP), coordinated from the Research Station, Swift Current, Sask. The Co-op Forage Oat Test is coordinated from here, with most of the entries from Indian Head. Three lines show excellent promise.

For more information, correspondence should be addressed: Director, Experimental Farm, Research Branch, Agriculture Canada, Box 760, Indian Head, Sask. S0G 2K0.

E. Buglass
Acting Director

AGRONOMY

Rotations and Soil Fertility

For 15 yr continuous cropping of wheat has been compared with cropping sequences that include a season of fallow. The average yields of wheat per cultivated hectare were as follows: continuous wheat 11.09 q; 2-yr fallow, wheat 11.16 q; and 3-yr fallow, wheat, wheat 11.63 q. When N at 21 kg/ha and P at 9 kg/ha were applied to wheat after wheat, and N at 6.2 kg/ha and P at 11.6 kg/ha to wheat on fallow, the yields per cultivated hectare for the cropping sequences were 15.39 q, 12.37 q, and 13.98 q respectively. The 1972 yields were below average, the greatest reduction being in wheat after wheat. Perennial weeds, particularly Canada thistle, have been gradually increasing and could become a problem in the continuously cropped areas.

When a grass-legume mixture was included in the cropping sequence, the average yield of wheat on fallow was similar to that of wheat fertilized in the 2-yr fallow, wheat sequence. A grass-legume mixture (left down for 3 yr) with an application of barnyard manure (26.9 t/ha every 9th yr) has been included in a 9-yr rotation for 61 yr. The yield of wheat on fallow has increased slightly during this period. Fertilizer did not increase the yield. The yield of wheat on fallow in a fallow, wheat, wheat sequence for the same period has decreased slightly.

When N at 6.2 kg/ha and P at 11.6 kg/ha were applied with the wheat on fallow, the 19-yr average increase was 2.62 q/ha.

For 15 yr wheat, oats, barley, and flax were compared in a cropping sequence of fallow, grain, grain. The yield of the crop after flax was not significantly lower than after one of the cereals. Highest yields were obtained when flax was grown on the fallow and the cereals after the flax. Barley after flax averaged 32% higher than wheat and 28% higher than oats. When N at 21 kg/ha and P at 9 kg/ha were applied, the yield increases were 21% and 13% respectively.

Rates of Seeding

Rates of seeding wheat on fallow were compared at eight locations in southeastern Saskatchewan for 4 yr. With good weed control the optimum rate of seeding was 0.7 q/ha in the Dark Brown soil zone, and 1.0 to 1.3 q/ha in the Black soil zone. Higher-than-optimum rates decreased the number of days to maturity and provided better competition for the weeds. Seed and fertilizer should be applied on a per hectare basis irrespective of the row spacing. As the row spacing increased beyond 15 cm, the yield decreased. Changes in the concentration of seed and fertilizer within the row as a result of changes in row spacings did not change the response pattern.

Fertilizers

The response of wheat, oats, and barley to N was compared at eight sites in southeastern Saskatchewan. The soils contained a low to medium level of $\text{NO}_3\text{-N}$ and a low level of available P. P was applied uniformly at 19.5 kg/ha. The N was more efficiently used when placed with the seed; N at 22 kg/ha with the seed gave the same yields as 44 to 66 kg broadcast. The average increase in the yield of wheat and barley was 13 q and of oats 21 q/ha. Small additional increases in yield were obtained with the higher rates of N broadcast.

In a 3-yr rotation of fallow, wheat, wheat for 28 yr, P at 4.7 to 23.7 kg/ha was applied to the wheat on fallow. The response has been relatively uniform throughout the period, ranging from 1.3 q/ha with the low rates of P to 4.0 q/ha with the high rate. The level of available P in the 0- to 15-cm depth of soil has gradually increased from 8 kg/ha to 35 kg/ha with the high rates of P. In 1972 the high rate of P increased the yield by only 4.7 q/ha, even though the level of available P in the soil had increased to a high level.

Before seeding a mixture of brome grass and alfalfa in 1970, 12 rates of N and P in combination ranging up to 74 kg N/ha and 140 kg P/ha were incorporated into the soil. Four rates of N ranging up to 67 kg/ha were broadcast annually. There was a decrease in the percentage of alfalfa in the sward and an increase in the total yield when more than 40 kg N/ha along with P was incorporated into the soil before seeding or when 22 kg N was broadcast.

Twelve rates of N and six rates of P were broadcast on established stands of brome grass-alfalfa mixtures for 3 consecutive yr, 1969-71, at two locations. The residual responses from the three annual applications were determined in 1972. At one location the yields were similar to the 3-yr average, but at the other location the yields were 50% below the average. At the latter location the early-spring moisture conditions were less favorable than during 1969-71.

PLANT SCIENCE

Cereals

Regional tests were carried out at seven locations as well as at the Experimental Farm. Glenlea, a new feed wheat variety,

yielded the highest, 28 q/ha, in the northern and eastern parts of the area, where moisture conditions were more favorable. Pitic 62, the other feed variety, yielded the highest, 29 q/ha, in the drier western section of southeastern Saskatchewan. Neepawa was again the highest-yielding bread wheat, 24 q/ha. The other varieties, such as Manitou, Napayo, and Cypress, were 1-2 q/ha lower. Wascana, the new durum variety, yielded 25 q/ha, about 1-2 q more than the other varieties. Random, the new oat variety, yielded about 52 q/ha; Fraser and Sioux yielded 47 q/ha. The other varieties were a few quintals per hectare lower than Fraser and Sioux. In the barley varieties, the six-rowed malting varieties Bonanza and Paragon yielded about the same as Galt, 50 q/ha, a high-yielding feed barley. Betzes, the most popular two-rowed malting barley, yielded the lowest, 43 q/ha, about 3-4 q lower than the other two-rowed barleys. Centennial and Fergus yielded 46 and 47 q/ha respectively. The numbered lines TR 501 and 502 yielded 46 q/ha. Redwood and Norland, the late-maturing flax varieties, yielded 17 q/ha. The early variety, Noralta, yielded 16 q/ha. Linott was included in the test and yielded 15 q/ha.

Cooperative evaluation of Breeder seed material, varieties, and lines of common spring wheat, durum wheat, barley, oats, and flax continued. Several thousand early-generation lines of durum and common wheats from the SSWBP were grown, processed, and evaluated.

Forage Crops

Because there was no reserve moisture from the previous fall, all perennial crops had to depend on current rainfall for growth. The spring and summer were dry and unusually cool; only two effective rains fell during the growing season: June 22 (19 mm) and July 31 (32 mm). Most perennials were cut only once. Annual hay yields were about average. Evaluation of Breeder lines, varieties, and introductions continued in uniform cooperative tests.

Management practices. Four varieties of alfalfa, Rambler, Beaver, Roamer, and Drylander, cut at nine different stages from bud to full bloom showed no significant differences in yield at the various stages of cutting. Only one cutting was made; all varieties failed to bloom because of lack of moisture.

Six years yield data in three different tests from seedings in different years indicated no significant difference between alfalfa and grass in the same row or in alternate rows. The rows were spaced 30 cm apart. Sowing alfalfa at 1.1, 2.2, or 3.4 kg/ha did not affect this relationship.

During the period 1966-72, 11-48-0 fertilizer applied at 56 kg/ha in direct contact with the seed of Echo rape increased the yield by 3.6 q/ha. In 1972 the increase was 4.81 q/ha. The use of fertilizer markedly increased the seedling growth, because the fertilizer provided better establishment and weed competition. During 1970-72, 11-48-0 fertilizer applied at 90 kg/ha did not affect germination, and yield was increased by 6.14 q/ha. Some 140 large-seeded lines were selected from Span (XL-Span), the low erucic acid variety. They varied in erucic acid content from 0% to 41.1%, the composite being 6.3%. This serves to explain some of the variation in the erucic acid content found in the 1972 commercial crop. Preliminary tests, under isolation, indicate that the large seed size is being maintained, and the variations in seed yield are within satisfactory limits.

The use of an alfalfa-grass mixture in the rotation significantly increased the yield of wheat on both summerfallow and stubble

each year during the period 1968-72. The use of grass alone had no effect on wheat yields. In 1972 (7 yr after breaking) the increase was still significant. Application of N and P accentuated the increase. The average increase for 5 yr on stubble without fertilizer, where alfalfa was used in the mixture, was 6.1 q/ha; where both fertilizer and alfalfa were used it was 11.3 q/ha. Applying 11-48-0 at 67.3 kg/ha plus 34-0-0 at 112 kg/ha on the stubble where grass alone had been grown increased the yield by 7.2 q/ha. In no year has the interaction between grass and rate of fertilizer been significant. The fallow crop, 1968-72, where 11-48-0 fertilizer at 67.3 kg/ha and alfalfa had been used increased the yield of wheat by 1.5 q/ha.

The Co-op Forage Oat Test at 12 locations across Canada has been coordinated for the past 3 yr from Indian Head. During that time, the Indian Head line 1863-4 has averaged 13% more dry matter than Fraser. Unfortunately, it is lower in seed yield, varying with location, than Fraser. Interest from several locations is being shown in this line as a forage oat. An Ottawa line and another Indian Head line show promise. Early-generation material from three oat crosses from varying genetic sources shows some interesting prospects.

PUBLICATIONS

Research

Emmond, G. S., and Ledingham, R. J. 1972. Effects of crop rotation on some soil-borne pathogens of potato. *Can. J. Plant Sci.* 52:605-611.

Spratt, E. D., and McIver, R. N. 1972. Effects of topographical positions, soil test values, and fertilizer use on yields of wheat in a complex of Black Chernozemic and Gleysolic soils. *Can. J. Soil Sci.* 52:53-58.

Research Station Melfort, Saskatchewan

PROFESSIONAL STAFF

S. E. BEACOM, B.Sc., M.Sc., Ph.D. Director

Forage Production and Utilization

D. A. COOKE, B.S.A., M.Sc.	Program Leader; Breeding, evaluation, and production
J. A. ROBERTSON, B.Sc., M.Sc., Ph.D.	Forage utilization (beef cattle)
S. O. THORLACIUS, B.Sc., M.Sc., Ph.D.	Forage evaluation (sheep)
J. WADDINGTON, B.Sc., M.Sc., Ph.D.	Ecology and weed control

Cereal and Oilseed Production and Utilization

K. E. BOWREN, B.S.A.	Program Leader; Tillage and cropping
A. G. CASTELL, B.Sc., M.Sc., Ph.D.	Crop utilization (swine)
W. F. NUTTALL, B.S.A., M.Sc., Ph.D.	Soil fertility

Departure

H. R. BALLANTYNE, B.S.A. Retired August 1972	Cereal breeding and evaluation
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INTRODUCTION

The Research Station, Melfort, Sask., serves one of the largest and potentially most productive and diversified agricultural areas in Canada. The Station specializes in developing better systems for producing, harvesting, and utilizing forage crops and has an extensive research program on the production and utilization of cereal, oilseed, and special crops.

The rainfall during the 1972 growing season (April to August) at 18 cm was 6 cm below average. The average daily temperature was 12.1°C (0.3°C above the long-time average), and the killing frost-free period (above -2°C) was 132 days (10 days more than the long-time average).

Frequent showers and poor drying weather in June and early July interfered with haying operations. Showers and poor drying conditions during September delayed harvesting, but the weather was good for harvesting in October and although fall frosts reduced crop quality, yields were reasonably good.

Dr. S. O. Thorlacius, a ruminant nutritionist, joined the Melfort staff and is working on the utilization of harvested forages and cereal pastures. Mr. H. R. Ballantyne, in charge of cereal breeding and testing at the Station, retired after 26 years of service.

A tomato selection developed by Mr. R. H. Anderson before his retirement in 1970 was found to merit naming as a variety and will be released under the name 'Melfort'.

The Station publishes "Research Highlights" each year. Requests for this publication and any enquiries should be addressed to the Director, Research Station, Agriculture Canada, Box 1240, Melfort, Sask. S0E 1A0.

S. E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Variety Evaluation

Sainfoin

In 1970, 180 kg of Breeder seed of *Onobrychis viciaefolia* Scop. cv. Melrose was distributed to seed growers in Western Canada. This seed was multiplied to about 20,000 kg of Foundation seed, which in turn was released to growers in 1972 for the production of Certified seed. If a successful multiplication occurs in 1973, ample seed stocks of Melrose will be available for hay and pasture seedings in 1974.

Tepa Red Clover

Seed lots of the Finnish tetraploid *Trifolium pratense* L. cv. Tepa produced at various locations in Western Canada were tested in Finland to reveal possible changes in cultivar performance that might arise from seed multiplication outside the cultivar's region of proven adaptation. Producing seed in Canada did not appreciably alter the forage-yielding ability of the cultivar when grown in Finland. The seed lots produced in

northeastern Saskatchewan showed the least discernible change in population characteristics. Thus this area is considered to be a suitable region for commercial production of Tepa red clover seed.

Pollination Studies

Factors Affecting Contamination in Sweetclover Seed Production

A recessive low-coumarin gene was used as a marker to study the effects of isolation distance on contamination levels in sweetclover pollinated by honey bees. A 46-m isolation distance was found inadequate to maintain a high level of genetic purity. A considerable amount of contamination from crossing resulted with isolation distances of 46 to 804 m when there was little competitive bloom from other entomophilous crops. Rapeseed, *Brassica napus* L., a highly attractive and competitive crop, was an effective isolation barrier to contamination.

Alfalfa Leafcutter Bee

The alfalfa leafcutter bee, *Megachile rotundata* Fabr., was used to pollinate a 0.2-ha seed-increase plot of Angus alfalfa,

Medicago sativa L., seeded in 1971 with 180 g of seed. Rows were spaced 60 cm apart. Bees from 10,000 cocoons were released on June 20, when the alfalfa was at the 10% bloom stage; another similar release took place on June 29, at the 60% bloom stage. Despite an abnormally cold and cloudy pollination season, 168 kg of seed were harvested.

Production Management

Fertilizing Bromegrass-Alfalfa Pastures with N and P

N and P fertilizers were applied for the second successive year to bromegrass-alfalfa pastures established in the summer of 1966. On the average, the application of P at 20 kg/ha increased forage dry matter yield by 11% (3,203 vs. 2,890 kg/ha), and the addition of N at 134 kg/ha increased forage dry matter yield by 76%. On those pastures where the livestock was being fed supplemental barley, forage yields were higher, yield response to P fertilizer was less, and soil P level was higher than on pastures where the animals received no supplemental barley.

Weed Control in Forages

Investigations into the tolerance of sainfoin seedlings for herbicides have resulted in recommendations to register the herbicides MCPB and trifluralin for use on sainfoin. The reaction of sainfoin to several other herbicides was examined. Of these, nitrofen and dalapon damaged the sainfoin only slightly.

Alfalfa seedlings reacted only moderately to applications of 2,4-DB at rates up to 2 kg/ha; the herbicide gave excellent control of broadleaf weeds at the higher rates. Similar rates of 2,4-DB on established alfalfa during the early stages of crop growth in spring caused, at worst, a temporary check in plant growth, which showed up as a yield reduction when the crop was cut at 10% bloom. Regrowth was not affected.

Effect of Companion Crops on Forage Crop Establishment

Rapeseed and wheat as companion crops for forage markedly reduced forage yields in the year of establishment. Yields of alfalfa sown with wheat, *B. napus*, and *B. campestris* were only 6%, 2%, and 2%, respectively, of

yields when seeded alone. Yields of bromegrass seeded with wheat, *B. napus*, and *B. campestris* were only 6%, 2%, and 5% of yields when seeded alone. Yields of sainfoin and Russian wild ryegrass were also drastically reduced when *B. campestris* was used as a companion crop.

Forage Harvesting

Evaluation of Hay Harvesting and Storage Methods

Bromegrass-alfalfa (BrA) and sweetclover (Sc) hays harvested in 1971 using a variety of cutting and storage methods were ground and fed as the sole ration to growing lambs in 1972. Intakes of digestible dry matter (DDM) when Sc hay was harvested by means of the mower-conditioner, swath, and rake (M-C-S-R), the mower-conditioner-windrower (M-C-W), or the self-propelled conditioner-swather (S-P-C-S) were 12%, 20%, and 18% greater, respectively, than when the mower and rake (M=R) were used. DDM intakes of BrA hay harvested by M-C-W and S-P-C-S were 5% and 19% greater than by M-R, but intake of the hay harvested by M-C-S-R was 7% less. Storing Sc bales in the field in stooks or single bales resulted in a large decrease in hay quality, but the quality of BrA was reduced only when "field-stored" in single bales. Compared with hay stored under shelter immediately after baling, reduction in DDM intake of Sc was 28% for stooks and 25% for single bales; and for BrA 15% for single bales.

Significant correlations ($P < .01$) occurred between in vivo dry matter digestibility and in vitro organic matter digestibility ($r = 0.88$), dry matter digestibility and dry matter intake ($r = 0.85$), and dry matter digestibility and digestible dry matter intake ($r = 0.94$).

When 30% concentrate was added to the ground hay rations, there were no significant differences in lamb performance or feed intake among harvesting and storage treatments. Dry matter digestibilities were significantly different and the differences reflected those observed with 100% hay diet.

Assessment of a Mechanical Hay-stacking Wagon

Pure stands of bromegrass (Br), crested wheatgrass (Cwg), intermediate wheatgrass (Iwg), and sweetclover (Sc) were each dried in the windrow to approximately 65%, 70%,

75%, and 80% dry matter. The hays were then stacked by using a mechanical stacking wagon (Hesston Model 30 Stakhand). All stacks of Cwg and Iwg were in good condition when fed to steer calves the next winter. Mold developed in the center of the Br stacks that had been put up at 65%, 70%, or 75% dry matter, but no problems developed when the hay was fed to growing beef steers and feed intakes were higher than for the other two hays fed. A substantial amount of mold was evident throughout all stacks of Sc hay. Due to the risk involved in feeding moldy Sc, none of these stacks were fed.

Effect of Different Ensiling Techniques on the Feeding Value of Silage

Sc (34% DM) or BrA (43% DM) was ensiled in one-half of each of two divided bunker silos. The material in one silo was well packed; that in the other received no packing. The silos were covered with two layers of black polyethylene sheeting. Yearling steers fed BrA silage plus 0, 1.8, or 3.6 kg of barley daily gained 0.6, 0.8, and 0.8 kg per head per day; steers fed the Sc silage had corresponding gains of 0.5, 0.7, and 0.9 kg.

Steers fed packed silage had higher daily gains (0.1 kg) and required less dry matter per kilogram of gain (3.9 vs. 4.6 kg) than animals fed unpacked material. Two steers fed unpacked Sc died of suspected "sweetclover poisoning" after 7 wk on test and the feeding of the Sc silage was discontinued.

Losses due to spoilage and freezing were higher for packed silage (32.5%, due mainly to freezing) than for the unpacked material (22.4%, due mainly to spoilage).

Utilizing Pastures

Performance of Yearling Steers Related to Pasture Management

Four systems of managing yearling steers on rotationally grazed brome-grass-alfalfa pasture have been compared over the last 6 yr. In the summer of 1972 dry matter production was lower than average (3,251 vs. 3,811 kg/ha), and liveweight gain was adversely affected. Gains also suffered because of overstocking early in the season, and because the Angus calves used in the study had a much lower average daily gain (0.81

kg) than the Hereford (0.95 kg) and Charolais-Angus (1.06 kg) steers, which was not the case in previous years.

Over the 6 yr of the experiment, gains per hectare on pastures where no supplementary feed was used (put and take: low stocking rate, removal of surplus herbage as silage for late season feeding) averaged approximately 270 kg. When chopped green oats was fed as a supplement and a higher stocking rate used (3.7 steers/ha), gains increased to 381 kg/ha and when rolled barley was fed (stocking rate 3.7 steers/ha) gains averaged 464 kg. Good rates of gain (1.04–1.27 kg per head per day) have been maintained with a relatively fixed number of steers throughout the grazing season by using supplementary feed. Thus it has been possible to improve the economics of producing beef on pasture over the more conventional system of grazing practiced in Western Canada.

Oat Varieties Compared as Pasture

Two 0.1-ha plots of Fraser, Kelsey, Harmon, and OA 123-1 (a forage oat) have been grazed in rotation by growing lambs for 3 successive years. Dry matter production averaged 5,367 kg/ha and lamb gains averaged 536 kg/ha. OA 123-1 averaged 6% less DM and 10% less liveweight gain/ha than the other three varieties.

Utilizing Harvested Forages

Ground Hay in Starter Rations for Beef Steers

Charolais-Angus steers averaging 309 kg were gradually accustomed to a 90% grain ration (equal parts of barley and wheat) in 9, 42, 77, and 99 days, by being fed 18, 197, 394, and 607 kg of ground hay, respectively, per head as part of the starting ration. Steers receiving the least hay gained well for the first 100 days, after which the rate of gain decreased (average daily gain 1.45 kg). Steers fed the most ground hay gained fastest from the start of the test and maintained a good rate of gain to the end of the test (average daily gain 1.68 kg; $P < .01$). Feed-to-gain ratios for these two lots were 7.51 and 7.69, carcass weights 289 and 305 kg, and dressing percentages 56.2 and 55.8; carcass grades, depth of backfat, and area of eye of lean were similar in both groups. Returns to labor after all costs were subtracted from the value of the carcasses

favored steers fed the most ground hay when hay was valued at \$22 to \$27.50 and grain at \$44 to \$55/t (2,200 lb).

Anabolic Implants for Finishing Beef Steers

Finishing Charolais–Angus steers were implanted at an average weight of about 318 kg with 36 mg of diethylstilbestrol (DES) (Stimplants; Pfizer & Co.), 36 mg of Ralgro (Zeranol; Commercial Solvents Corporation), or 200 mg of progesterone and 20 mg of estradiol benzoate (Synovex S; E. R. Squibb & Sons). Comparable unimplanted steers served as controls. Steers receiving the Synovex S gained faster (1.68 vs. 1.52 kg/day, *P* approached .05), had a slightly higher dressing percentage (56.4 vs. 55.9), and graded as well as control steers. DES-implanted steers averaged 1.63 kg/day, dressed 64.8%, and had slightly less fat cover and larger area of lean eye than did control steers. Ralgro produced no significant response. Results are in contrast with last year's experiment, in which all three implant treatments produced highly significant increases in rate of gain. DES is no longer approved for use in Canada, but Ralgro has recently been approved for use.

Effect of Forage Quality, Fineness of Grind, and Initial Level in Wheat-based Rations for Finishing Steers

Roughages of good quality (bromegrass–alfalfa hay) and poor quality (intermediate wheatgrass hay and wheat straw) were ground through either a 1.27-cm or a 2.54-cm hammermill screen and incorporated at levels of 40%, 60%, or 80% of starter rations for finishing beef steers. Dry-rolled wheat, which constituted the bulk of the remainder of each ration, was increased gradually to 90% of each ration.

Feeding the good-quality roughage and grinding it through the coarse screen generally increased rate of gain and feed efficiency. Steers started on rations containing 40% or 60% roughage had similar rates of gain. Increasing the initial level of roughage to 80% decreased liveweight gain. Feed efficiency decreased with each increase in initial roughage level.

The choice of initial level of roughage would appear to depend primarily on the relative price of hay and grain plus the additional cost of processing each.

CEREAL AND SPECIAL CROP PRODUCTION AND UTILIZATION

Variety Testing

Wheat

At five sites in northeastern Saskatchewan, the feed wheat varieties Pitic 62 and Glenlea outyielded Manitou, a bread wheat, by 13% and 10%, respectively. Pitic 62 matures about 5 days later than Manitou and must be seeded by May 20 for satisfactory production.

Oats

A new oat selection, OT 618, developed at Melfort outyielded Garry, the standard, by an average of 15% at all stations and equaled the yield of Fraser and Random.

Rapeseed

The yield and oil content of SZ-69-687 (Midas) were equal to Target and slightly higher than Zephyr in tests in 1972. Torch, a new low erucic acid Polish variety, was equal in yield, oil content, and maturity to Span.

Field Corn

In a 16-variety hybrid corn test, Pioneer × 06012 (a flint-dent double cross) produced the highest yield of dry matter (13.9 t/ha) as silage. Some new hybrids have potential as livestock feed, but planting must be done early.

Winter Wheat

Tests on winter wheat were a failure in 1972. Varieties, dates, and depths of seeding are being compared in cooperative tests, and the early-seeded plots had produced good stands by freeze-up.

Fababeans (Horsebeans)

The varieties Ackerperle, Diana, Erfordia, Fioletowy, Kleinkornige, Maris Bead, Pavane, and Strubes produced essentially the same yields (3,000 kg of dry beans per hectare), required 125 days from seeding to maturity, and showed no response to inoculating with a *Rhizobium* culture in 1972.

Crop Production Management

Crop Rotations

The use of a grain-forage rotation has resulted in increasing net returns over those obtained on a straight grain rotation. The increase has been 5% at Melfort (Msic, 13-yr average), 25% at Somme (Tic, 16-yr average), and 92% at Archerwill (Wvl, 20-yr average), Sask. Over the past 3 yr the protein content of wheat produced in the grain-forage rotation has been about 0.5% higher than that of wheat produced on the straight grain rotation. The best cropping system was the one that involved 25–30% of the land in forage crops, 50% in cereal and special crops, and 20–25% in summerfallow.

Fertilizers

Barnyard manure. Barnyard manure applied at 34 t/ha every 5 yr in a grain-forage rotation on light-textured soil at Shellbrook, Sask., increased the yield of all crops in the rotation by 31% over the past 36 yr. Chemical fertilizer with each crop in the same rotation increased the yield by 23%.

Forms of nitrogen. Solution (28-0-0) and granular (34-0-0) N fertilizer alone and in combination with triallate applied in the fall or spring increased the yield of barley on stubble and gave satisfactory control of wild oats. The two forms of N produced a similar yield increase and the mixture of solution N and triallate was as effective as granular N and triallate applied separately for wild oat control.

Exchangeable NH₄-N in soils of northeastern Saskatchewan. Analysis of variance revealed that among-site variation (6 sites × 4 yr) in barley yield response to N on stubble was largely accounted for by soil tests for N. NO₃-N alone accounted for 63.8% of the variation. By adding the interaction of NO₃-N × NH₄-N and NH₄-N as independent variables, the R² value was significantly increased to 73.2%. Therefore, exchangeable NH₄-N could be used as an additional availability index for soil N to increase precision in estimating yield response to N fertilizers.

Chemical Summerfallow

During the past 7 yr it has been found that summerfallow prepared with herbicides (without tillage) produced the highest yield of grain; summerfallow tilled in the normal

way has given the lowest yields. The treatments were applied to the same plots in a fallow-wheat rotation to determine if there was an accumulative effect. Throughout the study, replacing some or all of the tillage on summerfallow with herbicides has resulted in a slight increase in the buildup of NO₃-N, P, and moisture in the soil. The cost of chemicals for controlling all the weeds on fallow is now so high that they cannot be recommended for general farm use.

Weed Control

Trifluralin at 1.1–1.4 kg/ha applied in the fall or spring controlled wild oats, *Avena fatua* L., in rapeseed. Several herbicides (mecoprop 1.1–1.7 kg/ha; bromoxynil-MCPA mixture at 420 g each/ha; and dicamba + 2,4-D + mecoprop at 140 + 420 + 420 g/ha) were found effective for controlling cleavers, *Galium* sp., in barley.

Effect of Organic Content on Crust Strength of Luvisolic Soils

Crusts formed on the surfaces of Luvisolic soils after heavy rainfall can prevent the emergence of cereal, forage, and oilseed crops. Surface samples of 12 Luvisolic soils in northern Saskatchewan were used to grow rapeseed, *Brassica napus* L. and *Brassica campestris* L., under crust-forming conditions in the greenhouse. Emergence of rapeseed plants was related to crust strength measured independently by modulus of rupture. Regression analyses revealed that crust strength was negatively related to the silt content (0.05–0.002 mm) and positively related to organic matter content (R² = 80.7%).

Crop Utilization and Animal Nutrition

Rapeseed Meal and Dehydrated Alfalfa in Rations for Beef Cattle

Eight groups of long-yearling steers were fed chopped wheat straw ad lib. plus either dehydrated alfalfa (dehy; 1.13 or 2.26 kg per head per day) or rapeseed meal (RSM; 0.57 or 1.13 kg per head per day). Dry-rolled barley was fed at 1.36 kg per head per day to one of the groups receiving each level of dehy or RSM. Steers fed dehy had higher average daily gains and lower costs per kilogram of gain (at current prices) than steers fed the equivalent amount of protein as RSM. Based on protein content, dehy is

worth approximately 50% of RSM, but for maintenance rations where digestible energy is often a limiting factor, the relative nutritive value of dehy probably increases to at least 60% of RSM.

Intake and Digestibility of Rapeseed Screenings by Wethers

Groups of four wethers were fed rapeseed (refuse) screenings (51% wild oats; 34% wheat, oats, and barley; 15% rapeseed, fines, and chaff) that had been ground to pass a 1.27-cm, a 0.80-cm, or a 0.16-cm hammer-mill screen, in either the meal or pelleted (0.32-cm die) form. Voluntary intakes and digestibilities were determined. Fine grinding reduced voluntary intake of meal rations, but had no effect on intake of pelleted rations. Pelleted rations were consumed in greater amounts than the meal rations (75.4 vs. 61.5 g/unit $W^{0.75}$). Digestibility of protein was similar for all rations. Reducing the average particle size decreased digestibility of dry matter, energy, and cellulose. Digestibility and intake of screenings were therefore maximized by coarse grinding and pelleting.

Utilization of Oilseed Products by Pigs

Rapeseed varieties. Two basal rations, one consisting of barley and meatmeal (MM), the other of barley and soybean meal (SBM), were each altered to include (a) 10% rapeseed meal from *B. napus* cv. Target (TRSM); (b) 10% rapeseed meal from *B. campestris* cv. Span (SRSM); and (c) 10% ground Span rapeseed (SRS) with adjustments made in barley, MM, and SBM to maintain 16% crude protein in all rations.

Each of the eight rations was fed, ad lib., to two pens of four 11-wk-old pigs over the

period from 23 to 91 kg average liveweight. Pigs fed rations with MM had similar rates of gain, better feed-to-gain ratio, higher dressing percentage, lower grading carcasses, and lower Record of Performance (ROP) percentage yield than pigs fed rations containing SBM.

The rapeseed supplements significantly reduced the growth rate, although the Span supplements improved the feed-to-gain ratio. There was negligible effect upon dressing percentage, grade, and ROP percentage yield. The better performance of pigs fed SRSM may have been due to the lower levels of glucosinolates in the meal. Although these levels were not determined, they are generally lower in *B. campestris* varieties than in *B. napus* varieties.

Unprocessed rapeseed. SRS was ground and included as 0%, 4%, 8%, and 12% of a 16% grower ration fed ad lib. to thirty-two 12-wk-old pigs from 29 to 92 kg average liveweight. Increasing the level of SRS reduced the growth rate but tended to improve the feed-to-gain ratio. Carcass quality was not significantly affected, although grades and ROP percentage yields improved with addition of SRS.

Raising the level of SRS changed the content and composition of the dietary fat. The increases in oleic, linoleic, and linolenic acid in the diet were reflected in significant changes in the backfat composition, that is, decreases in the proportion of palmitic, palmitoleic, and stearic acids and increases in linoleic and linolenic acids. The proportions of saturated fatty acids declined significantly ($P < 0.01$) in both the inner and outer backfat layers.

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Research Station Regina, Saskatchewan

PROFESSIONAL STAFF

J. R. HAY, B.S.A., M.S., Ph.D. Director

Biological Control of Weeds

P. HARRIS, B.S.F., D.I.C., Ph.D. Head of Section; Biological control—weeds
M. G. MAW, B.Sc., M.Sc. Biological control—weeds
D. P. PESCHKEN, B.S.A., M.Sc., Dr.Sci.Agr. Biological control—Canada thistle

Weed Control Section

J. D. BANTING, B.S.A., M.Sc., Ph.D. Head of Section; Weed science—annual grasses
K. F. BEST, B.S.A., M.Sc. Weed biology
G. G. BOWES, B.S.A., M.Sc. Weed science—range weeds
J. H. HUNTER, B.S.A., Ph.D. Weed science—agronomy
G. I. MCINTYRE, B.Sc., Ph.D. Weed biology
E. S. MOLBERG, B.S. Weed science—agronomy

Herbicide Behavior in the Environment

R. GROVER, B.Sc., M.Sc., Ph.D. Head of Section; Availability, mobility, monitoring
G. S. EMMOND, B.S.A., M.Sc. Residues
S. U. KHAN, B.Sc., M.Sc., Ph.D. Adsorption mechanisms
A. E. SMITH, B.Sc., Ph.D. Residues, metabolism, methodology

Seed Section

E. D. MALLOWH, B.S.A. Head of Section; Distribution
G. R. BOUGHTON, B.S.A., M.Sc. Verification

INTRODUCTION

This is a report of the work done in 1972 at the Research Station, Regina. The Station is the main center for weed control research in Western Canada. In addition, seed of new varieties of cereals, forage, and oil crops developed by the Branch is increased and distributed from the Station.

Three research scientists, Dr. P. Harris, Dr. D. P. Peschken, and Mr. M. G. Maw, were added to the staff in 1972, to continue work on the biological control of weeds. This program of the Branch was formerly located at the Research Institute, Belleville, Ont., but was transferred to Regina, where it could be more easily integrated with other weed programs. A new laboratory with greenhouse and quarantine facilities was constructed for this work. Candidate insects will be screened in the quarantine facilities before release. The program will provide a service to the whole country and will require the cooperation of workers across Canada.

The mailing address of this establishment is Research Station, Research Branch, Agriculture Canada, Box 440, Regina, Sask. S4P 3A2.

J. R. Hay
Director

BIOLOGICAL CONTROL

The Canadian program on biological control of weeds, previously centered at Belleville, Ont., was relocated at Regina, Sask. A priority list of 25 weeds for biological control was prepared by the Canada Weed Committee. New work was started on many of these weeds; on others, agents already established were monitored.

After 4 yr of defoliation by the cinnabar moth, *Tyria jacobaeae* (L.), tansy ragwort declined to less than 0.1% of its former density on a permanent pasture at Durham, N.S. A similar decline appeared to occur at Sussex, N.B. However, the moth population increased slowly and had less impact in northern New Brunswick and Prince Edward Island. It was least successful in British Columbia, where, despite annual defoliation, the weed regenerated during the mild winters.

The spurge hawkmoth, *Hyles euphorbiae* (L.), established on cypress spurge at Braeside, Ont., declined in density from 1.0 to 0.3 larva/m², possibly as a result of the damp summer.

Defoliation of St. John's-wort by the beetles *Chrysolina quadrigemina* (Suff.) and *C. hyperici* (Forst.), released in 1969, increased the yield of forage by about 50% at the release site in Ontario. The beetles also survived in Nova Scotia and New Brunswick.

The density of the seed-head weevil *Rhinocyllus conicus* (Froel.) increased fourfold each year since it was released on nodding thistle in 1968 at Craik, Sask. It has now reached a density of 0.25 weevil/head. Small numbers of the weevil continue to survive on welved thistle in Ontario.

The seed-head fly *Urophora affinis* (Frflid.) continued to increase in density and spread on diffuse and spotted knapweed near Kamloops, B.C.

The root and stem-boring weevil *Ceutorhynchus litura* (Fab.) persisted in Ontario. At the center of the release site, only 6% of the shoots of Canada thistle were attacked compared with 44% in the previous year, but density of the thistle decreased from 5.2 to 0.5 shoots/m². At the periphery the number of shoots dropped from 22/m² in 1971 to 9.2/m² in 1972, and the percentage of attacked shoots declined from 12.5% to 10.5%. Also, 21% of the shoots were infested with the rust *Puccinia punctiformis* (Str.) Roehl., whereas the average level was only 4% on six surrounding sites that were free of the insect. This adds to the circumstantial evidence found in 1971 that the weevil aids in dispersal of the rust.

WEED CONTROL

Tolerance of new varieties for recommended herbicides. A program was set up in

1967 to determine whether new cereal varieties were particularly susceptible to damage from the recommended herbicides. It is important to provide this information before a new variety is licensed.

Esters and amine salts of 2,4-D and MCPA, diallate, triallate, barban, TCA, dalapon, mixtures of dicamba and dichlorprop with 2,4-D, and mixtures of bromoxynil and linuron with MCPA were used at the highest recommended rates. Spring wheat, durum wheat, barley, oats, and flax were included in the program. Grain yield and quality, plant deformities, plant height, days to heading and maturity, 1,000-kernel weight, and percentage of germination were determined.

None of the new varieties introduced since 1968 was more susceptible than the previously recommended varieties. However, several of the old and new varieties showed some injury from the herbicide treatments in one test or another. This emphasizes that more attention should be given to these effects.

Under weed-free conditions, 2,4-D ester at 0.56 kg/ha (8 oz/ac), 2,4-D amine plus dicamba (3:1) at 0.56 kg/ha (8 oz/ac), and 2,4-D ester plus dichlorprop (1:1) at 1.12 kg/ha (16 oz/ac) caused a significant reduction in the grain yield of several varieties. Although the reduction in grain yield varied with the variety, it was large in some cases. For example, the yield of Selkirk wheat treated with 2,4-D ester at 0.56 kg/ha (8 oz/ac) was reduced by an average of 11.5%.

When four varieties of flax (Linott, Noralta, Redwood 65, and Raja) were treated with dalapon at 1.4 kg/ha (20 oz/ac), the blossoms were pale blue to white by contrast with their normal blue color. The petals remained tightly rolled together as in the bud, and the flowers failed to open normally. The flowers of Raja appeared to be affected more than those of the other varieties. Seed yields of the dalapon-treated plots were significantly lower than yields of the corresponding controls. As a result of this work the top rate for the use of dalapon on flax recommended by the Canada Weed Committee was lowered to 1.12 kg/ha (16 oz/ac).

Crop tolerance for new herbicides. Under weed-free conditions, wheat tolerated pre-planting and preemergence applications of soil-incorporated R 21403 (Stauffer Chemical Co.) at 3.36 kg/ha (4 lb/ac), preplanting

applications of glyphosate (Monsanto Chemical Co.) at 8.97 kg/ha, and postemergence applications of AC 84777 (Cyanamid of Canada) at 2.24 kg/ha. Wheat was not tolerant of USB 3584 (U.S. Borax) at 0.56 kg/ha (8 oz/ac), incorporated into the soil before planting.

Noralta flax had an acceptable degree of tolerance for a number of experimental herbicides and mixtures applied at rates likely to control weeds. Postemergence applications of a mixture of asulam plus MCPA delayed blossoming by 2–3 days and maturity by about 1 day, but flax yields were not significantly reduced. Flax tolerated a mixture of linuron plus MCPA, and BAS 3515 (BASF Canada Ltd.) applied after emergence; EPTC, and a mixture of EPTC plus R 7465 (Stauffer Chemical Co.) incorporated before planting; and IMC 3950 (Chipman Chemicals Ltd.) applied before or after emergence. The preemergence treatments with IMC 3950 caused less crop injury than postemergence applications.

Root rot. In 1971, a joint project was set up with Dr. R. D. Tinline of the Research Station at Saskatoon to determine the effect of recommended herbicides on the susceptibility of wheat to common root rot.

Esters and amine salts of 2,4-D and MCPA, triallate, barban, and mixtures of dicamba and 2,4-D, dichlorprop and 2,4-D, and bromoxynil and MCPA were used at the highest recommended rates. The number of diseased plants was determined at the six-leaf, late-flowering, and firm-dough stages.

With the exception of triallate, none of the herbicides affected the incidence of root rot. In 1971 and 1972, triallate significantly increased the occurrence of common root rot in the resistant variety Manitou at all sampling dates, and in the susceptible variety Cypress at the first two sampling dates. However, the yield of wheat was significantly higher in the plots treated with triallate, so that the increase in root rot was not of serious consequence.

Wild oats. Benzoylprop ethyl (WL 17731; Shell Oil Co.) significantly reduced the growth of wild oats without killing the plants. It was most effective if applied when the wild oats were in the four-leaf stage. Treatment with benzoylprop ethyl at 1.4 kg/ha (20 oz/ac) resulted in 43.5% and 38.9% decreases in the dry weight and seed weight of wild oats, and a 55.6% increase in the

yield of wheat. Its effectiveness was significantly reduced when it was applied in a mixture with 2,4-D. When the two products were applied separately, wild oat control was better when the 2,4-D was applied 4 days after the benzoylprop ethyl.

Chemical summerfallow. Terbutryn, an experimental triazine herbicide applied to annual weeds on summerfallow on July 20, 1971, caused visible injury and reduced yields of wheat grown on the land the following year. When terbutryn was applied earlier, on June 21, 1971, the 1972 crop was injured also, but to a lesser degree. This injury, and incomplete weed control in the fallow year, showed that the treatment was unsatisfactory for chemical summerfallow. These results were similar to previous findings at this Station from work with other triazine herbicides, which gave incomplete weed control, or injured the succeeding crop, or both.

Early- and late-flowering stinkweed. Two distinct types of stinkweed have been identified; one type flowers in less than 50 days, the other after more than 90 days. The leaves of these types have different shapes when growing as rosettes and can be easily distinguished in the field. There is some evidence that temperature may affect the expression of this difference, and that vernalization of the seed or seedlings may prevent its expression in the late-flowering type.

Control of brush on aspen parkland. Final assessments were made on a series of plots under study since 1966. Covers of aspen poplar and balsam poplar were reduced to less than 1% for at least 3 yr when treated with 2,4-D at 2.24 kg/ha (2 lb/ac) followed 1 yr later by an application of 2,4-D plus 2,4,5-T at 2.24 kg/ha (2 lb/ac). Control of prairie rose was not satisfactory except in the year after the second application.

Plots that received an ester of 2,4-D at 2.24 kg/ha (2 lb/ac) had less than 2% cover, whereas plots receiving oil- and water-soluble amine formulations of 2,4-D had 9.5% cover. The butyl, isooctyl, and butoxyethanol esters gave equally good control of aspen poplar. Applications of butyl ester of 2,4-D in water, oil, or a mixture of oil and water gave equally satisfactory results.

Control of brush 1 yr after an application during dormancy was not as good as control

after applications made during the growing season. There was little or no damage to the alfalfa after the dormancy application. Four years after dormancy applications, the cover provided by alfalfa, aspen poplar, balsam poplar, and prairie rose was the same as in untreated plots. Prairie rose was not controlled by the dormancy application of 2,4-D plus 2,4,5-T.

An application of 2,4-D at 2.24 kg/ha (2 lb/ac) plus picloram at 0.55 kg/ha (0.5 lb/ac) gave almost complete control of aspen poplar and prairie rose. It also eradicated the alfalfa.

HERBICIDE BEHAVIOR IN THE ENVIRONMENT

Air-monitoring for 2,4-D. In cooperation with the Saskatchewan Research Council, six monitoring sites were established in Saskatchewan: at Regina, Indian Head, Swift Current, Saskatoon, Naicam, and Rosetown. The butyl ester of 2,4-D at concentrations up to $0.18 \mu\text{g}/\text{m}^3$ was detected at all three sites in southern Saskatchewan, on a number of days. No isooctyl ester or amine forms were found in southern Saskatchewan.

Adsorption of diallate, triallate, and trifluralin. The adsorption of diallate, triallate, and trifluralin on several soils and various adsorbents was studied. Adsorption of all three herbicides was high; their relative order of adsorption was trifluralin \geq triallate $>$ diallate. The K values (μg adsorbed/g of soil when in equilibrium with a solution concentration of 1 ppm) were 100 to 1,000 times higher than those reported for acid herbicides.

Leaching behavior of 2,4-D. The 2,4-D acid leached readily in all soil types studied. The butyl and isooctyl esters of 2,4-D were hydrolyzed and the dimethylamine salt of 2,4-D was dissociated in moist soils. Thus, these forms all leached as readily as the parent acid.

^{14}C -dimethylamine salts of 2,4-D and dicamba were synthesized and their dissociation on moist soils was studied. Both salts underwent dissociation; the dimethylamine cation became strongly adsorbed on the soils, whereas the anions were not adsorbed on soils.

Persistence of linuron. Only 15–21% of linuron applied in the fall of 1971 at 2.24

kg/ha (2 lb/ac) was recovered from soil sampled in May 1972. None was detected in samples taken at depths below 5 cm.

Interaction of herbicides with humic substances and clay. 2,4-D, dicamba, and picloram were firmly retained or complexed with humic acids at pH 3. The mechanism probably involved the large surfaces or internal spaces of humic acid. More paraquat than diquat was bound to humic or fulvic acids. Humic acid complexed more of both paraquat and diquat than did fulvic acid. A complex of organic matter and clay also adsorbed more paraquat than diquat.

Triallate formed a complex with montmorillonite that was stable on heating to 50°C for 15 days. When the complex was shaken with water, the herbicide was completely displaced from the clay.

Herbicide residues. Analytical procedures were developed for the extraction from soil and analysis of residues of 2,4-D amine, dicamba, dichlobenil, USB 3584, and simazine. Recoveries were over 90% from three Saskatchewan soil types treated at levels of 0.1 to 1.0 ppm.

Over 70% of trifluralin, triallate, USB 3584, and simazine residues were recovered from the top 5 cm of soil at three locations. The following spring, 30% of the applied diallate, 20% of the dichlobenil, and 0% of dicamba and 2,4-D were detected. No residues were recovered at depths greater than 5 cm.

The persistence of triallate, trifluralin, USB 3584, dichlobenil, simazine, and dicamba was studied at three locations, in small field plots, to determine the percentage residues remaining in October after applications in May. Residues of all herbicides except dicamba were recovered from the top 5 cm of all soil types; simazine, triallate, and trifluralin were the most persistent. No residues were recovered at depths greater than 5 cm.

Disappearance of dicamba from soils at 25°C was studied in the laboratory. In general, degradation was rapid and dependent upon moisture. At field capacity levels, breakdown was complete in 2–3 wk, whereas at lower moisture rates residues could still be

detected after 6 wk. ¹⁴C-dicamba was applied to moist Regina heavy clay and incubated at 25°C. Thin-layer chromatography and autoradiographic techniques were used to isolate and identify soil degradation products. In addition to the parent compound, small amounts of 3,6-dichlorosalicylic acid were detected.

The persistence of atrazine, at various application rates, was investigated in small field plots at three sites in Manitoba. This work was carried out jointly with Mr. D. Dryden of the Research Station at Brandon. Approximately 30% of the atrazine applied in May 1972 was recovered in October at all sites.

SEED SECTION

Distribution and increase. Napayo (C.T. 432), a new variety of hard red spring wheat, was distributed to seed growers. In the eastern portion of Saskatchewan, 37 growers of Select seed received a total of 10,070 kg (22,200 lb) of seed in allotments of 270 kg (600 lb). In Manitoba 10,340 kg (22,800 lb) of seed were distributed to 38 growers of Select seed.

Two new low-erucic-acid strains of rapeseed were increased under contract. The *Brassica campestris* strain was placed under contract with 88 growers for the production of Foundation seed, and with seven growers for production of Certified seed. The *B. napus* strain was distributed under contract to eight growers for the production of Foundation seed. In addition, a contract was arranged for 220 ha (300 ac) in southern California to provide a winter increase of the *B. napus* strain.

Eight new varieties comprising one durum wheat, two two-row barleys, one six-row barley, two oats, one large-seeded green pea, and one sunflower were increased for possible distribution in 1973.

Breeder seed. Breeder seed of 60 varieties of 13 crops is maintained and distributed by the Seed Section. In 1972, 4,164 kg (9,197 lb) of seed from 27 varieties of 10 crops were made available to 400 growers; 11 varieties were added to the program.

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Research Station Saskatoon, Saskatchewan

PROFESSIONAL STAFF

J. E. R. GREENSHIELDS, ¹ B.S.A., M.Sc., Ph.D., F.A.I.C.	Director
R. K. DOWNEY, B.S.A., M.Sc., Ph.D.	Acting Director
J. C. BOYER	Administrative Officer

Scientific Support

F. CHEN (Mrs.), B.A., M.A., M.L.S.	Assistant Librarian
A. E. MCPHERSON (Miss), B.A., B.L.S., M.A.	Library Area Coordinator
H. K. MILNE (Miss)	Computer Systems Programmer
M. E. TAYLOR, B.S.A.	Research Information Officer

Crop Management Section

C. H. KEYS, B.S.A.	Head of Section; Weeds and crop management
W. L. CROWLE, B.S.A., M.Sc.	Cereals and crop management
L. G. SONMOR, B.S.A., M.Sc.	Irrigation
H. UKRAINETZ, B.S.A.	Soil fertility

Plant Breeding Section

R. P. KNOWLES, B.S.A., M.Sc., Ph.D., F.A.I.C.	Head of Section; Grasses
R. K. DOWNEY, B.S.A., M.Sc., Ph.D.	Oilseed breeding; rapeseed
B. P. GOPLEN, B.S.A., M.Sc., Ph.D.	Legume breeding
R. E. HOWARTH, ² B.S.A., M.Sc., Ph.D.	Legume bloat biochemistry
A. J. KLASSEN, B.S.A., M.Sc., Ph.D.	Oilseed breeding; rapeseed
D. I. MCGREGOR, B.Sc., M.Sc., Ph.D.	Physiology; Brassicas
S. H. PAWLOWSKI, B.Sc., M.Sc.	Oilseed breeding; mustard, sunflowers
G. R. STRINGAM, B.S., M.S., Ph.D.	Cytogenetics; Brassicas

Entomology Section

R. H. BURRAGE, B.S.A., Ph.D.	Head of Section; Wireworms
L. BURGESS, B.Sc., M.Sc., Ph.D.	Associate Head; Oilseed crop insects
A. P. ARTHUR, B.Sc., M.S., Ph.D.	Oilseed crop insects
R. E. BELLAMY, B.S., M.S., M.A., Ph.D.	Mosquitoes
N. S. CHURCH, B.Sc., M.S., Ph.D.	Insect endocrinology
C. H. CRAIG, B.A.	Forage crop insects
G. R. F. DAVIS, B.Sc., M.Sc., Ph.D.	Insect nutrition
J. F. DOANE, B.S.A., M.Sc., Ph.D.	Wireworms; ecology
A. B. EWEN, B.A., M.A., Ph.D.	Grasshoppers; physiology
R. J. FORD, B.S.A., M.Sc., Ph.D.	Pesticide application; engineering
F. J. H. FREDEEN, B.S.A., M.Sc.	Black flies
Y. W. LEE, B.S., M.S.	Pesticide chemistry
K. S. MCKINLAY, B.Sc.	Pesticide application; toxicology
J. J. R. MCLINTOCK, B.Sc., Ph.D.	Mosquitoes and arboviruses
H. MCMAHON, B.S.A., M.Sc.	Pollinators
R. PICKFORD, ³ B.S.A., M.Sc., Ph.D.	Grasshoppers; ecology
L. G. PUTNAM, B.S.A., M.Sc.	Rapeseed insects
J. G. SAHA, B.Sc., M.Sc., Ph.D.	Pesticide chemistry
W. W. A. STEWART, B.Sc.	Mosquito ecology and control

Plant Pathology Section

R. D. TINLINE, B.A., M.Sc., Ph.D.	Head of Section; Cereal root diseases
S. H. F. CHINN, B.Sc., M.Sc., Ph.D.	Soil microbiology
H. HARDING, B.Sc., Ph.D.	Legume and cereal diseases
R. J. LEDINGHAM, B.Sc., M.Sc.	Cereal root diseases
G. A. PETRIE, B.A., M.A., Ph.D.	Oilseed crop diseases
J. D. SMITH, B.Sc., M.Sc.	Grass diseases

Departure

H. McDONALD, B.S.A., M.Sc., Ph.D. Retired July 20, 1972	Assistant Director
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VISITING SCIENTISTS

National Research Council postdoctorate fellows

I. J. ANAND, B.Sc., M.Sc., Ph.D., 1969-72	Oilseed crops
M. H. BALBA, B.Sc., Ph.D., 1971-72	Pesticide chemistry
H.-C. HUANG, B.Sc., M.Sc., Ph.D., 1972-73	Cereal diseases

Colombo Plan graduate student

M. A. SALAM, M.Sc., 1969-73	Oilseed crops
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German Academic Exchange Service fellowship

G. RAKOW, Dipl.Agr., Ph.D., 1972-73

Oilseed crops

International Atomic Energy fellow

J. Y. Yoo, B.S., 1972-73

Pesticide chemistry

¹On Senior Postdoctoral Research Fellowship, Christchurch, New Zealand, October 1972 to April 1973.

²On transfer of work at Research Station, Summerland, B.C., June 1972 to August 1973.

³On transfer of work at London, England, October 1971 to September 1972.

INTRODUCTION

The Research Station at Saskatoon conducts a broad research program on crop production and crop and animal protection. Included are the breeding and management of rapeseed, mustard, sunflowers, wheat, barley, alfalfa, sweetclover, sainfoin, trefoil, brome grass, crested wheatgrass, intermediate wheatgrass, slender wheatgrass, reed canarygrass, turfgrasses, and a number of miscellaneous crops; the ecology and control of some of the more important plant diseases and weeds, and insect pests affecting these crops, animals, and humans; the histophysiology of insects; the fertility of soils; and pesticide application and residues in crops and soils. Accomplishments in selected subjects are summarized in this report.

The mailing address of this establishment is Research Station, Research Branch, Agriculture Canada, University Campus, Saskatoon, Sask. S7N 0X2.

R. K. Downey
Acting Director

CROPS

Oilseeds

Rapeseed varietal conversion. Over 85% of the 1.32 million ha (3.27 million ac) of rapeseed grown in Western Canada in 1972 was sown to the new low erucic acid varieties Span, Zephyr, and Oro. The changeover is 95% complete in Saskatchewan and Manitoba, but only 65% in Alberta. The conversion to these varieties, which produce nutritionally more desirable edible oils, has been achieved in 2 yr without the use of formal regulations or subsidies. The program is one of the most rapid, extensive, and complete changes in the use of commercial varieties ever attempted.

Extensive damage to Zephyr and Oro seed by early, severe frosts in September has emphasized the need for an earlier maturing variety of *Brassica napus* L. Because of the superior performance of strain SZ69-687 in the 1972 Cooperative Rapeseed Tests, application has been made to license and release this strain under the variety name Midas.

A *B. campestris* strain, SC69-818, tested in 1971 and 1972, was found to be equal or superior to Span in seed yield and higher in oil and protein content. Application has been made to license and release this strain under the name Torch. Torch is expected to replace Span in all areas except the Peace River region in Alberta.

Grasses

Nutritional quality of crested wheatgrass. In vitro analysis of forage from individual plants of various varieties and strains of

crested wheatgrass was undertaken to determine the possibility of improving the digestibility of this important forage. The widest ranges in percentage of in vitro digestible organic matter were found in the varieties Nordan (40.3% to 57.6%) and Fairway (45.7% to 59.1%). Ranges among individual plants of the Parkway variety and selected strain S-7461 were narrower, but the genetic variability in all varieties and strains was significant. The heritability for in vitro digestibility in the S-7461 strain was 0.54. This wide variability and high heritability show that the digestibility and nutritive value of varieties of crested wheatgrass could be improved through plant breeding.

Isolation requirements for seed production of crested wheatgrass. The development of two true breeding lines of crested wheatgrass with contrasting gray green and bright green foliage permits identification of seedlings resulting from outcrosses of gray green with bright green plants. Adjacent 0.2-ha (0.5-ac) plots of gray and bright green strains sown in 1966 have resulted in contamination in the gray green plot of 4%, 14%, 22%, and 6% for 1967-70. Similar levels of outcrossing (15%, 22%, and 10%) were recorded in 1968-70 in adjacent 0.08-ha (0.2-ac) plots. Contamination levels dropped to 5% in 1967, and 2% in 1968, when the distance between 0.2-ha (0.5-ac) plots of the two strains was increased to 10 m (33 ft). However, 2-ha (5-ac) fields of these two strains, when separated by a 46-m (150-ft) strip of intermediate wheatgrass, still showed contamination of 9% in 1970, and 2% in 1971.

These data emphasize the need for substantial isolation distances between different varieties of the same crop kind when producing pedigreed grass seed. It has been found that even at the minimum isolation distance (50 m, or 155 ft) required for the production of Certified grass seed, unacceptable contamination levels may occur under certain conditions.

Legumes

Investigations at the Research Station, Summerland, B.C., showed that the incidence of bloat in ruminant animals is associated with soluble Fraction 1 protein in legume forage. Bloating legumes contained 3.4% to 6.8% of this protein fraction compared with 0% to 1.4% in nonbloating legumes. One research scientist from this station was seconded to the Research Station at Summerland, B.C., to initiate a breeding program to develop a nonbloating alfalfa. In 1970 and 1971, large nurseries containing widely diverse sources of *Medicago* species, varieties, and strains were established for evaluation and selection. Before selection was made from these populations the most efficient and effective methods of identifying alfalfa plants low in Fraction 1 were investigated. These studies showed that Fraction 1 protein is not subject to diurnal fluctuations; green forage samples do not require instant freezing with liquid N, as had been previously done; all cells within the sample must be ruptured by means of a glass tissue homogenizer to ensure total release of Fraction 1 protein; large differences exist in Fraction 1 levels between leaves (5.07%) and stems (1.78%); Fraction 1 levels are highest (7.21%) in the earliest prebud stage (i.e., crop 10-15 cm (4-6 in.) high) and remain fairly constant at 5.0% from early bud to early seed set.

In 1971, approximately 100 varieties and strains of *Medicago sativa* L., *M. media* L., and *M. falcata* L. were analyzed for percentage of Fraction 1 by means of thin slab acrylamide gel electrophoresis. More than 4,000 individual plants were analyzed using samples (of the top 10 cm (4 in.)) from second-year mid-bud spring growth. Plants with less than 2% and more than 5.5% Fraction 1 were selected for reevaluation in 1972. Results indicate that the excess variance associated with the gel electrophoresis

technique does not permit accurate identification of low Fraction 1 plants. A new and more reliable method of analysis for measuring soluble proteins by means of spectrophotometry has been developed and will be used for screening plant breeding populations. Soluble Fraction 1 protein levels in alfalfa are expected to lower gradually through successive cycles of recurrent selection.

As the level of soluble Fraction 1 protein is reduced an increase in the tannin content of alfalfa forage is expected. Nonbloating legumes such as sainfoin, birdsfoot trefoil, and crownvetch have precipitating agents (probably tannins) at such concentrations that practically no soluble protein is released from the leaves after cell rupture. Despite high tannin contents, such nonbloating legumes may be highly palatable.

Soil Fertility

Nitrogen sources for wheat and barley. In the past 6 yr, studies on four soil types in western Saskatchewan showed that wheat and barley yields, stands, and fertilizer phytotoxicity were influenced by the rate and form of N applied, soil moisture, and soil cation exchange capacity (CEC).

On a Sceptre heavy clay with a CEC of 45 meq/100 g little or no phytotoxicity was found from either urea or ammonium nitrate up to 89.7 kg N/ha (80 lb/ac). Slightly higher seed yields were obtained with N:P at 1:1 rather than at 2:1. On this soil, N placed with the seed resulted in equal or higher seed yields than when N was broadcast and incorporated before seeding.

On two Gray Luvisols, Waitville loam (CEC = 15) and Loon River loam (CEC = 12), high rates of urea placed with the seed depressed germination, plant populations, and grain yield. Dry soil aggravated this condition and as little as 34 kg of urea N/ha (30 lb/ac) placed with the seed caused phytotoxicity and reduced grain yield. Neither form of N was phytotoxic when broadcast and incorporated before seeding. Ammonium nitrate placed with the seed gave equal or higher seed yields than when it was broadcast.

Barley was more sensitive than wheat to N phytotoxicity from urea and utilized broadcast N more efficiently. Under favorable moisture conditions, N applied with P greatly increased the yield on all soils tested for both cereals.

Weed Control

Herbicide control of Crepis tectorum L. This 2,4-D resistant, winter annual, commonly known as narrow-leaved hawk's-beard, has become a serious problem in northern Saskatchewan. At Loon Lake over the past 3 yr with the use of a herbicide this weed has been controlled in established alfalfa and in a cereal crop. A mixture of 2,4-D and picloram, at 0.35 and 0.52 litre/ha (5.0 and 7.5 oz/ac), applied to stubble land in the fall gave 98% to 100% control of *C. tectorum* in the cereal crop that followed. A control of 83% to 93% was also obtained with fall application of a mixture of dicamba, 2,4-D, and mecoprop (MCP) at 0.56 litre/ha (8 oz/ac) and 0.84 litre/ha (12 oz/ac) of total acid equivalent. A mixture of equal parts of 2,4-D and 2,4-DP at 1.12 litres/ha (16 oz/ac) gave only 75% to 77% control of *C. tectorum*. Only the mixture of 2,4-D and picloram significantly increased the yield of cereal.

Fall application of 2,4-DB to established Beaver alfalfa at 1.68 and 2.74 litres/ha (24 and 32 oz/ac) gave 93% to 97% control of *C. tectorum* without injuring the alfalfa crop. Other treatments resulted in either poor weed control or serious injury to the crop.

ENTOMOLOGY

Rapeseed Insects

Bertha armyworm. As a result of the record outbreak in 1971 of the bertha armyworm, *Mamestra configurata* Wlk., an expanded monitor and control program in cooperation with the prairie provincial departments of agriculture was organized and implemented. The outbreak in Saskatchewan in 1972 was serious, but less intense than in 1971. The insecticide methomyl (Lannate; DuPont of Canada Ltd.) gave adequate control, and some fields were protected also by a naturally occurring disease or diseases that killed the maturing larvae. The outlook for Saskatchewan in 1973 is for a further decline in the number of armyworms.

The usual method for determining methomyl residues could not be used on rape, because of interference from the sulfur-containing compounds that occur naturally in *Brassica* seed and foliage. A gas chromatographic method for methomyl residues was developed to overcome this problem. The

method is 90% to 93% efficient and can detect as little as 0.02 ppm of methomyl residue. Extensive analysis of rape plants and seed, with the use of the new analytical method, showed that methomyl disappears rapidly from rape plants, leaving almost no residue in the harvested seed. In rapeseed samples from 36 fields treated with methomyl, 33 samples showed no detectable residue and 3 samples showed only trace amounts (0.02 to 0.03 ppm). These data indicate that methomyl does not present a residual hazard in rapeseed.

Other insects of rape. A decline in numbers of the beet webworm, *Loxostege sticticalis* (L.), and the diamondback moth, *Plutella maculipennis* (Curt.), moths identified in the prairie light trap program in 1972, suggests an ebbing of the beet webworm threat and an interruption of what had appeared to be a 2-yr cycle of diamondback abundance and scarcity. Damage to rape fields by the red turnip beetle, *Entomoscelis americana* Brown, was reported in scattered locations. Flea beetles, *Phyllotreta* spp., continue to damage rape seedlings. Five or six species of flea beetle were collected in 1972, but only three of these were in sufficient numbers to constitute a real hazard. The taxonomic identities of these species are being studied.

Wireworms

Liquid lindane seed dressings. Because aldrin and heptachlor have been phased out as seed dressings for wireworm control, the only remaining approved product is lindane powder dressing. Liquid seed dressings are needed, however, because commercial treating plants will not use powdered seed dressings. Experimental liquid lindane seed dressing formulations (Ciba-Geigy and UniRoyal Ltd.), applied to wheat, rape, and sunflower seeds sown in field trials, appear to give adequate protection against wireworms without causing significant damage to the growing plants. At higher than recommended dosages, they caused more plant damage than the powdered lindane formulations. Therefore, only the recommended amounts may be used. The effects of storing seed that has been treated with liquid lindane are being studied to determine plant damage and insecticidal effectiveness.

Lindane seed treatments and wildlife. A 2-yr study of pheasants has shown that lindane insecticide is rapidly excreted, or

metabolized by birds after ingestion, or both, so that lindane-treated cereal seed in the field is not likely to be a hazard to wild birds. When hens were fed single capsules of up to 25 mg of lindane in the spring, or were allowed to feed on treated grain for up to 3 wk, the treatments did not adversely affect egg production, thickness of egg shells, hatch, or development of chicks. Residues of lindane were higher in the fat than in other tissues, but 2 wk after ingestion of lindane ceased the residues had declined to a low level. By fall no detectable residues remained in any of the tissues. Levels of lindane in the egg yolks rose to a maximum about 10 days after the ingestion of a single dose, but declined to a low level 3 wk later. The levels declined rapidly when the birds were placed on normal diets. When the pheasants were feeding continuously on treated grain, lindane levels in egg yolks reached and maintained a plateau. Preliminary studies with carbathiin (Vitavax, UniRoyal Ltd.) fungicide, which may be used as a seed dressing with or without lindane, show that this compound is largely excreted in the feces shortly after ingestion and does not appear in bird tissues or eggs in significant amounts.

Grasshoppers

General abundance. Because conditions during the past few years in Saskatchewan have been favorable for grasshoppers, a gradual population buildup has occurred. In 1972 populations increased substantially over the previous year so that control measures were necessary in various parts of the province. Another major increase in the density and area infested has been forecast for 1973.

Influence of weather on crop loss. Field cage studies of losses caused to spring wheat by the migratory grasshopper, *Melanoplus sanguinipes* (Fabr.), demonstrated the important role of the weather. During hot, dry conditions the voracious feeding and rapid development of the grasshoppers inhibited crop growth and increased damage. However, in cool, wet weather, feeding and development of the grasshoppers were reduced, and maximum growth of foliage occurred, which permitted the crop to keep ahead of the insects and to recover from previous damage. Early hatching brought on by warm, dry conditions in the spring caused increased crop damage due to the greater vulnerability of the seedlings at that time.

Reproductive biology. Studies on the insemination process in various species of grasshoppers showed that egg hatchability depends on proper fertilization. When sperm is depleted from the female receptacle, many eggs are infertile and hatching is drastically reduced. Investigations have shown two apparently distinct types of insemination processes in the various groups of acridids. One type involves the production of numerous tiny spermatophores, one after the other, during copulation. These spermatophores barely penetrate the spermatheca, where the sperm is discharged, and they find their own way to the storage area at the end of the spermathecal duct. In the other type, only a single large spermatophore is produced during copulation. This spermatophore extends the full length of the duct and discharges the sperm into the storage diverticulum of the spermatheca.

Forage Insects

Sweetclover weevil. Studies showed that under favorable growing conditions an infestation of one adult sweetclover weevil, *Sitona cylindricollis* Fahr., per three sweetclover seedlings, or under dry conditions one adult per five seedlings can result in a reduction of up to 45% in a seedling stand. Newly emerged seedling stands of sweetclover in Western Canada average 97 seedlings/m² (9/ft²), so that a population of 20 to 32 weevils/m² (2 to 3/ft²) can cause a 50% loss in stand. Weevil populations of this magnitude are common in Western Canada.

In the spring when the weather was favorable for growth and development of second-year sweetclover, 18 weevils per plant reduced a stand by 90%. Surveys in Western Canada indicate that second-year stands of sweetclover average 65 plants/m² (6/ft²). Therefore, about 1,170 weevils/m² (108/ft²) could completely destroy the crop. However, an infestation of 538 weevils/m² (50/ft²), about half the estimated number required for near total destruction, caused no stand loss in a second-year crop. Weevil populations as high as 538/m² (50/ft²) are rare in Western Canada, except in a maturing crop when new-generation adults are emerging, or along margins of first-year stands that are being invaded by new-generation adults from harvested second-year sweetclover fields.

Mosquitoes

Larvicides. Larvicide tests were conducted on mosquitoes in naturally infested ponds near Saskatoon. Two organophosphates, OMS 1155 (Dow Chemical Co. of Canada Ltd.) and chlorpyrifos (Dursban, Dow Chemical Co. of Canada Ltd.), possible replacements for chlorinated hydrocarbons, gave good control at low dosages; good control was obtained with chlorpyrifos at a lower dosage in 1972 than in 1971. Flit MLO (Humble Oil and Refining Co.), a surface-spreading oil, at 45 or 56 litres/ha (4 or 5 gal/ac) inadequately reduced mosquito larval populations, but caused perceptible stunting of fourth-instar larvae, whereas at 67 litres/ha (6 gal/ac) mortality was complete within 7 days. At the lowest dosage, Flit MLO slightly reduced emergence and prolonged the developmental period; at 56 litres/ha (5 gal/ac) emergence was reduced by about 50%, and the developmental period was doubled. At both rates the lethal effects of Flit MLO occurred within the first day of treatment. Those larvae not affected on the first day developed normally. At 67 litres/ha (6 gal/ac) all specimens died during a prolonged larval period.

Abundance and dispersal. Comparative abundance of larvae and adults was studied for the fourth year at a pond near Saskatoon. Adults were collected in five CDC (Communicable Disease Centre) light traps from May 5 to October 13. Larvae occurred from April 10 to June 26, a period of 77 days compared with 166 days in 1971. Adults, in order of abundance, were *Culiseta inornata* (Will.), *Aedes campestris* Dyar & Knab, *A. flavescens* (Muller), *A. dorsalis* (Meigen), *A. fitchii* (Felt & Young). The order for larvae was *A. flavescens*, *A. fitchii*, *C. inornata*, *A. dorsalis*, *Culiseta morsitans* (Theobald). These species accounted for 88% of all adults and 98% of all larvae taken. Adult and larval populations for 1972 were reduced to 15% of 1971 levels. The reduction in populations resulted from continual decrease of water levels during June, August, September, and October due to below normal rainfall.

Dispersal of adults from a breeding source, as measured by collections in CDC light traps in 1971, was shown to be random. Wind direction did not affect the numbers taken in traps surrounding the breeding area, but adults were taken only when winds were less than 4.8 km/h (3 mph). From May to

October adults were captured only when temperatures remained above 7.8°C. However, on October 16, two males of *C. inornata* were taken at -0.6°C to -1.1°C, probably owing to the development of prewinter hardiness in this species, which overwinters in the adult stage.

Black Flies

Ecology. Since the completion of the Gardiner Dam on the South Saskatchewan River in 1966, *Simulium arcticum* Mall. has been largely replaced in the main breeding rapids by two new immigrants, *Simulium vittatum* Zett. and *Simulium luggeri* Nicholson & Mickel. In August 1972, swarms of *S. luggeri* emerging from the South Saskatchewan River drove cattle from pastures south of Prince Albert. The North Saskatchewan River, unaffected by dams, continues to produce annual outbreaks of *S. arcticum*, and in 1972 an outbreak originating above the larvicide test site killed at least 18 cattle.

Control. Tests with single 15-min injections of methoxychlor in the Saskatchewan River show that about 0.3 ppm can eliminate most *S. arcticum* larvae for distances of up to 65 km (40 miles) and show some apparent effects for 145 km (90 miles). Plecoptera larvae are similarly affected, but Ephemeroptera and Trichoptera larvae are affected only in sites directly exposed to river currents. None of these effects are permanent, and populations mainly restore themselves within about 2 wk.

PLANT DISEASES

Common Root Rot of Cereals

Cultural practices and disease incidence. The incidence and severity of common root rot in field-grown Manitou and Cypress wheat increased with the depth of seeding. Shallow-seeded plants gave the highest grain yields. The amount of disease was closely associated with length of subcrown internodes. Long internodes (5.8 cm to 7.3 cm) incurred more disease than those of intermediate length (4.8 cm to 5.6 cm), whereas plants with short internodes (2.5 cm to 3.8 cm) showed the least infection. Loss of yield and incidence of disease were greater in Cypress than in Manitou.

Field trials to investigate relationships of stand density, disease, and yield of wheat

have shown that the level of common root rot is not significantly affected by plant density. However, tests in 1972 showed a trend to greater loss of grain yield in diseased plots that had high plant populations.

In 1972, the incidence of common root rot and its effect on yield were estimated from a survey of 102 common and 41 durum wheat fields in Saskatchewan. The common wheat fields had a mean disease index of 23%, with a calculated loss of yield of 10%. Durum wheat fields had an average estimated loss in grain yield of 9% and a disease index of 34%.

Resistance. A large number of wheat and barley lines from Canadian breeders and other sources were screened for resistance to common root rot in replicated or single row trials. Although lines differed widely in their reaction to the disease and some were selected that exhibited fair tolerance, none were immune. Many of the 6,000 wheat lines grown in the field appeared to be fairly resistant to the prevalent race(s) of leaf rust. However, 72 of the lines of *Triticum durum* Desf. and 92 of *T. aestivum* L. were markedly susceptible to septoria leaf blotch.

Two fungi of the many evaluated appear promising as possible "cross-protecting" organisms, which may inhibit the infection of wheat plants by *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur. When these two fungi were mixed into the soil, common root rot of greenhouse seedlings was reduced, but the level of control was not uniform.

Stem eyespot of red fescue. This disease, *Didymella festucae* (Weg.) Holm, was severe in 1972, not only in the main red fescue, *Festuca rubra* L., seed-growing area of the Peace River region but in adjacent areas as well. Observations suggest that severe infections of this disease in 1969 and 1971 were at least partly responsible for a 50% lower production than in 1970. In 1970, 11,000 t (25 million lb) were produced when the disease was light. Propane flaming of fescue stubble reduced the incidence of disease, but complete burning is hard to accomplish and the results are doubtful. Other cultural practices, such as the use of a fertilizer, could reduce the incidence of this disease, but development of resistant varieties appears to be the most practical solution. In 1972, six fescue clones showing resistance to stem eyespot were selected in a breeding population.

Snow mold. From Yorkton in southeastern Saskatchewan to Dawson Creek in northern British Columbia, three fungi were often isolated from snow mold patches on lawn and roadside turfs. One is an unidentified psychrophilic, microsclerotial basidiomycete, another belongs to the *Typhula* sp., and the third, with orange stromata, was tentatively assigned as a *Gliocladium* or *Tubercularia* sp. These organisms, with *Sclerotinia borealis* Bub. & Vleug., *Fusarium nivale* (Fr.) Ces., and the low-temperature basidiomycete (nonsclerotial) appear to form disease complexes in which one or the other is dominant according to environmental conditions. The nonmercurial fungicides quintozone, chloroneb, and benomyl were effective substitutes for mercurial fungicides against particular pathogens of snow mold.

Diseases of Alfalfa

Nine varieties of alfalfa were screened for their reaction to yellow leaf blotch, *Leptotrochila medicaginis* (Fckl.) Schuepp; black stem, *Phoma medicaginis* Malbr. & Roum.; common leaf spot, *Pseudopeziza trifolii* f. sp. *medicaginis-sativae* Schmiedeknecht; and downy mildew, *Peronospora trifoliorum* de Bary, with the use of natural inoculum. The varieties Ferax, Ranger, and Vernal appeared to be the most susceptible to yellow leaf blotch, whereas Rambler and Rhizoma were the least susceptible. Yellow leaf blotch continued to be the most serious alfalfa foliage disease in Saskatchewan, and caused substantial forage yield losses in 15 of 44 fields examined. The severity of this disease may be related to the increasing acreage of the very susceptible variety Vernal.

Diseases of Oilseed Crops

Economic losses from rapeseed diseases continue to mount as the area and intensity of rapeseed cultivation increase. Of great economic importance is the white rust or staghead disease, *Albugo cruciferarum* S. F. Gray, which attacks all varieties of susceptible *B. campestris*. Field surveys in Saskatchewan indicate that yield losses in fields of the susceptible species have climbed from 3% to 6% to 9% in 1970, 1971, and 1972. The annual losses from this disease for the 3 yr were 1.7, 4.1, and 2.5 million dollars. Alternaria blackspot disease, which attacks both species of rapeseed, also increased in severity. In 1972, the disease ratings were double

those recorded in the 1971 surveys. Foot rot disease, *Fusarium* spp., also increased in prevalence in Saskatchewan, but did not cause significant yield losses.

Development of varieties with greater disease resistance is essential to the continued growth and profitability of the rapeseed industry. Screening for resistance to white rust disease confirmed that all Canadian varieties of *B. napus* are resistant to this disease, but the Canadian and European varieties of *B. campestris* are completely susceptible. Fortunately, some wild strains of *B. campestris* introduced from Chile and Mexico have yielded a small percentage of resistant plants for use in the breeding

program. The lines of *B. oleracea* L. investigated contained from 0% to 10% susceptible plants.

Field observations have shown that some selected strains of Brown mustard are more resistant to the disease than the landrace that is being used in commercial production.

Studies of soil microbiology under different crop rotations showed that a marked increase of an apparently nonpathogenic fungus, *Dendryphion nanum* (C. G. Nees ex S. F. Gray) Hughes, occurred under rapeseed cultivation. Samples from some fields contained up to 3,000 conidia/g of soil. The spore population decreased slightly after a cereal crop and a drastic reduction was recorded after the subsequent fallow year in a crop rotation sequence of rapeseed, cereal, and fallow.

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Research Station Swift Current, Saskatchewan

PROFESSIONAL STAFF

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G. E. KERLEY, C.D.	Administrative Officer

Scientific Support

A. K. LAIRD (MRS.)	Librarian
H. MOEN	Computer Programmer
P. I. MYHR, B.S.A.	Research Information

Cereal Production and Utilization

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K. E. DUNKELGOD, B.S., M.S., Ph.D.	Turkey nutrition
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T. F. TOWNLEY-SMITH, B.S.A., M.Sc., Ph.D.	Durum wheat breeding
L. M. WRIGHT, B.Sc., M.Sc.	Cereal harvesting

Forage Production and Utilization

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C. A. CAMPBELL, B.S.A., M.S.A., Ph.D.	Soil chemistry
W. NICHOLAICHUK, B.E., M.Sc.	Hydrology
W. L. PELTON, B.S.A., M.S.A., Ph.D.	Micrometeorology
D. W. STEWART, B.S.A., M.Sc., Ph.D.	Environmental physiology

Research Equipment Design

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F. B. DYCK, B.E., M.Sc.	Seeding and harvesting equipment

Analytical Services

F. G. WARDER, B.S.A., M.Sc.	Head of Section; Soil chemistry
W. C. HINMAN, B.Sc., M.Sc.	Soil chemistry

Departure

J. E. TROELSEN, B.Sc., M.Sc., Ph.D. Died March 6, 1972	Ruminant nutrition
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INTRODUCTION

The climate of southwestern Saskatchewan is characterized by low precipitation, high evaporation, and wide extremes in temperature. Throughout the region, cereal grains are grown on a variety of soils, and cattle are raised in large numbers on natural grasslands and on grass-alfalfa mixtures. Small areas are irrigated. Research is focused on improving the economy and stability of all forms of agricultural production.

Moisture and temperature conditions during the growing season severely reduced the yield of forages, but the yields of cereals were normal. Spring moisture was the lowest in a decade. Rainfall during the growing season was below normal but well distributed. Temperatures and sunshine, and consequently evapotranspiration, were above average during May and June. However, July temperatures were the lowest recorded during the past 50 years; these, combined with below-average sunshine, resulted in a low rate of moisture loss by evapotranspiration.

Good progress was made in all areas of research. A new variety of durum wheat developed by Dr. E. A. Hurd and Dr. T. F. Townley-Smith was licensed and named Wakooma. A sister line of Wascana, it has stronger gluten and thus more closely meets the requirements of certain of our international markets.

Dr. K. E. Dunkelgod formulated new turkey rations that, when fed commercially, reduced the number of days to market weight by 42 days and the amount of feed per bird by 19.0 kg compared with previously used commercial rations.

These and other research accomplishments are described briefly in this report. Detailed information can be obtained from the publications listed at the end of the report, from P. I. Myhr, or from the individual scientists. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

It is with a great sense of loss that I record the death of Dr. J. E. Troelsen in March. Dr. Troelsen was an outstanding scientist who had gained an international reputation for his research on the value of forage to ruminants.

A. A. Guitard
Director

CEREAL CROPS

Breeding

Spring wheat. The South Saskatchewan Wheat Program continued with breeding, selection, and testing at Swift Current, testing at the Research Stations at Regina and Indian Head, Sask., and winter increase of hybrid materials in California and Mexico. In tests throughout Western Canada, two selections from this program showed particular promise. One is a hard red spring wheat selection that is resistant to both leaf and stem rust and is 10% higher yielding than Manitou in the Brown soil zone. The other is a white wheat that is susceptible to leaf rust but has excellent baking qualities. It is nearly as high yielding as Glenlea in northern areas and, if suitable for production, may find a place in world markets as an FAQ (fair average quality) or filler wheat.

Durum wheat. A sister line of Wascana developed from Lakota² × Pelissier was licensed under the name Wakooma. Wakooma has shorter and stronger straw and stronger gluten than Wascana. It is similar to Wascana in yield and all other agronomic characteristics. Seed will be released to growers for production during 1973.

Rye. Several winter-hardy lines are in advanced stages of testing. These lines have outyielded Frontier but not Cougar or Puma.

Management of Wheat

Crop sequence. Wheat grown continuously for 6 yr gave a net return per year of \$29.97/ha when N and P in the soil were maintained at adequate levels. Where P was maintained at an adequate level but no N was added, the net return was \$26.61. When the wheat was grown in a summerfallow-wheat-wheat rotation with supplementation of N and P, the

net return was \$27.75, whereas it was \$26.51 when N was not maintained at an adequate level and \$23.87 when P was not added. When wheat was grown in a summerfallow-wheat rotation in which N and P were maintained at adequate levels, the net return per year was \$25.87. With proper supplementation of N and P, a summerfallow-flax-wheat rotation gave a net return of \$25.08, a summerfallow - fall rye - wheat rotation \$24.66, and a flax-wheat-wheat rotation \$22.83. Wild oats and other grassy weeds are now invading the plots under continuous cropping. Control of these weeds will substantially increase the cost of production and thereby decrease the net returns.

Seeding equipment. Seeding with a hoe press drill, a double disc press drill, or a discer followed by a packer did not affect the yield of wheat during 6 yr of a summerfallow-wheat rotation. This held true whether the summerfallow was maintained by tillage or by herbicide. In both types of summerfallow, preseeding tillage had no effect. When seeding was performed with a discer followed by packing, there was a 10-15% reduction in plant density both for direct seeding and when seeding was done after tillage. The discer placed the seed deeper in the soil, and this caused an increase in length of the subcoronal internodes of the plants. The reduced stand did not influence yield because the wheat plants compensated for reduced plant density by tillering. In another 2-yr comparison, seeding with the discer and packer, the cultivator - rod weeder drill, the hoe, the high-clearance hoe, the triple disc press drill, and the single disc press drill produced similar yields, kernel size, and protein content when the seed was placed into undisturbed soil.

Combining hollow- and solid-stemmed wheats. During 1969 and 1970, combining losses for the hollow-stemmed cultivar Canthatch and the solid-stemmed cultivar Chinook increased as the rate of pickup of the material from the swath increased. A Gleaner-Baldwin Model A self-propelled combine was used. The combine had a maximum feed rate of 125 kg/min for Canthatch and 136 kg/min for Chinook. The grain loss for Canthatch was 3% at a feed rate of 125 kg/min, but the grain loss for Chinook did not exceed 1%. The greater grain loss for Canthatch was caused by heavier loading of the straw deck due to

pulverization of the straw as it passed through the cylinder.

Chemically Induced Cold Tolerance in Winter Wheat

Glucose, sucrose, and mannitol. Increased frost survival of winter wheat seedlings after exposure to solutions of glucose, sucrose, or mannitol was not explained simply by changes in the osmotic potential of the leaves. In some cases, increased survival resulted from either an increase in the percentage of total carbohydrate and reducing sugars, or a slight decrease in the water content of the leaves. The dependency of osmotic potential and percentage of total carbohydrate and reducing sugars on the plant's water status made evaluation of the importance of each factor to frost survival difficult.

Decenylsuccinic acid. Decenylsuccinate did not increase cold hardiness in winter wheat in a nonhardening environment. After 3 days of exposure to 10^{-3} and 10^{-4} M decenylsuccinic acid, plants wilted and died. Decenylsuccinate at 10^{-3} M inhibited ^{32}P uptake by roots of wheat and barley, and resulted in leakage of previously absorbed ^{32}P and total P. The effects of decenylsuccinate on ^{32}P uptake and retention were attributed to increased permeability of cell walls caused by injury. Decenylsuccinate at 10^{-4} M did not inhibit uptake of ^{32}P by roots, but decreased movement into the shoot. This indicates reduced transpiration, or inhibition of the movement of ^{32}P into the transpiration stream.

TURKEY NUTRITION

Dietary Fat

The fatty acids of abdominal depot fat and thigh and breast meat of turkeys fed 0%, 2%, and 11.4% palm oil or rapeseed oil from 1 day to 24 wk old were strongly influenced by the level and source of dietary fat. Birds fed no added dietary fat deposited palmitic, palmitoleic, stearic, and oleic acids in greater proportions than were provided in the diet. Increasing the level of fat in the diet resulted in the deposition of fat that resembled the dietary fat in composition, the greatest similarity occurring at the highest level of added fat. Levels of palmitoleic, stearic, and oleic acids increased with age, indicating an

FORAGE CROPS

increasing rate of fatty acid biosynthesis as the birds approached maturity. Thigh meat contained a higher level of stearic acid than depot fat, and breast meat contained higher levels of stearic and arachidonic acids and fatty aldehydes than thigh meat. These differences reflect the presence in thigh and breast meat of a greater proportion of phospholipids, which would also account for the decreasing sensitivity of the meat lipids to changes in fatty acid composition in response to dietary fat. After a change of dietary fat at 16 wk, half of the total change in fatty acid levels took place in 2.4 wk.

Nutrient Density

Feeding standards based on feed intake, genetic growth potential, nutrient requirements, nutrient balance, and physiological age were developed for use in linear-programmed diets for male and female turkey poults. Eight strains and two varieties of turkeys fed at nutrient density levels of 2.78, 3.08, and 3.38 kcal/g utilized the dietary nutrients with approximately the same efficiency. Feed intake and feed conversion were inversely related to nutrient density level, regardless of strain, sex, or variety. Females required a higher energy intake level and males a higher protein intake level.

Many feed manufacturers across Canada now use these feeding standards to formulate rations. Producers using these rations are obtaining 12- to 13-kg males at 20 wk with a feed conversion ratio of 2.7. The rations thus save 42 days and 19.0 kg of feed per bird, compared with rations formulated on the basis of proportional units of a prepared feed.

Feed Additives

Use of dried brewer's yeast, distiller's dried solubles, dehydrated alfalfa, or dried whey did not influence the growth of turkey poults up to 6 wk old. Farmacto 500 added at 0.25% to diets that included distiller's dried solubles and brewer's yeast improved the feed conversion efficiency of males by 3% but did not influence the efficiency of feed conversion of females.

Breeding

Alfalfa. A diallel study of eight plants with low and eight with high Fraction 1 (F-1) protein content showed that plants differed in both general combining ability (GCA) and specific combining ability (SCA). The GCA component of variance was 33% and the SCA was 20%, with an error component of 47%. These heritability components compare favorably with those for protein content, yield, and root type. Therefore, it should be possible to decrease F-1 protein content in alfalfa by breeding and selection. A breeding program that allows for best exploitation of SCA may be the most satisfactory.

Russian wild ryegrass. A population of tetraploid Russian wild ryegrass developed at the University of Idaho was obtained from Dr. A. E. Slinkard. Preliminary studies to assess the value of tetraploidy in this species showed that, although the tetraploid seed is 1.5 to 2 times larger than the diploid seed, it cannot emerge from deep planting. Coleoptile length rather than seed reserves appeared to determine the ability to emerge from deep seeding. Seedling dry weight, height, and vigor were similar for the tetraploids and diploids. The tetraploid had slightly wider leaves than the diploid, but this did not appear to be associated with greater seedling vigor.

Altai wild ryegrass. A third cycle of mass selection for seed yield, plant type, and freedom from disease was completed. In the field, 540 single plants with blue foliage, 230 with green foliage, and 1,078 with blue green foliage were selected. These will be further reduced by selection for seed quality in the laboratory, and the final selections used as a seed source for establishing progeny tests and new breeding nurseries.

Intermediate wheatgrass. Approximately 1,000 single plants were selected from a breeding nursery established in 1971. These selections will be screened for seed quality in the laboratory and seedling vigor in the greenhouse. Final selections will be assessed in a progeny test.

Establishment

Effects of soil temperature. Temperatures of 2°C for 12 h and 13°C for 12 h caused lower germination of 8 legumes and 13 grasses than when the temperature was held at the mean of 7°C for 24 h. Alternating higher temperatures did not affect germination. Temperatures below 10°C reduced the rate of germination; both constant and alternating temperatures gave similar reductions.

In another experiment, the rates of emergence and development of seedlings of Altai wild ryegrass, Russian wild ryegrass, brome-grass, tall wheatgrass, and intermediate wheatgrass were lower at a soil temperature of 10°C than at 15 or 20°C. The development of Altai wild ryegrass was most seriously retarded by the cool temperature. These results suggest that very early spring or late fall seeding of grasses and legumes may reduce the stand, and that the reduction is particularly serious with Altai wild ryegrass.

Role of secondary roots. Crested wheatgrass produced secondary roots sooner and more abundantly than the Russian or Altai wild ryegrass. However, when these secondary roots were prevented from absorbing water, the rate of development of the young plants was the same as that of plants growing with primary and secondary roots in moist sand. Thus, in crested wheatgrass, the secondary roots are not necessary when moisture is adequate.

Survival

Effect of root temperature on flooding tolerance. Alfalfa and sainfoin improved in flooding tolerance as root-zone temperatures were lowered, whereas birdsfoot trefoil survived equally well under flooding at root-zone temperatures of 25, 19, and 13°C. After 28 days of flooding, no plants of alfalfa or sainfoin at root-zone temperatures of 25°C were alive, but 25% of the alfalfa plants and 11% of the sainfoin plants at 19°C were alive, and 95% of the alfalfa plants and 54% of the sainfoin plants at 13°C were alive. It appears that less damage from flooding occurs in the spring when soil temperatures are low than when the soil is warm during the summer.

Sick alfalfa. Little progress has been made in determining the cause of loss of vigor and

occasionally death that periodically occurs in mature stands of alfalfa throughout the central and northern areas of Western Canada. This condition is commonly referred to as "alfalfa sickness" and is thought to be associated with production on "alfalfa-sick" soil.

The expression of symptoms was not influenced by the cultivar, the soil temperature, or the nutrient status of the soil. Attempts to extract the toxic agent from the soil with various solvents and the subsequent culture of alfalfa in the extract or extracted soil did not give conclusive evidence of a toxic agent, although aqueous extracts were somewhat detrimental to growth and soils after aqueous extraction gave slightly better growth of alfalfa. Attempts to fractionate and concentrate various water-soluble extracts were not successful, because growth was not suppressed by any of the concentrated extracts. Large numbers of the nematode *Paratylenchus projectus* Jenkins were sometimes found in soil on which alfalfa grew poorly, but it was not possible to establish a firm relationship. Both the roots and the shoots of alfalfa growing on alfalfa-sick soil contained less methionine than normal plants; however, feeding methionine and precursor amino acids through the roots failed to alleviate the symptoms. Also, there was a very large year-to-year variation in the toxicity of the soil and this finding led to the decision that the condition is too nebulous to warrant continued study.

Longevity of crested wheatgrass pastures. Crested wheatgrass pastures seeded on a well-prepared seedbed remained almost free from weeds for approximately 15 yr. After that, native species became established and the number of species increased with age of the pasture. However, even after 35 yr, native plants seldom constituted more than 10% of the stand on loam soils and not more than 25–30% on sandy soils. This invasion was presumably due to death of the crested wheatgrass plants after a normal life-span of 15–20 yr and incomplete replacement by self-seeding, even though the wheatgrass produced seed profusely in some years. It appeared that in very old crested wheatgrass pastures a seminatural plant community became established, with crested wheatgrass as the dominant species.

Forage Yield

Response of crested wheatgrass to N and P. In a number of tests to determine the soil nutrient requirements of old stands of crested wheatgrass, the application of N usually increased yield. At Maple Creek and at this station, where N was applied at rates of 25–200 kg/ha in 1969, fall regrowth in 1972 was still directly proportional to the initial N application, but only the higher rates gave an appreciable increase in yield. At Piapot, where similar rates of N were applied in 1970, all rates of application increased forage production in 1972. In another test where N was applied at up to 800 kg/ha, the soils that had received N at 400 and 800 kg/ha still contained more $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$ in the fall of 1971 than measured in plots that had not been supplemented. The application of P did not increase yield.

Response of grass-alfalfa mixtures to N and P. A number of tests were made to determine the response of grass-alfalfa mixtures to supplementary applications of N and P. The addition of N increased yield at the first cutting after application, but usually reduced the alfalfa in the stand; this in turn reduced subsequent yields. The application of P increased the yields of both alfalfa and the mixtures only when the level of soil P was less than 15 kg NaHCO_3 -extractable P/ha in the top 15 cm of soil. When there was a response to P application, the increase in yield was sustained over at least 3 yr from the time of application and was most profitable when P was applied at 22 kg/ha.

N accumulation under grass-legume mixtures. The amount and distribution of $\text{NO}_3\text{-N}$ were determined under a 7-yr-old stand of unfertilized alfalfa-grass mixtures seeded in various patterns. Although soil N was very low at all depths to 90 cm, there was more N near the surface where the grass and legume components were grown in separate rows rather than as mixtures. The soil $\text{NO}_3\text{-N}$ in the top 15 cm was 2.0 ppm where the components were separated, and 1.5 ppm where the grass and legume were grown together in the row. The differences were mainly due to the higher N content just beneath the rows of pure alfalfa. There was more $\text{NO}_3\text{-N}$ under intermediate wheatgrass than under crested wheatgrass or brome grass.

Yield of combinations of annuals. After 7 yr, the hay production from pure alfalfa or a crested wheatgrass – alfalfa mixture exceeded the hay yields from small grains, corn, and sunflowers growing in various sequences. The average annual dry matter yields in kg/ha were 2,326 for crested wheatgrass – alfalfa, 2,254 for alfalfa, 2,210 for a 3-yr rotation of fall rye – oats – summerfallow, 1,969 for a 2-yr oats – fall rye rotation, 1,795 for a 3-yr oats-sunflowers-summerfallow rotation, and less than 1,600 for each of the annuals grown on summerfallow in a 2-yr crop-summerfallow rotation.

Annual cereal pastures. From 1966 to 1970, an in-season annual pasture system was studied. Fall-sown fall rye and spring- and summer-sown oats were successively grazed, and provided pasture from mid-May to mid-September. Fall rye provided 51 days of grazing, spring-sown oats 36 days, and summer-sown oats 32 days, for a total of 119 days of grazing, whereas a Russian wild ryegrass – alfalfa mixture provided 83 days. The fall-sown rye provided 1,205 kg/ha of total digestible nutrients, the spring-sown oats 907 kg/ha, and the summer-sown oats 698 kg/ha, for an average of 936 kg/ha; the Russian wild ryegrass – alfalfa mixture produced an average of 412 kg/ha. Annual animal gains in kg/ha were 241 for fall rye, 159 for spring-sown oats, and 111 for summer-sown oats. This gave an average animal gain of 170 kg/ha, compared with 76 kg/ha on the Russian wild ryegrass – alfalfa mixture.

Effect of date of first harvest. Roamer alfalfa, Carlton brome grass, and a mixture of the two were grown under irrigation from 1965 to 1970 and harvested every 4 wk. The best distribution of forage yield was obtained when harvesting began in early June, but the highest yield of forage occurred when harvesting was delayed until mid-June. These results have a practical application for the management of alfalfa-brome grass mixtures grown under irrigation. Since persistence was not influenced greatly by time of first defoliation, the forage can be pastured early if required. If the forage is not needed in early June, removal can be delayed until mid-June to obtain maximum yield.

Seed Yield

Effect of removing aftermath from Altai wild ryegrass. During a period of 6 yr, removal of the aftermath of Altai wild ryegrass after seed harvest increased seed yields from 34 to 62 kg/ha. Removal of the aftermath prevented mesocotyl development, which raises the apices above ground level, where they are sometimes damaged by frost. This response is very similar to that of Russian wild ryegrass.

Forage Quality

Quality of bromegrass grown under irrigation. The dry matter yield of Carlton bromegrass increased steadily to about 8,000 kg/ha by mid-June but did not increase significantly thereafter. From May 25 to June 15, the amount of leaf dry matter declined from 69% to 42% of the total. Crude protein content of the leaves declined from 27% in May to 14% by early August, and that of the stems from 23% to 5% during the same period. Digestible energy was 70% for both leaves and stems during the early stages of growth, but after late May the digestible energy of the leaves declined gradually throughout the season to approximately 57%, and that of the stems to 40%.

ENVIRONMENT

Soil Nitrogen

Effect of method of simulating spring temperatures on ammonification, nitrification, and microbial populations. Unamended soils were frozen and then incubated at a constant temperature of 8.5°C, or at temperatures that fluctuated from 14 to 3°C. The fluctuating temperatures were harmful to the microflora, and the rate of nitrification was lower than at constant temperatures. When the fluctuating temperatures followed a square-wave pattern, the damage to the microflora was slightly greater than when the fluctuations followed a sine-wave pattern. When these soils were amended with NO₃-N, NH₄-N, and peptone-N and then treated in a similar manner, the damaging effect of the fluctuating temperatures on the microflora was reduced considerably, and nitrification was actually greater under sine-wave fluctuating temperatures than at constant temperatures or under square-wave fluctuating temperatures.

Effect of previous soil temperature on changes in microbial activity. Unamended soils and soils amended with NH₄-N were incubated for 14 days at three different cyclical growing-season temperatures, and also at the mean of each cyclical temperature; they were then incubated for a further 14 days at combinations of these temperatures. The pattern of population change in response to temperature treatment was similar for bacteria, actinomycetes, and fungi. When the temperature was either increased after 14 days or maintained at the same level for 28 days, microbial numbers and the rate of N transformation increased. However, when temperatures were reduced after 14 days, microbial population levels decreased greatly and ammonification and nitrification rates increased, resulting in a temporary flush of mineral N. This killing of microbial cells and the resultant flush in N mineralization were much greater under fluctuating than under constant temperatures.

Soil Moisture

Quality of spring runoff water. During the past 2 yr, spring runoff from fields that had a late-fall application of fertilizers exceeded the allowable maximums for N and P. However, not all the excess N and P came from the fertilizer. Snow samples collected from a Nipher snow gauge during the winter, and from snow accumulated in the field, had concentrations of NO₃-N as high as 1.0 ppm, NH₃-N up to 1.3 ppm, and P as high as 0.05 ppm. In the snow samples, the high quantities of N and P were caused by contamination of the snow by drifting soil during the winter. Rainfall would not normally contribute to the quality of the spring runoff water, but during the summer rain samples showed concentrations of NO₃-N and NH₃-N of more than 1 ppm and of P up to 0.5 ppm.

Influence of soil moisture on the response of wheat to soil nutrients. When Thatcher wheat was grown in tank-type lysimeters during the past 7 yr, the addition of water to remove moisture stress increased the yield of continuous wheat by 50% and the yield of wheat grown after summerfallow by 75%. With only natural rainfall, the addition of N and P to the soil did not influence the yield of wheat; however, when moisture stress was removed by the addition of water, the yield of continuous wheat was increased by 100%

and the yield of wheat after summerfallow by 30%. The N content of the kernel was increased or decreased by the addition of N, or P, or additional water, depending on the balance among these. The P content of the kernel was not affected by the addition of N or P but was higher for continuous wheat than for wheat on summerfallow; it was increased by the addition of water. Under conditions of natural moisture, surplus available N accumulated as $\text{NO}_3\text{-N}$ at lower soil depths, but when supplemental moisture and N were applied the surplus $\text{NO}_3\text{-N}$ was apparently immobilized at the surface in organic form. Addition of N and P resulted in a sharp increase in bicarbonate-soluble P, and the increase was particularly large when supplemental water was applied. Where additional water only was applied, there was a large reduction in soluble P.

Reliability of soil moisture determinations. At this station, approximately 6,400 soil cores are taken each year for gravimetric determinations of moisture and some 15,000 soundings are taken for neutron determinations of moisture. Study of these data showed that, at a confidence level of 10% and with three replications, the mean soil moisture in a 120-cm soil profile of a 6×11.5 m plot can be determined with fiducial limits of 2.5 cm for gravimetric determinations and 3.0 cm for neutron meter determinations. Similarly, for an area of 2 or 3 ha, the fiducial limits of the mean were 3.7 cm. To reduce these to approximately 7 mm, 25 samples would have to be taken from each plot.

In an attempt to develop a more suitable method for estimating soil moisture, improvements were made to the versatile soil moisture budget of Baier and Robertson, and the system was tested for the determination of soil moisture for wheat on summerfallow. The method was tested against gravimetric determinations of soil moisture in 30-cm layers to 120 cm, taken at approximately 10-day intervals during the growing seasons of 1970, 1971, and 1972. The coefficient of determination for calculated vs. observed soil moisture was 89%, with a standard error of estimate of 5 mm, for 80 pairs of values. This suggests that better determinations of soil moisture could be obtained by combining the budget technique with more intensive gravimetric sampling at fewer intervals, to provide more accurate bench mark data.

Methods of Measuring Transpiration

During 1968 to 1971, the black Bellani plate atmometer and the Ogopogo, a modification developed by the Research Station at Summerland, B.C., gave similar measurements of mean seasonal evaporation. The correlation coefficient for mean seasonal evaporation as measured by these two instruments and a Class A pan was 0.86. However, when measurements of evaporation were averaged over 10-day periods, the black Bellani plate and Ogopogo sometimes gave significantly different measurements of evaporation.

When evapotranspiration was calculated by the Baier-Robertson, Penman, and Thornthwaite methods, the estimates of evapotranspiration based on the Baier-Robertson and Penman formulas gave correlation coefficients of 0.82 with actual evaporation and 0.68 with evapotranspiration. The comparable correlation coefficients for the Thornthwaite method were 0.57 and 0.50 respectively.

Actinomycetes in Brown Soils

Quantitative and qualitative analyses of the actinomycete flora in Sceptre heavy clay and Hatton fine sandy loam under grass and cultivation showed that the number of actinomycetes was always much higher in the heavy clay than in the sandy loam, and in the surface 10 cm of soil the population was strongly influenced by environmental changes and cropping practices. However, the populations of actinomycetes in the 20- to 30-cm soil zone were similar for both soils, fairly static throughout the growing season, similar from year to year, and unaffected by cropping practice. A consistent inverse relationship existed between soil moisture content and proportion of actinomycetes within the microbial populations of both soils, which suggests that actinomycetes generally possess a greater tolerance for moisture stress than the bacterial population.

RESEARCH EQUIPMENT

Magazine Seed Dispenser for the Model SC 701 Seeder

A seed dispenser system was designed as the first step toward complete automation of the four-row cereal seeder. The design is

centered around a commercial 24-compartment plastic container. The container is preloaded with seed and placed in a holder on the machine. As the seeder moves across successive plots, the container is advanced manually and seed is dropped into each of the four cones. Initial assessment of the device was favorable; it will form the basis of a completely automated seeding system that will make continuous seeding possible and eliminate prepackaging of seed in individual containers.

Mobile Track Harvester

In 1971, it was decided that the design of an efficient, all-weather, cereal plot harvester could best be accomplished by suspending the harvesting head on a track, thereby eliminating the need for supporting the harvester on small wheels that traveled on the ground. The first part of the system was a large mobile track that spanned the plot, and that could be moved from one plot to the next on wheels that traveled in the pathways at the end of each range of plots. The self-propelled track was designed, constructed, and tested during 1972, and performed reasonably satisfactorily. The track consists of a rigid, bridged beam 8 m long supported 2 m above the plot by an A frame placed at each end. Each A frame is supported on two wheels spaced 2 m apart, of which one is rigid and powered and the other is a castor wheel. Hydraulic power, supplied by two variable displacement pumps driven by an 18-hp engine, is used to operate the mobile track and its accessories. Power is transmitted independently to the drive wheel on each A frame. This hydrostatic drive is bidirectional and has infinite speed selection. The operator is seated on a platform on one of the A frames. Travel and steering of the frame are accomplished by regulating the speeds of the two drive wheels. When the frame is in position for harvesting a plot, the hydraulic power from one wheel is transferred to a winch system that pulls the harvester back and forth on the track. The power from the other wheel is transferred to the hydraulic motor that drives the harvesting head.

A rotary cutting mechanism using forced air and vacuum to move the material from the cutter was also constructed and tested. This cutting head was not successful because there was not enough air movement to clear the cut material from the cutting mechanism.

Also, the rotary cutting mechanism tended to cut the stalk of grain in such a way that the heads would fall forward rather than backward into the collection pan. The cutting head was modified by using vertical belt conveyors to carry the grain into the cutting mechanism and into the collection basket. This modification improved the performance, but further changes are needed.

Hydraulic Load Cell Lysimeter

The need for economical installation of a number of lysimeters led to the development of a load cell consisting of two sheets of 1.6-mm nylon-reinforced butyl rubber clamped between three metal hoops. The top and center hoops were made of 12.7-mm square rod and the bottom hoop of 3.2×12.7 mm flat iron. The outside diameter of the hoops was 12.7 mm less than the inside diameter of the outside tank. The inlet was located in the center hoop and the air escape vent in the top sheet. The diaphragm load cell was connected to 6.4-mm copper tubing that ran horizontally for a distance of 3 m, and then vertically 0.9 m out of the ground. The top 0.75 m of the pipe was glass of the same diameter, for sighting purposes. The stand-pipe was supported in a $3.2 \times 12.7 \times 25.4$ mm channel to which a metric tape was cemented. A second dummy tube for temperature correction was supported in a similar channel. The system was filled with a 1:1 mixture of antifreeze and water. The load cell has been operated satisfactorily for 4 yr.

Incubator for Soil Biological Research

A 6.0-m³ household freezer was converted to an incubator by incorporating a heating coil, a circulating fan, and a controller unit. The controller unit was designed to automatically control the freezer cooling unit and the heating coils, to maintain the temperature according to a predetermined program. The temperature in the incubator was measured by a thermistor, which formed one arm of a bridge circuit; the programming potentiometer formed the opposite arm. An operational amplifier was used to amplify the error signal from the bridge and to drive a thermistor push-pull switch, which in turn controlled the freezer, compressor, and heating coil. The programming potentiometer was driven by a timing motor through a crank mechanism. The timing motor allowed the temperatures to be varied sinusoidally over a 24-h cycle.

The incubator can be operated at constant temperature by switching off the timing motor, thus holding the programming potentiometer at a constant set point. The unit

provides a maximum temperature of 38°C, minimum temperature of -21°C, maximum sinusoidal temperature range of 22°C, and minimum sinusoidal temperature range of 4°C, with an accuracy of 0.5°C.

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Research Station Beaverlodge, Alberta

PROFESSIONAL STAFF

L. P. S. SPANGELO, B.S.A., M.Sc., Ph.D.
M. D. HAMILTON

Director
Administrative Officer

Environment and Special Crops Section

R. E. HARRIS, B.S.A., M.S.A., Ph.D.

Head of Section; Environment and
special crop breeding

A. L. DARWENT, B.S.A., M.Sc., Ph.D.

Weed research

J. S. MCKENZIE,¹ B.Sc., M.Sc.

Plant survival

Cereal and Oilseed Crops Section

D. G. FARIS, B.S.A., M.S.A., Ph.D.

Head of Section; Cereal breeding

Forage Crops Section

P. PANKIW, B.S.A., M.Sc., Ph.D.

Head of Section; Legume seed
management

S. G. BONIN, B.S.A., Ph.D.

Grass breeding

C. R. ELLIOTT, B.Sc., M.Sc., Ph.D.

Grass seed management

D. L. NELSON, B.S.A., M.Sc.

Apiculture

W. L. PRINGLE, B.S.A., M.S.F.

Production and utilization

Soils Section

P. B. HOYT, B.S.A., M.S., Ph.D.

Head of Section; Organic matter
relationships

A. M. F. HENNIG, B.Sc.

Crop management

W. A. RICE, B.S.A., M.Sc., Ph.D.

Microbiology

Experimental Farm, Prince George, B.C.

W. K. DAWLEY, B.S.A.

Superintendent; Forage utilization

J. N. TINGLE, B.S.A., M.Sc.

Forage management

Experimental Farm, Fort Vermilion, Alta.

B. SIEMENS, B.S.A., M.Sc.

Superintendent; Forage crops
management

Departure

A. C. FLEMING, B.A.

Resigned January 3, 1972

Administrative Officer

VISITING SCIENTIST

J. M. CLARKE, B.S.A.

University of British Columbia postgraduate
student

Grass seed physiology

¹Postgraduate leave to University of Minnesota, St. Paul, Minn., September 1971 to August 1973.

INTRODUCTION

The Northern Research Group, which comprises the Research Station at Beaverlodge and the associated Experimental Farms at Fort Vermilion, Alta., and Prince George, B.C., continued research aimed at agricultural problems of northwestern Canada.

Research activity in the far north is restricted to assessment of the Slave River Lowlands, approximately 0.7 million ha. Research plots are located 64.4 km north of Fort Smith, N.W.T., along the Slave River.

The herbage testing program for the Organization for Economic Cooperation and Development is a main concern of the Forage Section, and provides essential information for Canada's forage seed industry. Forage research was highlighted by the licensing of Castor reed canarygrass, introduced for its high seed retention and herbage production.

At the request of the Department of Indian Affairs and Northern Development, an assessment was made of agricultural land along the Mackenzie River, N.W.T., and for the Peace-Athabasca Delta Project, Fort Chipewyan, Alta., to determine the capacity of the Delta to support bison.

Forage crop production and management research continued as the main activity at Fort Vermilion and at Prince George, where beef animals are used to test forage utilization.

Two staff members attended Bureau of Staff Development and Training courses during the year.

This report summarizes the research that was carried out in 1972. The report and reprints of the publications are available on request. Correspondence to individual research scientists should be addressed to: Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta., T0H 0C0; Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta., T0H 1N0; or Experimental Farm, Research Branch, Agriculture Canada, Prince George, B.C.

L. P. S. Spangelo
Director

CEREAL CROPS

Physiology

Effect of plant density on tiller growth in barley. Three phases of tillering were recognized in barley plants grown at densities from 50 to 1,600 plants/m². The first phase, tiller bud initiation, was little affected by density. The number of buds that grew was controlled in the second stage by density, few buds developing at high densities. The morphology of the tillers that grew at high densities suggested that the tiller bud may be controlled by endogenous gibberellin. In the final stage, beginning when tillers emerged from the subtending leaf sheath, competition for light appeared to be the factor that determined whether a tiller survived to produce a head. This research was conducted at the Plant Breeding Institute, Cambridge, England, in cooperation with Dr. E. J. M. Kirby.

ENVIRONMENT

Shelterbelts

Effects of a series of shelterbelts on snow drifting. In the winter of 1972, snow depth on the windward side of the windward (most westerly) shelterbelt averaged 34 cm, and on the leeward side 43 cm. Snow drifts averaged 132 cm in the windward shelterbelt, and only 61 cm in the leeward shelterbelts. The drifts on both sides of the windward shelterbelt averaged 30% deeper than those around leeward shelterbelts. Thus, the adverse effects of snow buildup and delayed soil drying in the spring can be greatly reduced if a series of shelterbelts is used.

Effects of shelterbelts on the environment and yield. A shelterbelt was established that consisted of a row of *Caragana arborescens* Lam. 1.0 m high on the windward side, a row of mixed *Populus* spp. 10 m high in the center, and a row of *Picea pungens* Engelm. 6 m high on the lee side. In 1972, the shelterbelt decreased wind by 44%, evaporation by 26%, and maximum temperature by 2.3%, but it increased minimum temperatures

by 2.2% and the yields of barley by 41% and sunflowers by 247%. The yield of barley increased at a rate equivalent to 21.4 t more from a 65-ha square field protected by seven shelterbelts than from an unprotected 65-ha square field.

FORAGE CROPS

Breeding

Reed canarygrass. Castor, a new variety selected for high seed retention and good herbage production, was licensed in May 1972. It is a four-clone synthetic produced by the polycross method. Tests across Canada show that Castor gives at least double the seed yield of Frontier, and the same forage yield. Breeder seed of Castor is from the Syn. 2 generation. A 3.6-ha field was established under contract to the Canadian Forage Seed Project for the production of Foundation seed, starting in 1973. Breeder and Foundation seed are distributed exclusively by the Canadian Forage Seed Project.

Seed Production

Alfalfa leafcutter bees and pollination. Populations of alfalfa leafcutter bees increased 3.1-fold when domiciles were set up facing south, but only 1.7-fold when domiciles faced east. Movement of domiciles beyond the flight range reduced the productive potential, because many of the bees did not return to their domiciles at night and were lost.

Spacing effect on seed yield of alsike clover and birdsfoot trefoil. Marked reduction in seed yield resulted when row spacings were increased from 15 cm to 76 cm. Alsike clover in narrow spacings produced yields of 994 kg/ha but only 341 kg/ha in the wider spacings. Yields of birdsfoot trefoil were 741 and 301 kg/ha respectively.

Herbage Production

Effect of dates of seeding of alfalfa and bromegrass on yields of hay. At Fort Vermilion, delayed seeding of hay crops reduced yields. In the year of establishment, 3,300–4,400 kg of dry matter (DM)/ha were obtained from May and June seedings. Seedings made in July and August did not produce enough growth for a harvest. One year after seeding, May and June seedings averaged 8,200 kg/ha, July seedings yielded

6,600 kg/ha, and August seedings gave 3,800 kg/ha. Two years after establishment, yields were similar from all treatments.

Timothy and reed canarygrass for pasture. Second-year pastures at Prince George provided 110 days of grazing, compared with 84 days during the first year. When used as the only feed, timothy produced more beef than reed canarygrass. The addition of a grain supplement (at 1 kg/100 kg of beef on pasture) for steers grazing reed canarygrass enhanced beef production. Zero grazing of both species showed an advantage over normal grazing, because of greater use of the available herbage and a higher stocking rate.

In the early grazing season, approximately 30% of the steers assigned to reed canarygrass developed a physiological disorder that closely resembled the symptoms described for sheep grazing *Phalaris tuberosa* L. in Australia; this was identified as *Phalaris* staggers.

Perennial forage yields in central British Columbia. Seven grass species and seven legume species were sown at seven locations in each year from 1969 to 1971. In three harvests from the 1969 seedings, Frontier reed canarygrass and Chief intermediate wheatgrass produced the highest total DM yield. Meadow foxtail was the first grass to reach heading. Beaver alfalfa and Altaswede red clover averaged the highest DM yields of the legumes at most locations. Tetra alsike clover outproduced all other legumes at one dry location.

Effect of N on yield and quality of meadow foxtail forage. Three applications of N at 56 kg/ha each on meadow foxtail in spring and after the first and second cuts (total application, 168 kg/ha) did not result in a better DM yield than one application of 224 kg/ha in early spring. However, the split application produced a higher third-cut yield than the single spring application. Crude protein levels ranged from 9% for the control to 20% for the forage that was treated with 224 kg/ha.

Quality of whole-crop cereals harvested as silage. Ten cereal cultivars and two mixtures were sown at three locations in central British Columbia for 3 yr, to determine the effect of species, cultivar, and location on silage yield and quality as judged by protein content and digestibility. Digestibility was determined from dry matter disappearance by a nylon

SOILS

bag technique. Jubilee barley and Pitic 62 spring wheat produced more crude protein than Glen oats and Rosner triticale. Also, the DM disappearance levels of Jubilee and Pitic 62 were significantly higher than those of Glen and Rosner.

HORTICULTURE

Strawberry Hardiness

Both electrical conductivity and recovery methods can be used to determine the relative hardiness of strawberry plants throughout the winter, if sufficient cold stress is applied. In late October, a cold stress of -9°C was sufficient to show differences in hardiness among the four cultivars used, whereas a sequence of temperatures of -9 , -10.5 , -12 , and -13.5°C was required in January and March. The electrical conductivity method is preferred because it is faster, is not affected by dormancy, and allows differences to be determined more readily.

RR₄ was the hardiest cultivar at all sampling times, followed in decreasing order of hardiness by Protém, British Sovereign, and Northwest. This agrees with field observations.

Soil Fertility

Effects of increasing rates of fertilizer. The mean yield of unfertilized Galt barley in eight tests on fallow was 23.52 q/ha, compared with 17.92 q/ha in eight tests on stubble. On fallow, application of N alone was less beneficial than application of P alone; yield increases were 2.24 and 7.84 q/ha respectively. On stubble, N alone was more beneficial than P alone, with increases of 7.84 and 4.48 q/ha respectively. At the fixed rate of 22 kg P/ha, yields of barley on fallow were nearly doubled by an application of 100.8 kg N/ha, whereas on stubble a rate of 134.4 kg N/ha was required to double yields. Increasing the rate of P did not consistently influence barley on fallow or stubble.

The mean yield of unfertilized Span rape in six tests on fallow was 8.96 q/ha, compared with 4.48 q/ha in eight tests on stubble. On both fallow and stubble, applications of N alone and P alone increased yields similarly by 3.36 q/ha. At the fixed rate of 22 kg P/ha, yields of rape on fallow were more than doubled by an application of 67.2 kg N/ha. Increasing the rate of N did not result in further yield increases. On stubble, 134.4 kg N/ha increased the yield of rape by 8.96 q/ha. The addition of more than 22 kg P/ha did not further increase the yield of rape on fallow or on stubble.

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Research Station Lacombe, Alberta

PROFESSIONAL STAFF

J. G. STOTHART, D.S.O., B.S.A., M.Sc., F.A.I.C.	Director
W. J. MURRAY	Administrative Officer

Animal Science Section

H. T. FREDEEN, B.S.A., M.Sc., Ph.D., F.A.I.C.	Head of Section; Animal breeding
H. DOORNENBAL, B.S.A., M.S.A., Ph.D.	Physiology
A. H. MARTIN, B.S.A., M.S.A.	Meats research
J. A. NEWMAN, B.Sc., Dip. An. Gen., Ph.D.	Population genetics
E. H. REIMER (MRS.)	Systems and programming
G. M. WEISS, B.S.A., M.Sc.	Biostatistics
J. A. BRADLEY, ¹ M.R.C.V.S.	Veterinary medicine

Plant Breeding Section

H. T. ALLEN, B.Sc., M.Sc.	Horticulture
B. B. BERKENKAMP, B.S., M.S., Ph.D.	Plant pathology
L. P. FOLKINS, B.S.A., M.Sc.	Forage crops
M. L. KAUFMANN, C.D., B.S.A., M.Sc., Ph.D.	Cereal crops
L. J. PIENING, B.Sc., M.Sc., Ph.D.	Plant pathology

Crop Management and Soils Section

H. A. FRIESEN, B.S.A., M.Sc.	Head of Section; Weed research
D. A. DEW, B.E.	Crop management
L. A. HEAPY, B.Sc., Ph.D.	Plant nutrition
D. K. MCBEATH, B.S.A., M.Sc., Ph.D.	Plant nutrition
D. R. WALKER, B.Sc., M.Sc.	Soil chemistry

Solonetzic Soil Substation, Vegreville

R. R. CAIRNS, B.S.A., M.Sc., Ph.D.	Officer in Charge; Soil physics and chemistry
------------------------------------	---

VISITING SCIENTIST

National Research Council postdoctorate fellow

A. NISHIDA, B.Sc., Ph.D.

Population genetics

¹Seconded from Health of Animals Branch.

INTRODUCTION

The diversification of the research program at the Research Station at Lacombe is illustrated in this brief report of our findings in 1972. Further details are available on request.

The inauguration of the new beef carcass grading standards on September 5, 1972, represented the culmination of three years of intensive research on beef carcass evaluation.

Dr. J. A. Bradley was seconded to the staff in April 1972 from the Health of Animals Branch. His primary responsibility is the investigation of calf scours and development of control procedures. His work also includes investigations on the nature, causes, and control of leg damage in growing pigs.

Dr. Bernt Bech Anderson, NATO Science Fellow from Denmark, spent five months at Lacombe (June 1 - October 30) developing genetic and statistical theory for selection indexes applicable to beef cattle.

Dr. Akira Nishida, NRC Fellow from Japan, began a one-year tenure at Lacombe on August 1. His research problem in genetics will be based on the data from Dr. Newman's long-term selection program with mice.

Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Lacombe, Alta. T0C 1S0.

J. G. Stothart
Director

ANIMAL SCIENCE

Beef Cattle

Feedlot and carcass performance of Simmental and Charolais crossbreds. Contemporary male progeny from Simmental sires (162 animals) and Charolais sires (172 animals) produced carcasses that were equivalent in all measures of carcass merit. Those from Simmental sires had slightly more external and internal fat, but the breed differences were not statistically significant. There were no interactions of sex, breed, and slaughter age. Breed-of-sire differences in feedlot performance were not statistically significant, but Charolais crosses had a significantly higher dressing percentage (61.2 ± 0.04) than Simmental crosses (59.6 ± 0.03). The main component of this difference was hide weight, Simmental-Hereford crosses having the heaviest hides and Charolais-Angus crosses the lightest. With the exception of this trait, there were no differences in feedlot or carcass performance associated with the breed of dam (Angus, Hereford, Shorthorn).

Comparative performance of bulls and steers. In comparison with the performance of bulls, feedlot growth rate of steers was 8% less, rib eye areas smaller (14%), fat depth and amount of kidney fat greater (42%), and lean yield from prime cuts less (7%). Age at slaughter had an important bearing on

measures of lean yield and lean content, particularly for steers. The sexes were similar in carcass composition at 12 mo of age, but lean yield of steers declined after this, whereas there was little evidence of change for bulls up to 15 mo of age.

Embryo transplants. Embryos from one Limousin and one Simmental cow, superovulated and inseminated in December 1971, were transplanted into recipient cows. From these, six living calves were obtained from the Limousin and one from the Simmental donor. The Limousin calves, all produced by Jersey recipients, averaged 35 kg at birth, with a range of 28 to 42 kg. The one Simmental calf (female) from a Short-horn recipient weighed 49 kg at birth. Both donor females conceived at subsequent breeding.

Scours in young calves. Various known pathogens, including the Nebraska CSV II virus, have been isolated from calves produced in the Lacombe herd. Reduction of sickness and mortality has been sought mainly through changes in management systems to reduce stress on the newborn calf. However, the need remains for extensive use of oral fluid therapy, administered in large volumes by stomach tube, to treat severe cases of dehydration. Various chemotherapeutic agents to control bacterial infections are also required. Loss of calves because of

scours has been reduced from a maximum of 44 deaths in 1970 to nine in 1971 and one in 1972, out of approximately 400 calves each year. This improvement was attributed mainly to the reduction of stress imposed on young calves, brought about by providing clean calving areas and by segregating cow herds at calving.

Swine

Crossbreeding. In comparisons of straightbred Lacombe swine with Chester-White, Duroc, and Pietrain topcrosses, the Pietrain crosses had the slowest growth rate to 90 kg liveweight, and Lacombes the most rapid rate. Pietrain crosses had the highest phenotypic rating for muscular development, particularly in the hams, but evaluation of live animals at 90 kg did not show any consistent pattern of breed differences in subcutaneous fat cover. All litters were produced by straightbred Lacombe females artificially inseminated with fresh semen. Conception rates from a 6-wk breeding period were approximately equivalent to those obtained from natural service (approximately 87%).

Meats Research

Beef muscle pH. Average pH of the *trapezius cervicales* muscle taken 20 min post-mortem was 6.99 for heifers and 7.04 for bulls. Subsequent measurements taken at intervals up to 13 days post-mortem demonstrated that almost all of the reduction in carcass pH levels occurred by 24 h post-mortem. Neither absolute pH values nor the extent of postmortem pH change were useful for predicting tenderness of the *longissimus dorsi* from steer or heifer carcasses. For bull carcasses, however, pH of the *longissimus dorsi* 24 h post-mortem was moderately correlated ($r = -0.7$) with determinations made with the Warner Bratzler shear apparatus. Objective scores of color brightness of the *longissimus dorsi* from bulls were also correlated (+0.7) with tenderness of this muscle. It was concluded that pH was not a useful predictor of ultimate meat tenderness except in the case of bull carcasses, and, for these, color brightness 24 h post-mortem provided a simpler and equally reliable method. For all determinations the sample comprised 147 heifers, 168 steers, and 259 bulls, all slaughtered in the age range of 12 to 16 mo.

Muscle properties of pork. No significant relationships were found among measures of carcass muscling and measures, both subjective and objective, of quality. Based on subjective quality rating, specifically the extent of "weeping" of the cut muscle, 13% of the barrows, 11% of the gilts, and 18% of the boars were judged to exhibit the PSE (pale, soft, exudative) condition. Final pH (48 h post-mortem) and transmission value (a measure of water-soluble protein) were moderately correlated ($r = +0.7$), and each was a reasonable predictor of subjective quality score (r^2 values of 0.6). This study was based on carcasses from 146 barrows, 192 gilts, and 120 boars, slaughtered at 90 kg liveweight.

Consumer acceptance of boar meat. Fresh hams and cured bacon from 70 carcasses each of barrows, gilts, and boars were distributed to 840 consumers for product evaluation. Samples of fat from each carcass were also evaluated for cooking aroma by three independent methods, one of which was a taste panel trained to identify 5- α -androst-16-en-3-one. Chemical analyses to detect this compound were performed on the boar samples. Most of the consumers (64%) could not differentiate between the three sexes; 10% gave boar meat a higher score than that from gilts and barrows, and 5% discriminated against boar meat. The latter figure was reduced when samples identified by the hot-iron technique as possessing undesirable odors were eliminated from the study. Androstenone content, determined chemically and by trained taste panel, was not a useful predictor of consumer response.

Beef carcass grading. The revised beef carcass grading standards, inaugurated on September 5, 1972, identify maturity, quantity of lean, and meat quality as the main criteria of carcass merit. The two top grades, reserved for youthful carcasses, are subdivided into four categories according to the degree of external finish (i.e., meat quantity). The distinction between grades A and B is based on meat color, texture, firmness, and other meat quality attributes. The research background for this system, developed at Lacombe, involved detailed dissection and laboratory evaluation of more than 1,100 beef carcasses. It was shown that the difference between each fat category (5 mm in fat) in the percentage yield of closely trimmed bone-in retail product approximated 2%.

There was no difference in yield between various carcass-weight classes of the same fat category, or between A and B carcasses of the same fat category. Steer and heifer carcasses at the same level of fatness were identical in lean content, but differed in carcass weight by approximately 90 kg (heifers lighter). Within each weight class, the rib eye area decreased with increasing fat cover, demonstrating that early-maturing cattle (those fattening at the lightest weights) are less well muscled than those that mature later.

Trends in hog grades. The hog carcass grade standards inaugurated on December 30, 1968, have noticeably influenced the carcass merit of slaughter pigs. In 1969, 42.4% of the 7.5 million pigs slaughtered had an index of 102 or higher. In 1971, the corresponding figure was 45.6% of 10.1 million carcasses. Over the same period there was an upward trend of approximately 1.4 kg in average slaughter weight. Thus, reduction in carcass fatness has occurred simultaneously with an increase in carcass weight. Three years is a short time in which to achieve meaningful genetic change, and it is concluded that the trends observed derive mainly from changes in management and nutrition practices.

Physiology

Pattern of fat deposition. The proportion of carcass fat, chemically determined from the entire carcasses of 90 pigs slaughtered in the liveweight range of 10–132 kg, increased in a linear fashion with increased body weight. Growth patterns of fat in ham, loin, and shoulder paralleled those of the carcass, but the belly cut showed a more rapid increase in fat content. Data from animals of more than 120 kg liveweight gave some indication of accelerated fat deposition.

PLANT BREEDING AND PATHOLOGY

Cereal Crops

Diseases. Experiments to explain the death of cattle grazing on rust-infected summer-sown rye confirmed that severe infection of leaf rust, caused by *Puccinia recondita* Rob. ex Desm., on leaves of greenhouse-sown rye could increase the nitrate content of the plant to toxic levels.

Leaf-diseased barley treated throughout the growing season with maneb showed a significant increase in yield at both Lacombe and Cheddarville, although the level of disease was not reduced by this chemical. Climatic conditions, and high rainfall in particular, may have contributed to this result.

Disease surveys. Disease surveys of cereal crops in central Alberta indicated losses of yield in barley of 13% due to common root rot, 9% to scald, 1% to net blotch, and 1% to smut. Traces of leaf rust were found on over 80% of the wheat fields examined and stem rust on 10%. In no case were these infestations severe. Other diseases of wheat commonly encountered were ergot, take-all, a black discoloration of the heads, and common root rot.

Forage Crops

Annual species for forage. With heat units ranging from only 1,800 to 2,100, oats outyielded both corn and barley for silage in central Alberta. Over a 15-yr period, oats averaged 8,000 kg/ha and corn 5,600 kg/ha. Oats averaged the same over an 8-yr period, whereas barley averaged 7,200 kg/ha. Under more limited testing, sudan grass and sorghum-sudan hybrids were also lower yielding than oats.

When spring-seeded fall rye or fall rye and oats were clipped two or three times per season as simulated pasture, their yields equaled or surpassed that of oats alone and they gave a more uniform distribution of production over the season. Annual ryegrass alone or in mixture with oats also yielded well as annual pasture, especially in seasons when moisture was adequate.

Crown and root rot of birdsfoot trefoil. A disease affecting the internal tissue of the crown and tap root of birdsfoot trefoil was found in second-year and older stands in central Alberta. Fungi and bacteria associated with the disease were isolated and tested for pathogenicity on trefoil seedlings. Two lines of *Fusarium* spp. and *Stemphylium loti* Graham were found to be the most pathogenic, but a single causal organism could not be specified. Various commercial fertilizer applications did not influence the disease incidence.

Disease survey. In an extensive survey of foliage diseases of forage crops in central

and northern Alberta, losses of legume and grass species were estimated as follows: alfalfa 5.9%, red clover 13.2%, alsike clover 12.2%, sweetclover 0.4%, white clover 13.8%, brome 2.3%, timothy 1.6%, and fescue 13.5%. The 34 diseases of the various species, when adjusted for the area grown, resulted in an average crop loss of 6.8% throughout the northern portion of Alberta (census divisions 8-15). The financial loss was estimated to be 5.9 million dollars annually.

Oilseed Crops

Root rot of rapeseed. Fungi were isolated and identified from diseased roots of rapeseed from several areas of Alberta. *Rhizoctonia solani* Kuehn. was the most prevalent, followed by several varieties of *Fusarium roseum* Lk. Some isolates were tested for pathogenicity on seedlings. *Rhizoctonia* was the most pathogenic fungus, followed by *Alternaria* and several isolates of *Fusarium*.

Disease survey. Eighty-four rapeseed fields in central and northern Alberta were surveyed for diseases. White rust, gray leaf spot, stem ring spot, and alternaria pod spot were found in trace amounts. Staghead was found in 20 of the fields examined, with an average of 6.5% of the heads infected. An average of 11.7% of the plants of all fields showed root rot symptoms.

Horticultural Crops

'Booster', a new tomato cultivar. This introduction from the Co-operative Tomato Breeding Project for the Prairie Provinces was selected at Lacombe from the backcross Morden BB3 × Earlinorth³. Its maturity is similar to that of Rocket, but the average fruit weight is 40 g greater. Although its yields are lower, the fruits do not burst as frequently as those of Rocket under field conditions.

Effect of green-sprouting whole and cut seed on early potato yields. When harvested 74 days after planting, early-planted Warba and Norland potatoes produced significantly greater yields from green-sprouted whole seed than from whole seed after storage, or from cut seed of stored or green-sprouted tubers. Whole seed was superior to cut seed when planted 7 days later, but green-sprouting proved to be of no advantage.

Effect of transplanting and mulching on sweet corn maturity and yield. At three

locations, transplants of Spancross mulched with 0.05-mm (2-mil) clear polyethylene matured an average of 12 days earlier than corn field-seeded without mulch. Transplants without mulch and plants field-seeded with mulch matured 5 and 8 days earlier, respectively. The first harvest from the transplants was nearly double that of the field-seeded corn.

Effect of mulching and spacing on yields and maturity of cucumbers. Results in 1972 confirmed earlier findings, in that there was no advantage in spacing Marketer transplants closer than 0.9 m in the row when mulched with clear polyethylene. Mulching advanced earliness by 9 days and increased yields by 4.8 fruits per plant compared with the controls without mulch.

CROP MANAGEMENT AND SOILS

Weed Research

Herbicides applied postemergence to wheat and barley for control of wild oats. Studies were begun in 1969 with various formulations of ethyl-*N*-benzoyl-*N*-(3,4-dichlorophenyl)-2-aminopropionate. Formulation FX-2182 (Shell Canada Ltd.) not only gave better control of wild oats, *Avena fatua* L., than barban but could be applied over a much longer period of development of the weed, from the three- to the five-leaf stage. The degree of control increased when the spray date was delayed to the five-leaf stage. However, crop yield was lower because of the longer period of competition when the spray was applied later. Wheat was highly tolerant, rapeseed appeared tolerant in preliminary tests, but barley and oats were highly susceptible. FX-2182 was test-marketed under the trade name Endaven (Shell) in 1972.

The postemergence herbicide AC-84777 (American Cyanamid Co.) for control of wild oats in barley, which showed promise in 1971, was further tested in 1972 and performed similarly to FX-2182 in wheat. However, there was evidence that rapeseed, notably the variety Zephyr, was sensitive. Like FX-2182, it tended to increase in efficacy as the wild oats advanced from the two- to the five-leaf stage, thus giving considerable latitude in spray date.

Both compounds in tank mixtures appeared to be compatible with MCPA, 2,4-D, and bromoxynil but not dicamba.

Factors affecting control of wild oats in rapeseed with trifluralin. Placement of trifluralin in the soil was found to be most important, because the main site of activity on wild oats was through the shoot or coleoptile. Polish rapeseed, *Brassica campestris* L., was not affected by trifluralin up to 1.4 kg/ha, regardless of placement. Activity of the herbicide was not seriously reduced by soil moisture as low as 10%, which is lower than in air-dry soil. Activity was reduced by a high content of organic matter in the soil, and by incorporation of the herbicide to depths below 7.5 cm.

In field experiments, trifluralin sprayed in the spring at 1.12 kg/ha and immediately tandem-disced 7.5 cm deep gave better than 80% control of wild oats without injury to rapeseed. Yield increases depended on the density of the infestation by wild oats. Bioassay showed a loss of more than 90% of trifluralin activity in one growing season, and cereals planted the year after trifluralin treatment were not affected. At Lacombe, Alta., and Melfort, Sask., when trifluralin was sprayed and incorporated in October and rapeseed sown the following May, the treatment controlled wild oats almost as well as spring applications. This procedure has important practical implications, in that it avoids the excessive tillage and soil drying associated with spring application.

Index of competition for estimating crop loss due to wild oats. An "index of competition" was derived that can be used to estimate crop loss due to weeds when weed and crop species, density of weed stand, and expected weed-free yield are known. Experimental data were used to derive this index for wild oats in barley, wheat, and flax. Loss, in g/m², equals $ab_1\sqrt{x}$, where a equals the expected weed-free yield in g/m², x equals the number of wild oats/m², and b_1 equals the "index of competition". This index is 0.0230, 0.0339, and 0.0601 for wild oats in barley, wheat, and flax, respectively.

Breakthrough in perennial weed control. Growth-cabinet and field studies have shown that glyphosate [*N*-(phosphonomethyl) glycine] (Monsanto Canada Ltd.) was capable of translocating from the vegetative parts to the underground roots and rhizomes of

perennial plants and destroying them, without residual activity in the soil or a premergence effect on crops. It is the first time this has been achieved by a weed control herbicide. Quack grass was the most susceptible perennial species. Applications made in the spring of 1972 reduced the stand of quack grass by 90%, and doubled the yield of barley seeded 2 wk after treatment. Control of Canada thistle and dandelion was not so complete, but is still encouraging.

Soils

Effect of forages on subsequent barley production. Barley was grown continuously for 8–9 yr at six locations. At each location, an adjacent site produced forage until 1970, then barley from 1971. In contrast to effects observed the previous year, no evidence was obtained in 1972 that barley productivity benefited from previous forage production. Soil reserves of available P were depleted to a greater extent by forages than by continuous barley production. Rooting volume of the barley crop was not influenced by previous forage production. Depth of barley root development varied considerably among soils, ranging from 40 to 110 cm. Earlier forage cropping improved the rates of water intake into the soils, but this effect disappeared in the second year after breaking.

Soil test for N. Experimental data collected over several years at six locations indicated that a barley crop used soil NO₃-N from depths greater than 15 cm. However, for predicting the requirement for N fertilizer, no appreciable improvement was obtained from evaluating NO₃-N below 15 cm.

Identifying S deficiency. Sulfur has been shown to be a very important, even limiting, element to crop production in certain soils in central Alberta. It has been a problem to identify these soils accurately.

Extractable soil SO₄ was measured by precipitating it as ¹³³BaSO₄ and counting the activity of the ¹³³Ba, or by reducing the SO₄ to H₂S and measuring the methylene blue formation. Agreement between the two methods was assumed to indicate accuracy of analyses. Based on this assumption, measurements were found to be reliable for all subsurface soil extracts and surface soil extracts containing > 2 ppm SO₄-S.

Deficiencies in soil S available for legume growth were predicted with 86% accuracy by measuring extractable SO₄ in the 0- to 30-cm

layer of soils. To attain this accuracy, soils should be sampled before active plant growth commences and air-dried before analysis.

SOLONETZIC SOIL SUBSTATION, VEGREVILLE

Effects of mixing Solonetz soil horizons on the availability of N to plants in the greenhouse. Samples of single and mixed horizons of Solonetz soils were incubated and analyzed for $\text{NO}_3\text{-N}$. Similar samples were used for the production of barley seedlings and the uptake of N by the plants was measured. In general, the measurement of $\text{NO}_3\text{-N}$ in soils after incubation showed that there was less mineralization of N in mixed horizons than in Ap horizons. However, in three of the four soils, barley seedlings took up more N from the mixed horizons than from the Ap horizons.

Probable role of Ca compounds in increasing crop yields on deep-plowed Solonetz soil. Samples of the Ap horizon and Ap-Bnt horizon mixtures of four Solonetz soils were treated with NH_4NO_3 , CaSO_4 , and CaCO_3 , singly and in combinations. Calcium carbonate increased the soil pH, NH_4NO_3 had no

lasting effect on soil pH, and CaSO_4 decreased the pH relative to that of untreated but cropped soils and its effect increased with time. Seedlings grown on CaCO_3 -treated soil recovered about the same amount of additional N as seedlings grown on soil treated with 200 ppm NH_4NO_3 . Yield increased with N supply, and K uptake increased with N uptake. However, the application of K to a soil that provided little to plants did not cause a very great yield increase. Calcium sulfate increased yields only with the first crop on one soil and with the second crop on another soil. It was concluded that increasing the pH of the Ap horizon of Solonetz soils by deep plowing increases the availability of soil N to plants.

Effects of surfactants applied to samples of Solonetz soil on water penetration and plant growth. Water penetrates very slowly into Solonetz soils; surfactants were therefore applied to the Ap horizon of Duagh silt loam in an attempt to increase the rate of penetration and possibly also the productivity of plants. It was found that surfactants in general do not appear to increase the rate of water penetration into Solonetz soil, but their application at substantial rates could cause problems in plant nutrition.

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Research Station Lethbridge, Alberta

PROFESSIONAL STAFF

J. E. ANDREWS, B.S.A., M.S., Ph.D.	Director
I. L. STEVENSON, B.S.A., M.S.A., Ph.D.	Associate Director
S. B. ARNASON, B.S.A.	Head, Administration Section
C. G. SCHOENING	Administrative Officer - Accounts
D. H. WHITFIELD	Administrative Officer - Personnel

Scientific Support

P. E. BLAKELEY, B.S.A., M.Sc.	Technical Liaison Officer
G. C. KOZUB, B.Sc., M.Sc.	Biometrician
J. P. MISKA, B.L.S.	Library Area Coordinator
K. C. PIEUK (Mrs.), B.A., M.L.S.	Assistant Librarian
P. H. WALKER, C.D., B.Sc.	Editor

Economics Section

B. H. SONNTAG, B.S.A., M.Sc., Ph.D.	Senior Economist
K. K. KLEIN, B.S.A., M.Sc.	Economist
K. D. RUSSELL, B.Sc., M.S.	Economist
R. P. J. ZENTNER, B.S.A.	Economist

Animal Science Section

S. B. SLEN, B.A., B.Sc., M.S., Ph.D.	Head of Section
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D. M. BOWDEN, B.S.A., M.S.A., Ph.D.	Animal nutrition
K.-J. CHENG, B.Sc., M.Sc., Ph.D.	Rumen microbiology
E. E. GARDINER, B.S., M.S., Ph.D.	Poultry nutrition
R. HIRONAKA, B.Sc., M.Sc., Ph.D.	Animal nutrition
J. E. LAWSON, B.S.A., M.S.A.	Beef cattle breeding
J. A. P. VESELY, B.S.A., M.S.A., Ph.D.	Sheep and dairy cattle breeding

Crop Entomology Section

N. D. HOLMES, B.Sc., M.Sc., Ph.D.	Head of Section; Wheat stem sawfly
W. A. CHARNETSKI, B.Sc., M.Sc., Ph.D.	Insecticide residues
A. M. HARPER, B.Sc., M.Sc., Ph.D.	Aphids
G. A. HOBBS, B.S.A., M.Sc., Ph.D.	Forage-crop insect pollinators
R. KASTING, B.Sc., M.Sc., Ph.D.	Plant and insect biochemistry
C. E. LILLY, B.Sc., M.Sc.	Potato and sugarbeet insects
S. McDONALD, C.D., B.Sc., M.Sc.	Toxicology
D. S. SMITH, B.Sc., M.S., Ph.D.	Grasshopper ecology and survey
D. L. STRUBLE, B.A., M.A., Ph.D.	Insect attractants; insecticide residues
G. E. SWAILES, B.S.A., M.S., Ph.D.	Cutworms and special crop insects

Plant Pathology Section

J. B. LEBEAU, B.Sc., M.S., Ph.D.	Head of Section; Forage and turfgrass diseases
T. G. ATKINSON, B.S.A., M.Sc., Ph.D.	Cereal diseases
F. R. HARPER, B.Sc., M.Sc., Ph.D.	Vegetable diseases
E. J. HAWN, D.F.C., B.S.A., M.Sc., Ph.D.	Nematode diseases
G. A. NELSON, B.Sc., M.Sc., Ph.D.	Bacterial diseases
D. W. A. ROBERTS, B.A., Ph.D.	Cryobiology

Plant Science Section

D. B. WILSON, B.Sc., M.S., Ph.D.	Head of Section; Irrigated pastures
J. R. ALLAN, B.Sc., M.A., Ph.D.	Aquatic plant physiology
S. FREYMAN, B.Sc., M.S.A., Ph.D.	Crop physiology
M. N. GRANT, B.Sc., M.Sc., Ph.D.	Winter wheat breeding
M. R. HANNA, B.S.A., M.S.A., Ph.D.	Forage legume breeding
A. JOHNSTON, B.S.A., M.S.	Range ecology
M. S. KALDY, B.Sc., M.S., Ph.D.	Food science
G. A. KEMP, B.Sc., Ph.D.	Vegetable breeding
R. I. LARSON (Miss), B.A., M.A., Ph.D.	Wheat cytogenetics
M. D. MACDONALD, B.Sc., Ph.D.	Corn breeding; wheat cytogenetics
H. MCKENZIE, B.S.A., M.Sc., Ph.D.	Spring wheat breeding
N. B. McLAUGHLIN, B.Sc. (Eng.), M.Sc.	Forage systems engineering
J. J. SEXSMITH, B.Sc., M.Sc.	Crop weeds
S. SMOLIAK, B.Sc., M.S.	Dryland pastures; Grass breeding
W. E. TORFASON, B.S.A., M.Sc., Ph.D.	Vegetable culture
S. A. WELLS, B.S.A., M.Sc., Ph.D.	Barley breeding

Soil Science Section

D. C. MACKAY, B.Sc., M.S., Ph.D.	Head of Section; Plant nutrition
D. T. ANDERSON, B.S.A., M.Sc.	Agricultural engineering
J. B. BOLE, B.S.A., M.Sc., Ph.D.	Plant nutrition
J. M. CAREFOOT, B.S.A., M.S.A.	Chemical analyses
J. F. DORMAAR, B.S.A., M.S.A., Ph.D.	Chemistry and genesis

S. DUBETZ, B.Sc., M.S.	Irrigation agronomy
E. H. HOBBS, B.Sc.	Irrigation engineering
K. K. KROGMAN, B.Sc., M.Sc.	Irrigation efficiency
C. W. LINDWALL, B.Sc.	Agricultural engineering
L. E. LUTWICK, B.Sc., M.Sc., Ph.D.	Chemistry and genesis
J. L. NEAL, B.S., M.S., Ph.D.	Soil microbiology
U. J. PITTMAN, B.Sc.	Dryland agronomy
A. D. SMITH, B.Sc.	Dryland forages
T. G. SOMMERFELDT, B.Sc., M.S., Ph.D.	Drainage engineering
J. C. VAN SCHAİK, M.Sc., Ph.D.	Soil physics

Veterinary-Medical Entomology

W. O. HAUFE, B.A., M.Sc., D.I.C., Ph.D.	Head of Section; Bioclimatology and behavior
K. R. DEPNER, B.Sc., M.Sc., Ph.D.	Black fly ecology
M. A. KHAN, G.V.Sc., M.S., Ph.D.	Toxicology
W. A. NELSON, B.Sc., M.Sc., Ph.D.	Physiology (ectoparasites)
R. H. ROBERTSON, B.A., M.Sc.	Serology
J. A. SHEMANCHUK, C.D., B.Sc., M.Sc.	Biting fly ecology
J. WEINTRAUB, B.A., M.S.	Cattle grub ecology
P. R. WILKINSON, B.A., M.A., Ph.D.	Ticks and economic entomology

Departures

E. J. CANNINGS (Miss), B.A., B.L.S. Resigned February 27, 1972	Assistant Librarian
K. POHJAKAS, B.S.A., M.S.A. Resigned March 16, 1972	Irrigation management
D. J. LARSON, B.Sc., M.Sc. Resigned February 25, 1972	Forage-crop insect pests

VISITING SCIENTISTS

National Research Council postdoctorate fellows

U. SOEHNGEN, B.Sc., M.S., Ph.D., 1971-72	Forage-crop insect pollinators
J. R. GALLAGHER, B.Sc., M.Rur.Sc., Ph.D., 1971-72	Reproductive physiology
R. K. CROOKSTON, B.Sc., M.Sc., Ph.D., 1972	Crop physiology

INTRODUCTION

This report summarizes the results of the multidisciplinary research programs related to Western Canadian agriculture undertaken at the Research Station, Lethbridge, during 1972. Emphasis continues to be placed on research concerned with assessment of crop losses; development of new crops; forage, grass, and grain breeding; nutrition, management, and breeding practices for beef and sheep production; biological disposal of crop and animal wastes; management of pesticide residues; and control of economically important diseases and insects. The installation of a computer terminal and the improved data-processing facilities have increased our capacity to handle data and evaluate experimental results.

Extensive planning was carried out during the year for a new office-laboratory complex, which will include a wing for Regional Officers of the Alberta Department of Agriculture and offices for the staff of the Production and Marketing Branch, Agriculture Canada. Thus, most federal and provincial staff serving agriculture in southern Alberta will be brought together to allow better coordination of effort, avoid duplication of service, and enable the public to find all agricultural services at one location.

Dr. R. W. Salt, who retired in 1970 after 40 years of service at this Station, was presented with the Gold Medal of the Canadian Entomological Society in recognition of his distinguished and pioneering contributions to insect physiology in Canada.

The Station maintains its close liaison with the Alberta Department of Agriculture and grower and producer organizations in the application of its research results. Research personnel continue to participate actively on federal-provincial committees, workshops, and courses concerned with provincial and local agricultural problems.

Detailed information on research results can be obtained from the scientists or from the publications listed in this report. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

J. E. Andrews
Director

ANIMAL SCIENCE

Beef Cattle

Structure of siliceous calculi. The average contents of 74 calculi that had caused urethral obstruction in range steers were silica, 50.7%; calcium oxalate, 13.8%; water, 3.0%; and organic matter, 20.1%. Most of the calculi consisted of white porous material overlaid with dense laminations of silica or oxalate. Under the electron microscope, the porous material appeared to have the structure of aggregated colloidal silica. Siliceous laminations were composed of similar but more highly compacted material. Apparently, most siliceous calculi form by deposition of layers containing silica, and sometimes oxalate, on a preformed mass of colloidal silica aggregate.

Salt intake and calculus formation. Prairie hay and a supplement containing 15–25% salt (NaCl) and 75–85% barley were given to 350-kg steer calves. Supplement intake was 1–2 kg/day, thereby providing 220–380 g of

salt. Prairie hay alone caused high levels of silicic acid in urine and formation of calculi. Intake of 300 g of salt markedly lowered urine levels of silicic acid and nearly eliminated calculus formation; calculus formation was reduced but not eliminated by an intake of 200 g of salt. Thus, supplements that induce range calves to consume at least 300 g of salt/day should reduce calculus formation.

Particle size of feed and bloat. The rumen fluid of cows fed an all-concentrate diet of fine particle size was foamier and more viscous (indicative of bloat) and had a lower pH and more soluble carbohydrate than rumen fluid from cows fed the same diet of coarse particle size. The fine-particle feed produced more gas per gram of rumen dry matter than the coarse feed (3.46 vs. 2.35 mg/g dry matter per h). The pH of the rumen in two of five cows on the fine feed fell below 4, and the cows became so emaciated that they were removed from the experiment. The numbers of *Streptococcus bovis* in the rumen dropped precipitously

when the cows were fed the all-concentrate diets. It was concluded that, contrary to earlier suggestions, *S. bovis* is not a primary cause of feedlot bloat.

Electron microscopy of cells from the rumen contents of animals suffering from bloat showed that the rumen flora had spheroplasted, or broken. The presence of extracellular alkaline phosphatase in the rumen fluid supports our view that substances released when cells rupture induce the foaming and high viscosity that contribute to bloat.

Fat reduction in feedlot steers. Excessively fat steers fed 80% of their estimated maintenance requirement lost an average of 26 kg liveweight and 10 kg warm carcass weight in 4 wk. Warm carcass weight remained unchanged in the first 3 wk, even though liveweight loss averaged 17 kg. Cattle slaughtered after 4 wk of feed restriction tended to yield carcasses with less fat than those slaughtered at the beginning of the experiment.

Highland cattle performance. Highland calves were surpassed by the Hereford and the reciprocal crosses in birth weight, weaning weight, and feedlot gain, but both breeds needed the same amount of total digestible nutrients to make the same gain. Highland cows were excellent mothers and weaned almost all calves conceived. F₁ cows of Hereford × Highland had higher conception rates and weaned heavier calves than either parental breed, and had fewer calving problems than the Hereford. They equaled the Hereford but surpassed the Highland in carcass grades. The Highland will not play an important role in range herds as a pure breed, but F₁ females sired by Highland bulls can make a valuable contribution.

Blood constituents and plane of nutrition in female beef cattle. Blood cholesterol level was increased when plane of nutrition of nonpregnant 2-yr-old heifers was increased to produce average gains in body weight of 0.57 kg rather than 0.19 kg/day. During 10 mo this difference in plane of nutrition did not affect monthly levels of 10 other blood constituents. In 5 of the 10 mo, Angus heifers had higher packed cell volumes and blood levels of glucose and sodium than Hereford heifers. Monthly levels of all blood constituents sometimes varied significantly, indicating the influence of factors other than plane

of nutrition of breed of animal. During the last 3 mo of pregnancy in Angus and Hereford heifers, levels of blood glucose decreased and levels of plasma of nonesterified fatty acid and plasma ketone increased. These changes were greater in heifers fed to maintain their weight than in those fed to gain about 0.3 kg/day.

Sheep

Crossbreeding. Lambs from two-breed and three-breed crosses of Romnelet, Columbia, Suffolk, and North Country Cheviot breeds outperformed purebred lambs in weaning weight by 5% and 14.6%, in feedlot gain by 7% and 7%, and in final market weight by 7.3% and 11.4%. Purebred ewes that raised lambs from two-breed crosses and crossbred ewes that raised lambs from three-breed crosses produced 16.6% and 32.5% more kilograms of lambs per ewe bred than purebred ewes that raised purebred offspring.

Muscle, bone, and fat in lambs. Complete separation of lean, bone, and fat showed that carcasses of lambs of Rambouillet were significantly leaner ($P < 0.01$) than those of Columbia. Targhee, Suffolk, and Romnelet carcasses were intermediate. Weight ranges showed significant differences ($P < 0.01$) in the amount of lean and fat. The lightest carcasses had 4.7% more lean meat (51.1% vs. 46.4%) and 9.5% less fat (27% vs. 36.5%) than the heaviest carcasses.

Dairy Cattle

Milk solids. Annual rates of genetic improvement in Holstein and Ayrshire cattle selected for high 180-day total milk solids during a 10-yr period were estimated at 4.5 kg for Holsteins and 4.4 kg for Ayrshires. Compared with the expected increase of 1.3% based on a heritability of 0.3, these increases were 1.1% and 1.3% of the most recent average milk-solids yield. Correlated genetic responses for percentage of fat and solids-not-fat in Holsteins were significant but small. Percentages of fat, solids-not-fat, and protein in Ayrshires did not change, nor did those of protein in Holsteins.

CROP ENTOMOLOGY

Aphids

Five American varieties of alfalfa were found to be good potential parental sources

for an alfalfa resistant to the pea aphid in Alberta. These varieties demonstrated resistance to the Alberta biotype of the pea aphid and were winter-hardy at Lethbridge.

Cutworms

The laboratory rearing of redbacked cutworms was improved when they were maintained undisturbed in individual containers on an artificial diet from 2 wk old to pupation. Preliminary field trials showed that traps baited with virgin females were superior to conventional light traps.

Grasshoppers

Grasshoppers continued to increase in number; by the fall of 1972 the infestation covered 79,230 km² (30,591 mi²) in southern Alberta. Severe outbreaks were forecast for 1,909 km² (737 mi²) in 1973. In a crop-loss study 10 grasshoppers/0.8 m² (1 yd²) caged over wheat destroyed 20% of the plants, 15 destroyed 44%, and 20 destroyed 50%.

Results of simulated field tests in 1972 led to the removal of malathion and carbaryl from the list of insecticides recommended for control of grasshoppers in cereal and oilseed crops in Western Canada. Neither insecticide was effective at recommended rates against two major species, the two-striped and the migratory grasshopper. Dimethoate effectively controlled both species and continues to be recommended. A promising new insecticide, propoxur, was as effective as dimethoate, but another candidate, fenitrothion, was effective only against the migratory grasshopper.

Cabbage Root Maggot

Chlorfenvinphos applied to rutabagas at seeding and 1 mo later was the best treatment for the control of the cabbage root maggot, but even this treatment failed to protect more than half the roots against maggot damage. Thus, the maggot continues to be the major pest that limits rutabaga production in this region.

Wheat Stem Sawfly

A population study for the past 3 yr shows the potential of the wheat stem sawfly for rapid increase. For example, in 1 yr, when only 7% of the stems of a wheat crop were cut by sawfly larvae, the number of adults that emerged the next spring was sufficient to

produce an infestation of 65% in the stems of adjacent wheat.

Crop-loss studies showed that the average losses in yield from sawfly damage for 8 yr were 12.8% in Thatcher and 18.3% in Red Bobs.

Insecticides—Environmental Quality

Chlorpyrifos, which in 1971 effectively controlled cutworms, has been shown unlikely to leave undesirable residues. After this insecticide was applied at recommended rates to wheat seedlings, no residues were detected in the kernels. Only 0.003 ppm of chlorpyrifos remained in the straw; its oxygen analogue, a potential hazard, was not detected in either kernels or straw. New methods were developed for analyzing growing wheat plants, straw, and kernels for residues of this insecticide.

Six years after aldrin was applied to irrigated plots, the soil still contained appreciable residues of aldrin or dieldrin. This further attests to the persistence of this organochlorine insecticide.

Pollinating Insects

The best way to control mold on cells of larvae of the alfalfa leafcutter bee was to provide alternate tunnels of 6.3 and 7.1 mm in diam and hives built with porous backs. Fungicides did not control the mold.

Potato Insects

In field tests, fonofos at 2.24 kg/ha (2 lb/ac) in-furrow or 5.6 kg/ha (5 lb/ac) broadcast controlled wireworms in potatoes. Chlordane, which is currently recommended, gave less satisfactory control.

Endosulfan was 30 times more effective than DDT on DDT-resistant Colorado potato beetles. Chlorfenvinphos and carbofuran were 90 times more effective than DDT as oral toxicants.

Rape Insects

In laboratory tests chlorpyrifos and leptophos were more effective than methomyl against the bertha armyworm. Methomyl, the only recommended insecticide for the bertha armyworm, was applied to about 89,100 ha of rapeseed in Alberta in 1972.

A laboratory bioassay demonstrated that female moths of the bertha armyworm produce a sex pheromone. One of 50 synthetic compounds tested produced strong

responses in the males at a concentration of 1 ng. If this sex attractant proves as effective in the field, it could provide the means of early detection and warning of outbreaks of the bertha armyworm.

Excellent control of flea beetles, which are widespread pests of rape, was obtained with carbofuran at 0.14 kg/ha (2 oz/ac). Control of flea beetles in heavily infested plots of rape with this insecticide increased seed yield by over 20%.

Phytotoxin in Residues of Rape

The phytotoxin previously reported as occurring in the residues of rape plants was found to be produced in rape grown under a wide range of environmental conditions. Advances have been made in developing the chemical procedures to isolate the phytotoxin. Results of tests indicate that the active fraction may be present among a group of phenolic compounds.

Sugarbeet Insects

Tests showed that larvae of the sugarbeet root maggot survive the winter because they are protected by the presence of sorbitol in their body tissues. Resistance to freezing increased with an increase in sorbitol content to 1.4% of their body weight. It was also discovered that the larvae can survive freezing.

PLANT PATHOLOGY AND PHYSIOLOGY

Cereal Diseases

Soil-borne spores of *Urocystis occulta* (Wallr.) Rabh. proved to be more important than seed-borne inoculum in causing stalk smut of fall-sown rye in a field where rye had been grown continuously. This is the first report in Canada of stalk smut caused by soil-borne inoculum. In plot experiments in this field, the cultivars Cougar and Frontier were significantly more susceptible than the older cultivars Antelope and Sangaste. Incidence of stalk smut in Cougar was reduced from 9% to 1.8% by seed treatment with Vitaflo (UniRoyal Limited), a systemic non-mercurial formulation not licensed in 1972 for use on rye. Seed treatment with methylmercuric dicyandiamide did not provide protection from the soil-borne inoculum. Both

seed treatments improved emergence by over 25%.

Leaf Diseases of Barley

Standardized methods of sampling and assessing diseases were used to determine the extent and severity of barley leaf diseases in 1971 and 1972. The effects of scald, *Rhynchosporium secalis* (Oud.) Davis, and net blotch, *Pyrenophora teres* (Died.) Drechs., the most important leaf pathogens present, were more serious in 1972 than in 1971. A procedure was developed for inoculating barley with *R. secalis* without mechanically damaging the leaves, thus permitting accurate assessment of the area affected by the pathogen.

Rape Diseases

A standardized survey to determine the extent and severity of diseases in rape, *Brassica campestris* (L.) and *B. napus* (L.), was conducted in southern Alberta in 1972. White rust, caused by *Albugo cruciferarum* S. F. Gray, and alternaria black spot, caused by *Alternaria* spp., were the diseases most often encountered on *B. campestris*, but only *Alternaria* was found on *B. napus*. Foot rot, caused by *Fusarium* spp. and *Rhizoctonia* spp., and ring spot, caused by *Mycosphaerella brassicicola* (Duby) Oud., were occasionally found.

A pictorial key was developed for identifying the growth stages of *B. campestris* as an aid to relating disease measurements to specific stages in the growth of the crop.

Forage and Turf Diseases

Snow mold or winter crown rot. Of 10 forage legumes tested in the field for susceptibility to winter crown rot, cicer milkvetch was the most resistant, even more resistant than strains of Siberian alfalfa. Sainfoin and birdsfoot trefoil were more resistant than the common varieties of alfalfa.

Borax effectively controlled snow mold of alfalfa, but produced a very toxic effect on the foliage. Borax also effectively controlled snow mold on turfgrass this year with no phytotoxicity.

Alfalfa sickness. Although extremely large populations of pin nematodes, *Paratylenchus projectus* Jenkins, were obtained when soils causing alfalfa sickness were planted with birdsfoot trefoil, *Lotus corniculatus* (L.) var. Leo, no damage to the host was detected.

Losses in yield of alfalfa did not correlate with pin nematode infestation.

Potato Diseases

Yields from precut seed pieces of potatoes were significantly lower than those from fresh-cut seed. Treatment of precut seed pieces with fungicides produced significantly greater marketable yields of potatoes than the untreated seed, but seed treatment had little effect on fresh-cut seed.

In a field experiment, yield losses of 70%, 55%, and 78% were recorded from potato plants infected with ring-rot bacteria, leaf roll virus, and a combination of ring-rot and leaf roll pathogens.

Cold Hardening of Wheat

Major changes occurred in the proportions of the forms of invertase present in leaves of the cold-hardy winter wheat, Kharkov 22 MC, during cold hardening. No such changes occurred when the frost-sensitive wheat, Rescue, was subjected to the same conditions. The forms of invertase that increase during cold hardening in Kharkov 22 MC are associated with carbohydrate; thus, changes in glycoprotein probably are associated with the cold-hardening process.

PLANT SCIENCE

Cereals

Yield-awning relationship in wheat. Reciprocal backcrosses between two cultivars of spring wheat, awned Lee and awnletted Thatcher, provided "awnletted" Lee lines and "awned" Thatcher lines. Comparisons between yields of awned and awnletted forms of the two cultivars at several locations in southern Alberta over 4 yr showed a relationship between awning and yield. The awnletted form generally was superior to the awned in yield. This finding differs from those of previous studies in which awned forms outyielded the awnless and awnletted lines.

Wheat cytogenetics. Individual disomic substitutions have been made of the three *Agropyron* chromosomes present in a hybrid of wheat \times *Agropyron elongatum* that is resistant to wheat streak mosaic, wheat spot mosaic, and their vector, the wheat curl mite. The authenticity of the substitutions has been

confirmed by test crosses with known ditelocentrics. The *Agropyron* substitution for chromosome 6D is highly resistant to colonization by the wheat curl mite. By contrast, the substitutions for 4D and 5D are as susceptible as wheat and show severe leaf rolling and leaf trapping, which support a rapid buildup of mite populations. The full resistance of the original hybrid to the mite is conferred by the *Agropyron* chromosome that substitutes for chromosome 6D of wheat.

Barley scald. In the greenhouse, yield losses of susceptible barley genotypes from scald incited by *Rhynchosporium secalis* (Oud.) Davis were negligible when infection occurred during the tillering stage, variable when it occurred during the stem extension stage, and severe when it occurred at or near heading. A scald-resistant line derived from Galt by backcrossing developed no lesions when inoculated at an early stage of growth, but did develop lesions when inoculated at heading time. Nevertheless, the disease did not appreciably affect the yield of this line.

Corn

Developing earlier hybrids. In yield tests of 180 experimental hybrids from the Research Station, Morden, Man., and from private breeders, two hybrids from Morden matured significantly earlier and yielded higher than the commercial hybrid used as the control.

Crosses of flint and exotic maize from Mexico, supplied by Centro Internacional de Mejoramiento de Maiz y Trigo, produced some early maturing plants with good stalk strength but generally small ears.

Over 250 single crosses and three-way crosses of Morden and Ottawa inbreds were made for evaluation in 1973.

A program of recurrent selection for high grain-to-stover ratio is under way to isolate early maturing high-yielding plants with good stalk strength.

Growth rates. Leaf area indices (LAI) were higher when seeded sugar beets were grown between rows of corn than when either seeded crop was grown separately. Highest LAI's were obtained by transplanting greenhouse-grown beets in the spring. Crop growth rates and net assimilation rates per unit area of ground (measured with an infrared CO₂ analyzer) were closely related to the LAI. Consequently, the maximum rate of dry matter accumulation and final yield

was from transplanted beets, followed by mixed seedings and either crop alone. Sugar beets between the rows did not affect the growth of corn, but the size of beets was reduced as a result of shading. Sugar beets and corn emerged together on May 3. The beets continued to photosynthesize until late October, a month longer than the corn, which by then had been killed by frost but remained standing.

Forage

Gains of yearling steers greatest on Russian wild ryegrass. Steers continuously grazed on Russian wild ryegrass pastures gained 6.3 times as much as those on native range pastures. In tests over a 6-yr period, yearling steers gained 17.6 kg/ha on native range, 27.8 kg/ha on a rotation, 29.9 kg/ha on a free-choice system, and 111.1 kg/ha on Russian wild rye. The rotation system included crested wheatgrass during spring, native range during summer, and Russian wild rye during fall, over the 6-mo grazing season. The free-choice pastures had swards of the three types fenced as one field. The main advantage of Russian wild rye was during the fall, when the steers continued to gain weight. The Russian wild rye was seeded in rows 45 cm apart.

Alfalfa management. Experiments conducted over 4 yr have shown that maximum yields of alfalfa can be obtained on irrigated land by cutting three crops each season. In 1972, yields increased as the time of cutting the first crop was delayed from the early bud stage, through one-tenth bloom, to the full-bloom stage. Cutting the second crop in the early stages of regrowth also reduced yields but less so than early cutting of the first crop. Yields of the third crop and those of the first crop in the following year were greater when the third crop was cut in mid-October rather than during September.

Forage engineering. On-farm studies of mechanized systems for handling forage showed that lack of operator skill and improper machine adjustment are two major reasons for inefficient performance. Highly mechanized bale-handling systems appeared to have capacities similar to those of some semimechanized systems, though their labor requirement was less. Loose-hay systems operated by one man were handled with various degrees of efficiency and had some features that appeared useful for conserving

forage maintenance feeding. Studies were started to evaluate storage losses in variously constructed horizontal silos in southern Alberta.

Seedling growth of four species of wheatgrass. Dry weight accumulation in 6-wk seedlings of Greenleaf pubescent wheatgrass and quackgrass exceeded that in Summit crested wheatgrass and Primar slender wheatgrass, although the net assimilation and relative growth rates were the same for all species. Pubescent wheatgrass produced the greatest total root weight, total leaf weight, leaf area, and leaf area ratio; quackgrass excelled in total sheath weight, total weight of top growth, and percentage of total nonstructural carbohydrates. The results suggest that the desirable characteristics of quackgrass, a noxious weed, should be utilized in Canadian grass-breeding programs.

Horticulture

Fiber content of pods in snap beans. Fiber development in pods of size 5+ snap beans was inhibited by both conventional irrigation and low-volume misting (1.3 mm/h). When soil moisture was maintained in the upper half of the available range, fiber formation was low and was not reduced when low-volume misting was applied to raise the humidity and to cool the air above the plant canopy. When the beans were grown under soil moisture stress, fiber content increased substantially except where low-volume misting was applied each time the ambient air temperature exceeded 27°C.

Cabbage plant populations. Yields of King Cole and Emerald Cross cabbage cultivars increased as plant populations were increased from 10,000 to 83,000 plants/ha, though the rate of yield increase slowed down at populations above 50,000 plants. Yields of King Cole were 224 and 102 t/ha for the highest and lowest populations, and those of Emerald Cross were 185 and 55 t/ha. Head size varied inversely with population density, but by a slightly greater extent in King Cole. There were no differences in maturity among populations within a cultivar.

Browning of parsnips. Field investigations have shown that browning of parsnips is a varietal characteristic and can be influenced by soil type and storage temperature. Browning was greater in sandy loam than in

clay loam soil. The cultivars Harris Model and Model Hollow Crown developed less browning than All American or Guernsey. Parsnips stored at 4°C became darker than those stored at 1°C. Laboratory studies showed that the browning is enzymatic in nature and most of the enzymatic activity is in the peel. Therefore most of the brown can be removed by peeling.

Weeds

Control of aquatic plants. The 1:1 mixture of diquat and paraquat used in three Western Canadian lakes at up to 1.0 ppm controlled all submergent rooted aquatics except Richardson pondweed and stonewort. Copper plus diquat at 0.8 ppm controlled Richardson pondweed, and dichlobenil at 11.2–13.4 kg/ha controlled stonewort and the yellow pond-lily. Unless the bottom of the pond or lake was hard (stone or gravel), removal of stonewort was considered undesirable because this low-growing aquatic plant prevents the silt from being stirred up, offers cover for small aquatic invertebrates, and provides excellent plant competition to prevent other rooted aquatics from recolonizing after herbicide treatment.

Dichlobenil applied to exposed pond beds gave excellent control of most submergent and floating-leaved aquatics for 2 yr. Very little (less than 0.1 ppm) herbicide was released back into the water when the ponds were refilled. Potted water-lilies were undamaged when reintroduced 7–10 days later.

SOIL SCIENCE

Soil Fertility and Management on Dryland

Response of dryland cereals to applied N and P. Applications of N and P fertilizer had no effect on plant stands, but increased tillering and yield of five cultivars of spring wheat. On clay soil in the Black soil zone, root rot of wheat was most severe where 45–90 kg N/ha was applied. Applied fertilizers increased the protein content of Manitou, Cypress, Glenlea, and CT773 without loss in quality for bread making, but anomalies in quality characteristics occurred when protein content exceeded 16%. The low baking quality of Pitic 62 did not improve as the protein content increased.

In autumn applications of P generally increased winter survival and yield of winter wheat and fall rye, but winter survival

decreased where 90 kg N/ha was applied. Protein content increased as rates of applied N were increased. Applications of fertilizer generally improved the protein quality of Kharkov and Winalta for bread making, but the baking quality of Kharkov was highest when the protein content was about 14%.

Response of forage to applied P. Most of the P added to fertilized plots was NH_4F -extractable (Al-P, Chang and Jackson method), although the exchange complex was mainly Ca-saturated. A large amount of Ca-P (350–1,000 kg/ha was found at 30–45 cm deep; it was neither related to fertilizer application nor detected by NaHCO_3 or NH_4F extracts, which are usually used in soil testing. The presence of this native P in the soil probably accounted for the failure of the plots to respond to P fertilizers. A knowledge of the amount of acid-extractable P in the subsoil may complement a surface-soil P test when recommendations are being prepared for the use of fertilizers on forages.

Grass tetany and applied N. At Lethbridge, ammonium nitrate fertilizer applied to dryland grass at up to 940 kg N/ha increased the yield and the total N, $\text{NO}_3\text{-N}$, and protein contents of Russian wild rye- and brome-grasses. The Mg and Ca concentrations in Russian wild rye decreased, whereas those in brome increased with higher rates of N. The tests showed no definite indications that grass tetany could be a problem with N fertilization of grasslands in southern Alberta.

Nitrification in grasslands. When added to grassland soil, root exudates of selected native grasses and forbs that dominate on overgrazed grasslands significantly reduced the rate of microbial oxidation of $\text{NH}_4\text{-N}$ to $\text{NO}_3\text{-N}$. This result shows the potential of living roots for altering the rate of soil nitrification.

Rhizosphere studies on wheat. Bacteria that are antagonistic to *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur in vitro in the rhizosphere soil of root-rot-resistant and root-rot-susceptible cultivars of spring wheat and selected homoeologous substitution lines were studied. It was found that their relative frequency distribution was not related to genetic mechanisms that control resistance of these wheats to common root rot.

Zero-tillage on dryland. Experimental plots not tilled for 5 yr produced greater yields of spring wheat than conventionally tilled plots. Weeds were controlled with the use of paraquat on the untilled plots and with a subsurface blade cultivator on the tilled plots. Three-year-average yields of spring wheat were 1,912 kg/ha on a zero-tillage fallow and 1,777 kg/ha on a bladed fallow. In a wheat-wheat-fallow rotation, the 3-yr-average yields of wheat on fallow and wheat on wheat stubble were 2,180 and 1,037 kg/ha under zero-tillage, whereas the yields under conventional tillage were 1,642 and 767 kg/ha. Increased yields were attributed to greater reserves of soil moisture before seeding. The upright stubble of the zero-tillage treatment also provided very good protection for the subsequent crop in its early growth stage.

Irrigation and Drainage

Response of wheat to N on irrigated land. In experiments conducted at two locations for 2 yr with five rates of N (0, 55, 110, 165, and 220 kg/ha), average grain yields of Pitic 62 were 30% higher than those of Manitou but protein content was 20% lower. The highest yield of Pitic was 6,765 kg/ha and of Manitou 4,794 kg/ha. The protein content of both varieties increased with each succeeding increment of N fertilizer. The lowest and highest percentages of protein were 11.6 and 18.6 for Manitou and 9.2 and 15.2 for Pitic. Therefore, it is possible to grow wheat with high protein content on irrigated land.

Reaction of three cultivars of wheat to soil water stress and N. A soil water stress of 8 bars imposed at the early boot stage reduced yield by severely reducing the number of kernels per spike. N increased yield by increasing tillering. Pitic 62 withstood the stress and, whether subjected to stress or not, responded to high rates of N fertilizer better than Manitou or Kenhi.

Efficiency of water use. When bean plants were cooled by means of sprinklers, transpiration was reduced by 52%, or 0.27 mm/h. Since the reduction equaled only 42% of the water applied, the cooling practice actually decreased the overall efficiency of irrigation.

Crust strength of three soils placed in trays on plots during each of three irrigation seasons and dried in the greenhouse for 6 wk was the same for both low and normal rates of sprinkling.

Evapotranspiration during the growing season for irrigated rapeseed yielding 3,171 kg/ha was 45 cm of water; for nonirrigated rapeseed yielding 1,682 kg/ha evapotranspiration was 20 cm of water. In tests in 1971 irrigated rapeseed contained 35.6% oil, and nonirrigated rapeseed 31.5%.

Among four cultivars of soft and feed wheats (Pitic 62, Lemhi, Twin, and 5505-2) fertilized with 112 kg N and 56 kg P/ha. Pitic yielded highest and used water most efficiently. In another experiment in which Pitic and Lemhi were grown on fallow, Pitic outyielded Lemhi (7,684 to 7,006 kg/ha) and used less water (59 to 65 cm).

Irrigation practices. The risk of winterkilling of alfalfa can be reduced by allowing soil moisture stress to develop in late summer. Studies have shown that irrigation in late July delayed harvest until September and resulted in 60% winterkill. Discontinuance of irrigation in early July permitted seed harvest in August and only 4–20% loss of stand due to winterkilling.

Soil Properties

Organic matter. In a Dark Brown and a Black Chernozemic soil, humic substances extracted with chelating resin from the Ah horizon and fractionated on Bio-Gel P gave similar elution profiles. Most of the humic substances were of high molecular weight or size and values were closely distributed around a single mean. Because they had a low ash content of about 1%, their true carboxyl acidity could be obtained unimpeded by cations. Transformation of the Black Chernozemic Ah horizon by poplar encroachment caused a decrease in the ramified structure of the extractable humic substances.

Electrodialysis of soil for 72 h followed by extraction with chelating resin was the most effective procedure for extracting humic substances from Chernozemic Ah horizons. Ultrasonic treatment of soil before electrodialysis was more effective as the Ca content of the exchange complex decreased. However, more than half of the organic matter remained unextractable.

Soil structure. Water, air, and a nonpolar liquid, Soltrol "C", were used to evaluate the structure of soils adjusted to various levels of exchangeable Na. Soltrol did not cause a breakdown of the soil structure, because permeability values were slightly higher for

Soltrol than for air. Determination of air permeability can be avoided if Soltrol-to-water permeability ratios are used as indices of stability of soil structure.

Measurements of tritium and chloride diffusion showed a linear relationship between moisture content and tortuosity except when the soil was near saturation or below wilting point. These findings were used to develop a method for separating liquid and vapor flow in soils so that estimates of nutrient movement in soils may be improved.

Environmental Quality

P movement in soils. Analysis of total P showed that, 6 yr after fertilization, of 660 kg P/ha applied to the surface of a forage plot in the Black soil zone, 63% remained in the top 15 cm and 8% was retained between 15 and 30 cm deep. In a similar plot in the Brown soil zone, 88% of the applied P was retained in the surface 15 cm and no evidence of further leaching was found. At lower rates (135 kg P/ha) 73–83% of the applied P was recovered in the soil, and plant uptake accounted for 15%.

Feedlots. None of the six feedlots studied in the Lethbridge area was found to be a serious contributor to local soil and water pollution. The amounts of $\text{NO}_3\text{-N}$ and available P in the soil adjacent to each feedlot were usually greater than those of the soil away from each feedlot; but below 120 cm the differences were usually small. Accumulations of $\text{NO}_3\text{-N}$ in the groundwater were found at the feedlots, but they disappeared a short distance away. Repeated annual applications of manure did not cause an undesirable buildup of N, P, or soluble salts in the soil.

VETERINARY-MEDICAL ENTOMOLOGY

Biting Flies

Mosquitoes. In collaboration with the Department of Botany, University of Washington, Seattle, Wash., methods have been developed in the laboratory to infect larvae of *Culiseta inornata* (Williston) with the fungus *Coelomomyces psorophorae* Couch and to propagate the pathogen for experimental purposes. Physical and chemical

properties were defined for maximum germination of sporangia in a standard medium. An infection of *C. psorophorae* was discovered in a field collection of *Aedes vexans* (Meigen). This discovery indicates that the pathogen may have potential for biological control of more than one genus of mosquitoes.

Eight species of mosquitoes were identified as pests in infestations interfering with the maintenance of cattle in Athabasca County. Control strategies will probably have to extend for long periods from May to September for effective abatement in northern environments.

Black flies. Serious outbreaks of *Simulium arcticum* Malloch occurred this year in areas near the Athabasca River in Alberta. Several cases were documented in which exogenous cattle were killed during heavy attacks from black flies within a few hours of being imported into the area. Indigenous cattle, though seriously affected, appeared to have a lower rate of mortality. In 1972 the source of outbreaks was mainly the portion of the Athabasca River lying 56–105 km (35–65 mi) downstream from the town of Athabasca. Larvae of *S. arcticum* were also present in parts of the river near Fort Assiniboine, but not in sufficient density to create outbreaks. Adult flies were found in sufficient numbers along 225 km (140 mi) of the Peace River that they caused economic problems in adjacent areas in northeastern British Columbia.

Warble Flies

The effects of γ -irradiation on sexual sterility, vigor, and competitiveness of warble flies were determined in laboratory and field experiments. Treatment of chilled puparia of *Hypoderma lineatum* (de Villers) with 4,000–5,000 rad at 65–85% development neither reduced emergence of flies significantly nor impaired their vigor and longevity in the laboratory. Larval hatch in the laboratory from treated matings was reduced to 0.02% and 0.2% by the highest and lowest levels of irradiation. Irradiated males released with normal males at an aggregation site in the field in a ratio of 2:1 engaged in three-quarters of all the matings observed with normal females. All eggs from females mated with irradiated males were sterile.

Host-Parasite Relations

Host pathology. In histopathological investigations of the penetration of newly hatched larvae of *H. lineatum* into the skin of cattle, strong cellular invasion by eosinophils was found in previously parasitized animals, but none in uninfected animals. This discovery indicates an immediate reaction caused by oral secretion of grubs. The strong reaction impedes the survival of penetrating grubs, because ACTH injected during penetration into one animal from each of several sets of twins significantly increased the ability of grubs to survive to encystment in the animal's back. Grubs usually penetrate the skin perpendicularly to the surface and progress mainly by the lytic action of their oral secretions.

Serology. Serological reactions in rabbits exposed to various species of Diptera for a blood meal before infestation by ticks were not discernibly different macroscopically from those unsensitized rabbits infested only with ticks for the first time. Collections of blood-feeding arthropods have been assembled for preliminary comparative biochemical fractionation of whole bodies, salivary glands, and saliva, and for identification of sensitizing components.

Chemical Control

Toxicology. Evaluation of adverse effects of systemically active pesticides in mice has

been extended beyond F₁ generations. Dermal treatment of female mice with crufo-mate at 100 mg/kg 21 and 35 days before they were paired with males did not adversely affect growth of F₂ males and females or reproduction in F₁ and F₂ females. Extension of these studies to cattle showed that crufo-mate at 40 mg/kg applied as a pour-on to cows 3 mo after breeding had no adverse effects on the fetus or the gestation period, which was 285 days whether the cows were treated or not.

Efficacy trials. Enforced self-treatment of cattle with 3% crotoxyphos in dust bags located over approaches to watering places provided continuous protection from horn flies. Dermal application of 20% fenthion at 4 ml/head to calves weighing 68-136 kg and 8 ml/head to heavier calves effectively reduced mean grub infections from 55/head in untreated animals to 1.4/head in treated animals, for 97.5% systemic efficacy.

Dermal application of phosmet at 12 mg/kg to protect steers from black flies significantly increased the average daily gain of steers over untreated controls in a 57-day test. The untreated animals compensated for their weight losses in a 49-day period after black fly activity had ceased. Treatments reduced the number of black-fly bites by an average of 42% on eyelids, canthi, udders, and close-clipped areas on the backs of cows.

Continued surveillance in the County of Wetaskiwin of the Alberta Warble Eradication Program, which was started 4 yr ago, has shown a further reduction from a mean of 1.5 grubs/animal in 1971 to 0.2 in 1972.

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Research Station Agassiz, British Columbia

PROFESSIONAL STAFF

D. K. TAYLOR, B.S.A., M.Sc., Ph.D.	Acting Director; Turfgrass management
H. A. DAUBENY, B.S.A., M.S.A., Ph.D.	Plant breeding, small fruits
W. E. P. DAVIS, ¹ B.S.A., M.S.A.	Forage management
R. J. FORREST, B.S.A., M.S.A., Ph.D.	Animal physiology; meat studies
J. A. FREEMAN, B.S.A., M.S.A., Ph.D.	Physiology of small fruits; herbicides
A. T. HILL, ² B.S.A., M.S.A., Ph.D.	Poultry genetics and management
M. K. JOHN, ³ B.Sc. (Agr.), M.S., Ph.D.	Soil chemistry; soil fertility
E. F. MAAS, B.S.A., M.S.A.	Soil fertility
A. R. MAURER, B.S.A., M.Sc.	Physiology of vegetable crops
D. E. WALDERN, B.S.A., M.Sc., Ph.D.	Animal nutrition

Departure

M. F. CLARKE, B.S.A., M.S.A., Ph.D.	Director
Transferred to Ottawa as Research Coordinator (Forage Crops) September 5, 1972	

¹Seconded to Tanzanian Agronomy Project, July 1971.

²On transfer of work to the British Agricultural Council, Edinburgh, Scotland, from September 1, 1972.

³On transfer of work at the Soils Departments of the University of Western Australia, Perth, Australia, and Lincoln College, Canterbury, New Zealand, from August 23, 1972.

INTRODUCTION

This report summarizes the main research findings for 1972 at the Research Station, Agassiz. Additional information may be obtained from the scientific papers and other publications listed at the end of this report. The Station also publishes a Quarterly Report to provide extension specialists, agricultural business, and farmers with up-to-date information on developments in the research program. Copies of this report and reprints of the publications listed are available on request. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, P.O. Box 1000, Agassiz, B.C.

Dr. Mills F. Clarke, Director of the Station since December 29, 1953, and formerly in charge of forage crops research, was transferred to Ottawa as Research Coordinator (Forage Crops) in September 1972.

D. K. Taylor
Acting Director

SOIL SCIENCE

Soil Contaminants

Cadmium in soils and plants. Studies of factors affecting Cd uptake by food crops were conducted with the aim of minimizing dietary intake. In 33 farmland soils from the lower Fraser Valley and in soil samples taken at various depths and distances from a battery smelter, the extent of contamination was evaluated from determinations of HNO₃-soluble Cd. An inverse relationship was observed between the Cd content of radishes grown on 30 different CdCl₂-treated soils and the abilities of these soils to adsorb Cd from solution. In another study, each soil was equilibrated in CdCl₂ solutions at four different concentrations; adsorption of Cd by each soil fitted the Langmuir isotherm. The affinity of the soil for Cd increased with increasing clay and organic matter contents.

Radish and lettuce were grown in pots in a Hjorth silty clay loam soil. The Cd content of edible parts of the plants varied with the level of CdCl₂ applied to the soil, whereas applications of lime reduced the Cd uptake. Water and ammonium acetate extracted less Cd from soils as the rate of lime increased, and the amounts extracted were significantly correlated with plant content. Growth of eight food crops under three regimes of soil Cd on Hazelwood silt loam showed that the highest Cd concentrations were accumulated in the edible parts of lettuce and spinach, followed by broccoli and cauliflower, radishes and carrots, and peas and oats.

Lead in food crops and its availability from contaminated soils. In a factorial experiment

to study the growth of seven food crops, Pb was added to Hazelwood silt loam soil in pots to give three levels of soil Pb. Concentration of Pb varied widely in some 18 plant parts studied. High concentrations of Pb were found in the edible tissues of lettuce, spinach, radish, and carrot, intermediate concentrations in those of broccoli and cauliflower, and low concentrations in oat grains.

In another growth-chamber study, the Pb content of lettuce and oats was compared with soil Pb extracted by various procedures, and with other properties of the 29 contaminated soils. Normal HNO₃-extractable Pb in soil gave the most significant correlation with Pb in lettuce. However, milder extraction by 0.01 N HNO₃ and N ammonium acetate provided better correlation of soil Pb with Pb in oat shoots and roots. The Pb content of plants increased with decreasing pH and increasing extractable Al and total Ni.

Available Phosphorus

Soil test methods for available phosphorus related to forms of phosphorus and other soil properties. Based on observations of 343 different soils from eight soil orders, representing both the coastal and dry interior regions of British Columbia, seven soil tests for available P were related to six forms of soil P and seven other soil properties. When correlations between soil test values were high, similarity was found in the selective dissolution of specific forms of P. From linear regression analyses, the greatest contribution to values obtained by Olsen's test (0.5 M NaHCO₃) or Bray's test (0.03 N NH₄F in

0.025 N HCl) was from Al-P; to P determined by isotopic exchange it was from Fe-P; and to values from the North Carolina test (0.05 N HCl in 0.025 N H₂SO₄) it was from Ca-P. Multiple regression equations to predict soil test values from significant forms of P and soil properties included dithionite-extractable Al and Fe, organic matter, soil texture, base saturation, and soil reaction. The equations reflect the significant influence of these factors on the dissolution of specific forms of P and the secondary reactions occurring during the extraction process.

VEGETABLES

Precision Seeding of Onions and Carrots

On muck soils, the use of a Stanhay precision seeder to plant coated onion and carrot seeds increased marketable yields of both crops over those produced by standard practices. Although seed spacing influenced the size of onion produced, twin 7.6-cm rows with a spacing of 6.3 cm between seeds gave the best yield of uniform onions. Precision seeding allows growers to plant five twin rows instead of four scatter rows in standard 1.73- to 1.83-m beds.

Precision seedings of coated carrot seed, cultivar Gold Pak, in four triple rows per bed increased the yield of marketable carrots over those from standard scatter-shoe seedings of uncoated seed. Precision seeding at intrarow spacings of 3.8 and 5.1 cm gave carrots suitable for the fresh market, whereas the 3.2-cm spacing resulted in small, slender but marketable carrots. Fewer forked, split, and undersized carrots were produced by the precision seeding method than by the standard practice.

Stylepak Sweet Corn

Consumer tests to evaluate quality and maturity of sweet corn showed that, when produced in coastal British Columbia, the cultivar Stylepak was outstanding for the processing and fresh markets. Stylepak produced high yields of large ears, well covered with deep, narrow kernels of an attractive, bright, pale yellow color. Its quality was superior to other processing cultivars such as Mellogold and Jubilee.

Reaction of Potato Cultivars to Herbicide

Preemergence application (June 5) of Bay 94337 (Bayer) herbicide at five rates of application on six potato cultivars gave good weed control without any detrimental effect on the yield of any cultivar. On the other hand, postemergence treatments (July 4 and Aug. 15) gave less effective weed control. They also significantly reduced yields of Warba at all rates of application and of Norland, Red La Soda, and Pontiac at certain rates; however, the yields of Norgold, Russet, and Kennebec were not affected significantly. The early postemergence treatment also delayed flowering.

Thiocarbamate Herbicides for Corn

Thiocarbamates, alone and in mixtures, gave excellent control of barnyard grass and good early control of broad-leaved weeds. However, within 7 wk (July 15) there was considerable growth of broad-leaved weeds with Eptam (Stauffer Chemical Co. of Canada) at 6.7 to 13.5 kg/ha and vernolate at 6.7 kg/ha. Mixtures of atrazine at 1.12 to 1.68 kg/ha and vernolate at 2.24 to 4.48 kg/ha gave excellent control of broad-leaved weeds and grasses. A mixture of R 15320 (Stauffer) at 1.12 to 1.68 kg/ha and vernolate at 4.48 kg/ha gave satisfactory weed control.

R 25788 (Stauffer), an antidote to herbicides, was incorporated with the herbicides into the soil. It protected the corn, cultivar Earlipak, from injury from the thiocarbamate herbicides and did not appear to alter the efficacy of the herbicides.

SMALL FRUITS

Raspberry

New cultivar Haida. Haida (BC 201) is a promising raspberry cultivar released from the breeding program at this Station. Haida is a selection from the cross Malling Promise × Creston and is a potential replacement for the cultivar Willamette. It is more winter-hardy, higher yielding, and more attractive in fruit color than Willamette; it is also less susceptible to spur blight and more tolerant of root rots. Haida is immune to the aphid vector of the red raspberry mosaic virus and thus will escape the virus.

Direct field-planting of root cuttings. The establishment of three raspberry cultivars by root cuttings planted in the fall (Nov. 29)

was 74.0% successful and was on the average superior to spring planting (March 1), 63.7% successful, but inferior to spring planting of dormant canes, 99.2% successful, as judged on June 8. Root cuttings of the cultivar Willamette did equally well when planted in spring or fall, whereas root cuttings of Matsqui and Meeker did better when planted in the fall. In a comparison of four sources of root cuttings, the percentages of plants that developed successfully ranged from 74 to 90%.

Strawberry

Differences in tolerance of viruses among genotypes. In a study conducted in cooperation with Washington State University, differences in relative tolerance for viruses (mostly mottle and mild yellow edge) were observed among strawberry cultivars and selections growing at two locations in the Pacific Northwest. Among the most tolerant were the cultivars Totem, Northwest, and Cheam, and several selections from breeding programs in Washington and British Columbia. Northwest and clones of *Fragaria chiloensis* (L.) Duchesne were parental sources of tolerance. The least tolerant cultivars were Puget Beauty, Marshall, Hood, and Quinault. The cultivars or selections most tolerant of viruses were also the highest yielding.

Postharvest screening technique for selecting lower levels of susceptibility to fruit rot. In cooperative studies with the Research Station at Vancouver, B.C., a postharvest screening technique was developed to determine differences in susceptibility to fruit rot among strawberry cultivars and selections. Good agreement was obtained with previously reported observations on relative susceptibilities to disease caused by *Botrytis cinerea* Pers. in the field. The technique was also successful in identifying variations in susceptibility to *Rhizopus* spp., a major problem in storage. Among the cultivars, Redgauntlet was low in susceptibility but Cheam, Siletz, and Agassiz were highly susceptible to both organisms.

Application of herbicides in the fall. The herbicides lenacil, chlorthal, and RH-315 (Rohm and Haas) were tested in preemergence applications in the fall (Oct. 29) to control weeds in Northwest strawberries. Later postemergence treatments (Nov. 22) with RH-315, alone and in combination with chloroxuron and simazine, were applied.

RH-315 at 1.68 kg/ha gave excellent grass control in either preemergence or postemergence applications; at 0.84 kg/ha it was slightly poorer. Control of broad-leaved weeds was better from preemergence than postemergence applications. Shepherd's-purse and pineappleweed were tolerant of this herbicide. The addition of chloroxuron at 5.6 kg/ha to RH-315 increased control of broad-leaved weeds.

Lenacil at 4.48 kg/ha gave good control of grass and broad-leaved weeds, except for shepherd's-purse, pineappleweed, and prostrate knotweed. Results with chlorthal at 13.5 kg/ha have varied from year to year.

ANIMAL SCIENCE

Ruminants

High-grain corn silage increases production of lactating cows. Trials with lactating cows showed that those fed high-grain corn silage (39% grain) produced 2.27 kg more fat-corrected milk (FCM)/cow per day than those fed low-grain corn silage (30% grain). Cows fed high-grain silage and a low level of concentrate, 1 kg meal/5 kg 4% FCM (1:5), produced the same amount of FCM daily as cows fed low-grain silage and a high level of meal (1:3.5). Cows fed high-grain silage and a high level of meal produced 4.08 kg more milk daily than those fed low-grain silage and a low level of meal. Digestion and nitrogen-balance trials indicated only minor differences due to treatment in the digestibility of dry matter, N, and fiber, and in utilization of N.

Efficiency of utilization of urea from ensiled forage corn and grain by lactating cows. Urea or a mixture of urea and dehydrated grass was added to low-N, high-moisture corn silage, or a grain mixture, or both, as a source of N for lactating cows. These rations were compared with a basal ration of corn silage plus grain containing rapeseed meal as the only source of supplemental N. Results of lactation and N-balance trials indicated that grain rations containing up to 5% urea or urea and dehydrated grass, and consumed to a maximum of 11.3 kg/cow per day, were acceptable to high-producing cows. Cows fed the high levels of urea produced more milk with a higher fat content than those fed the basal ration. Commercial grain rations for dairy cows should seldom exceed 2% urea.

Cows fed the grain ration containing urea and dehydrated grass utilized ingested N 28% more efficiently than cows fed urea alone in the grain ration. The efficiency was even higher than for cows fed urea in corn silage.

Nutritive value of forages predicted from an in vitro fermentation method. The percentage digestible dry matter (DDM) was determined in 203 forage samples (grass and legume hays and silages, green forages, and corn silage, all at various stages of maturity) by four laboratory methods. The same forages had been fed previously to sheep in standard digestion trials. One method for DDM determination combined the 48-h in vitro fermentation procedure of Tilly and Terry with subsequent determination of neutral detergent fiber (NDF) according to Van Soest. Values of DDM showed high correlations with percentage digestible energy (DE) by animals, DE content of the forages, and DE intake by animals offered the various forages. Regression equations were developed from these data to predict percentage DE, DE content, and DE intake of various types of forages from their in vitro DDM content. The equations are now being used by the British Columbia Feed Analysis Service.

Synovex, a promising hormone implant. Synovex (E. R. Squibbs), a combination of the two naturally occurring hormones progesterone and estradiol, effectively increased the growth rate of Holstein steers during the finishing stage. In a series of experiments involving 240 animals, those that received the Synovex implant gained 24.2% more rapidly and had an improved feed efficiency of 21.1% compared with the controls. There was also a significant reduction of 10.8% in carcass fat in the treated animals when slaughtered at the same weight as the controls. Although at present more expensive, Synovex is a promising replacement for diethylstilbestrol, which has been withdrawn from use as an ear implant or feed additive

when animals are reared for human consumption.

Poultry

Optimum population size and density for caged laying birds. When poultrymen are faced with declining egg prices that are near or below the cost of production, and production must be maintained at a lower level to meet a quota, it is more desirable to cull poorer birds to reduce density than to make an arbitrary cut in population size. When egg prices are high, birds can be housed more profitably at two birds/cage, with a density of 387 cm²/bird. The birds at 464 cm²/bird, and 4, 8, and 16 birds at 387 cm²/bird are the next most profitable. Higher densities may be practical, and are currently being tested.

FORAGE CROPS

Promising Cultivars of Turfgrass

In trials established in 1969 and 1970, certain turfgrass cultivars were outstanding for lawns. Among the fine fescues the most promising were Highlight, Koket, and Jamestown Chewings fescue; Dawson, Wintergreen, and SA 167 creeping red fescue; and C 26 hard fescue. Highlight, Rolax, Koket, and C 26 had some resistance to red thread disease caused by *Corticium fuciforme* (Berk.) Wakef.; C 26 was outstanding in this respect. Although classed as a hard fescue, C 26 was attractive, dark green, and easy to mow.

Among the Kentucky bluegrasses, only cultivars with some resistance to the leaf-spot-melting-out disease complex caused by *Helminthosporium* sp. were promising. Of the licensed cultivars, Nugget and Merion were most resistant, followed by Fylking, Baron, and Sydsport. Other promising cultivars were Birka, B 101, Golf, K 412, Pennstar, and Sodco. The cultivars Park and Delta were very susceptible; the resulting poor stands allowed severe encroachment by weeds.

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Research Station Kamloops, British Columbia

PROFESSIONAL STAFF

J. E. MILTIMORE, B.S.A., M.Sc., Ph.D.

W. B. G. HOLLIDAY

W. A. HUBBARD, B.S.A., M.Sc.

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

G. B. RICH, B.A.

A. L. VAN RYSWYK, B.S.A., M.Sc., Ph.D.

Director; Forage utilization

Administrative Officer

Forage management

Range and resource management

Tick-host relationships

Soil fertility and pedology

INTRODUCTION

The Research Station at Kamloops, B.C., is the only station in the Branch that specializes in range management studies. Integrated use of natural resources on rangelands, such as logging and forest regeneration, and competition for feed between deer and cattle are of special concern.

Highlights of the 1972 results include the isolation and purification of miserotoxin from timber milkvetch, demonstration of regional differences in selenium levels in feeds, and the study of a population explosion of a beetle that defoliates big sagebrush.

Details on the research at the Station are available by writing to Research Station, Research Branch, Agriculture Canada, P.O. Box 940, Kamloops, B.C.

J. E. Miltimore
Director

ENTOMOLOGY

Effectiveness of Crufomate Against Cattle Grubs

The effectiveness of crufomate against cattle grubs was studied in 83 specific tests involving 3,247 treated and 2,304 untreated cattle. Four methods of application were used. Spray application was the least effective and the most wasteful of crufomate, with high contamination of the external environment. Intramuscular injection was the most consistently effective method, and was the most economical of crufomate. Use of crufomate as a feed additive was effective and economical, but high numbers of grubs survived in some slow-feeding animals. Pour-on application was less economical of crufomate, but was the most efficient method, with little contamination of the environment. As the rate of pour-on application increased to 20 mg crufomate/kg animal, its efficacy increased rapidly until it provided 90% reduction of grubs, then increased slowly to 96.5% at 50 mg/kg. Applications late in the season were significantly more effective than those early in the season. Two applications at 18 mg/kg, with an interval of 3-4 wk, gave the highest reductions of grubs. Posttreatment reactions were insignificant when animals were treated when they had rather empty rumens and were given extensive exercise. Additional information is needed on repeated low-level applications by intramuscular injection and pour-on.

A Chrysomelid Beetle Defoliates Big Sagebrush in South-central British Columbia

A beetle of the genus *Monoxia* is an important insect defoliator of big sagebrush in the dry belt of British Columbia. An apparent population explosion in 1972 caused widespread damage to big sagebrush in the Thompson Valley, from Lytton to Pritchard and south to Spences Bridge. The areas seriously defoliated were estimated to total at least 2,700 ha. Larval leaf-mining appeared to be the main factor in defoliation because each larva destroyed a large number of leaves.

During late summer and early autumn in periods of bright sunshine, the beetles were very active, flying strongly and clearly dispersing outward from the heavily defoliated area. As autumn advanced the beetles became increasingly quiescent; they rested and fed in leaf bundles, and showed an increasing tendency to drop to the ground if disturbed. Dissections in late September disclosed large amounts of fat bodies and almost no ovarian development. This shows that the insects overwinter as beetles.

These observations give some indication that the life cycle consists of one generation per year. Oviposition appears to take place in early spring, with larval and pupal periods in early summer. The remainder of the year appears to be spent in the adult stage.

LIVESTOCK MANAGEMENT

The Toxic Principle in Timber Milkvetch

Livestock poisoning resulting from the ingestion of timber milkvetch, *Astragalus miser* Douglas ex Hooker var. *serotinus* (Gray) Barneby, is related to the toxic activity of miserotoxin, a naturally occurring

nitro compound. A rapid method for the isolation and purification of miserotoxin was developed in this laboratory and the chemical structure of our isolate was confirmed by infrared and nuclear magnetic resonance spectroscopy. With this standard reference compound it is now possible to start geographical and environmental surveys of miserotoxin distribution throughout British Columbia.

The procedures in the literature for the determination of miserotoxin concentrations were tested, and the two principal methods yielded conflicting values when applied to crude extracts of timber milkvetch. The presence of interfering compounds is suspected, and partial purification appears essential before colorimetric estimations are attempted.

Selenium Concentrations in Winter Feeds

A survey in British Columbia has revealed regional differences in Se levels of feeds. The mean values for all feeds sampled in an area ranged from 0.10 to 0.33 ppm on a dry matter basis. Areas with endemic nutritional muscular dystrophy in calves had some of the lowest mean levels, but the disorder has been diagnosed histologically in areas and on ranches with mean levels of Se in feeds as high as 0.50 ppm. The various classes of feeds also showed marked differences in Se levels. Corn silages were the lowest in Se, at 0.09 ppm, whereas legume hay and grains averaged three times that level. All feeds showed some levels of Se less than 0.05 ppm, and 5% of the samples of grass silage, corn silage, and oat hay had less than 0.03 ppm.

Beef Production from Sedge Meadow Hays

Beef production from hays of fertilized and unfertilized sedge grown on Organic soil was estimated and compared with that from hay of alfalfa grown on irrigated soil. The hays were fed to yearling steers with no supplements other than common salt and warmed water. Further evaluation of hay quality included analyses for digestible dry matter (DDM) by the nylon bag technique, crude protein and fiber, acid-detergent lignin and fiber, Ca, P, K, S, Mg, silica, Cu, Mo, Fe, Zn, and Mn.

Fertilization resulted in no appreciable improvement in the nutritional characteristics of sedge hay, but the yield of beef was

increased from 89 to 214 kg/ha per year because of the increased yield of dry matter. Both fertilized and unfertilized sedge hays were deficient in protein, P, Cu, and Zn, and had high Ca:P and low Cu:Mo ratios, whereas the alfalfa hay was deficient in Zn and Mn and had a high Ca:P ratio. In all hays, the other inorganic constituents analyzed were sufficiently high, according to published standards.

Consumption levels of the three hays were similar, about 4.7 kg dry matter/day, but beef conversion rates for both sedge hays were less efficient, with average daily gains of about 0.24 kg beef/day compared with 0.38 for alfalfa. The more efficient conversion of alfalfa may be attributed to its higher DDM, and possibly to higher protein and P.

The increase in yield of beef would more than offset the cost of fertilizer, at current prices. Earlier studies have shown that renovation of native sedge stands through the use of water control devices, conversion to reed canarygrass, and fertilization can greatly improve forage yields and digestibility, so that beef production from Organic soils could approach the level of 1,000 kg/ha estimated for alfalfa grown on irrigated soils.

RESOURCE AND FORAGE MANAGEMENT

Diets and Habits of Mule Deer and Cattle on Range

During the first winter of the project (1971-72), observations on the winter range of deer were confined to the mule deer herd on the Dewdrop range. From December to mid-February, the deer stayed mainly in the wooded areas and large gullies. Many deer moved to the talus slopes and rocky outcrops from mid-February to mid-March. From then until early May they were found in the steep, open, south-facing slopes.

Over 90% of the diet of the deer in December and January consisted of Douglas-fir needles and twigs. Big sagebrush, rabbitbrush, and pasture sage were well utilized from late February to April. In April the new blades of grasses were the preferred food. The diet of the deer shifted back to forbs and shrubs as these feeds developed and the deer moved back up the mountain.

On the forested fall range of mule deer, cattle browsed readily on willow, saskatoon,

and snowberry from July onward. Observations did not start until July.

Winterkill of Crested Wheatgrass and Russian Wild Ryegrass

Winterkill (up to 50% at some locations) of crested wheatgrass and Russian wild ryegrass near Kamloops, B.C., appeared to result from lower-than-average reserves of soil moisture. Damage was heavy on a silt loam but negligible on a sandy loam. Presumably the soil moisture had been held at a higher tension in the silt loam than in the sandy loam in the spring of 1971, and this moisture would be available to the plants. The winterkill resulting from low moisture reserves presumably interacts with effects of the low winter temperatures and drying winds that are common in the area.

Variations in Corn Maturity in Interior British Columbia

A phenological study of four corn hybrids was conducted in 1972, on plots extending from Hazelton in the north to Summerland in the south. The hybrids used, DeKalb 22, United Hagie 4, DeKalb 45, and Pioneer 3773, require respectively 2,400, 2,600, 2,800, and 3,150 heat units to reach physiological maturity. In 1972, Pioneer 3773 produced 9.93 t of dry matter/ha (4.49 tons/ac) at Hazelton, with 1,583 heat units, and 24.9 t/ha (11.26 tons/ac) at Agassiz, with 2,723 heat units. At Prince George, however, with only 1,207 heat units, Pioneer 3773 produced 14.9 t/ha (6.80 tons/ac).

This study suggests that the rating of corn maturities by the Canadian heat-unit system is satisfactory for most of the accepted corn-growing areas of British Columbia, but is not reliable for the area of Prince George.

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Research Station Sidney, British Columbia

PROFESSIONAL STAFF

H. ANDISON, B.S.A.

R. M. ADAMSON, B.A., B.Sc., M.Sc.

R. G. ATKINSON, B.S.A., Ph.D.

J. H. CROSSLEY, B.S.A., M.S.A.

N. V. TONKS, B.S.A., M.S.

D. R. BERTOIA, B.S.A.

(Production and Marketing Branch)

Director

Weed control and vegetables

Diseases of glasshouse crops

Ornamental crops

Insects of ornamentals

Officer in Charge, Post-entry

Quarantine Station

INTRODUCTION

Research at this station emphasizes the improvement, culture, and protection of ornamental and greenhouse crops. More attention is being given to the rapidly expanding work of the Post-entry Quarantine Station, operated jointly with the Plant Protection Division, Production and Marketing Branch. Since this project started in 1966, out of the 1,100 tree fruit and grape accessions examined about 42% have been found infected and 250 indexed for virus diseases and released. Accomplishments in 1972 that merit special mention are described in this report. Outstanding control of the greenhouse whitefly, a common greenhouse pest, was obtained with soil drenches of dimethoate and oxydemeton-methyl and ultralow-volume sprays of resmethrin.

Requests for information or publications should be addressed to the Research Station, Research Branch, Agriculture Canada, 8801 East Saanich Rd., Sidney, B.C.

H. Andison
Director

HORTICULTURAL CROPS

Greenhouse Tomatoes

Sand mulching of greenhouse tomatoes in a sawdust growing medium. A layer of medium coarse sand 1.27 cm deep applied to the surface of the sawdust growing medium soon after transplanting greenhouse tomatoes improved moisture distribution and speeded up establishment and early growth. The sand acts as a wick to spread moisture uniformly over the surface, from which it percolates down to wet the sawdust evenly. This method worked well in experiments, and is quickly being adopted by growers.

Fusarium wilt in sawdust medium. Systemic fungicides applied to the sawdust growing medium of greenhouse tomatoes to control *Fusarium oxysporum* Schlecht. f. *lycopersici* (Sacc.) Snyder & Hansen continue to show promise. For the spring crop, preplant drenches of benomyl at 100, 200, and 300 ppm increased marketable yields by 56%, 48%, and 45%, respectively, whereas eight weekly doses at 10 and 20 ppm, applied by trickle irrigation after planting, increased yields by 41% and 32%. Preplant drenches of thiophanate-methyl at 150 and 300 ppm increased yields by 54% and 25%. Although the fall crop was grown in very heavily infested sawdust, preplant drenches of benomyl at the rather low rates of 25, 50, and 100 ppm increased yields by 107%, 144%, and 135%, respectively. When 100 ppm benomyl was applied by trickle irrigation over the sawdust, half at transplanting and the remainder in two postplant applications, yield

was increased by 106%. Preplant drenches of thiophanate-methyl at 75 and 150 ppm increased yields by 140% and 163%. Steaming infested sawdust increased the yield by 180% over that from untreated sawdust.

Greenhouse Cucumbers

Soilless culture of seedless greenhouse cucumbers. Good commercial yields of the high-quality, long English cultivar Green Spot were obtained in wooden-sided beds containing sawdust, medium coarse sand, or sphagnum peat. Dolomitic lime and superphosphate were mixed with the medium before planting to supply Ca, Mg, and P, as was a complete minor element mix; N, K, and extra Ca were applied with the required water each day during the growing season by a trickle irrigation system. Moisture distribution in the sawdust was improved by a 1.27-cm layer of sand placed on the surface soon after planting. No significant differences in length, number, or weight of cucumbers were found. The plants maintained good shoot development and steady production throughout the 18-wk picking season.

Woody Plants

Propagation of commercial woody plants. Cuttings from Douglas-fir trees 20 to 150 yr old, selected as superior or "plus" and supplied by MacMillan Bloedel and Pacific (CPR) Logging Co., showed a great variation in their ability to root among various clones. Best results were obtained during December and January when heel cuttings were dipped in Jiffy Grow hormone (indolebutyric acid

and naphthalene acetic acid) for 5 s, before and after cold storage at 1°C for 7 wk.

Performance of apple cultivars on dwarf and semidwarf rootstocks. McIntosh, Spartan, and Tydeman Red apples were planted during 1965 on M 7, M 9, M 26, MM 104, and MM 106 rootstocks at a spacing of 3.0 × 5.2 m on Tolmie sandy clay loam. In 1972, M 26 rootstocks supported the highest yields and McIntosh was the highest producing cultivar. For Spartan, production was best on MM 106 and MM 104, and for Tydeman Red, on M 7.

Progress of the Post-entry Quarantine Station. The program of the Post-entry Quarantine Station, operating at this station in cooperation with the Production and Marketing Branch, is expanding rapidly. The total number of accessions since the program started in 1966 is 1,097, comprising 752 tree fruits and 345 grapes. Of these, 671 are foreign clones, from 20 countries, and 426 are domestic clones. Over 300 clones are being indexed for virus diseases. There were 278 clones, or 42%, found infected, and 245 accessions were virus-indexed and released.

Control of Greenhouse Whitefly

On poinsettia. Trials for control of the greenhouse whitefly on poinsettia cv. Dark Red Hegg showed that dimethoate 4E at 1.25 and 2.5 ml/litre (1 and 2 pt/100 gal) applied as a soil drench of 144 ml per 18-cm pot gave over 95% control of whitefly scale; at 3.75 ml/litre (3 pt/100 gal) control was complete, but slight to moderate leaf injury occurred. Similar drenches of oxydemeton-methyl 25% EC at 3.75 and 7.5 ml/litre (3 and 6 pt/100 gal) gave 91–99% control. The higher rate caused some slight leaf injury and appeared to be the threshold level of plant damage for this material.

On tomato. Good control of the greenhouse whitefly on tomato cultivars Vantage and Vendor was obtained with an ultralow-volume formulation of resmethrin, applied nine times at 7-day intervals through a Turbair Imp sprayer. Treatments caused no plant injury.

Very high populations of adult whiteflies persisted after the release of the parasite *Encarsia formosa* Gahan on April 13 in a commercial crop of greenhouse tomatoes cv. Vantage. Honeydew spotting on fruit became serious by mid-May. Under these conditions,

an integrated program with a material such as chinomethionat (Morestan; Chemagro Corp.) is necessary to provide more effective control.

Ornamentals

Insulation of cartons for bulk holly shipment. Styrofoam (1.9 cm), fiberglass wool (2.5 cm), and 0.1-mm (5-mil) aluminum foil were investigated as liners inside standard shipping cartons of 4.5 kg capacity, for protecting holly from freezing temperatures during shipment. Thermocouple temperature readings at 2.5 cm from the liners and at the center were recorded during stabilization of the carton and contents. Results indicate that these insulating materials have little value for protecting bulk holly from freezing temperatures of about -17.7°C, even for short periods.

Production of ornamental plants in containers. Shredded firbark and fir sawdust were evaluated for culture of five species of ornamental plants in containers. Six different fertilizer treatments were tested, with emphasis on the controlled-release, labor-saving kinds. Good plants of satisfactory market quality were produced in each medium, but response varied with the fertilizer, medium, and species. *Erica* × *darleyensis*, *Rhododendron* 'Anna Rose', *Juniperus chinensis* 'Pfitzereana Aurea', and *Thuja occidentalis* 'Pyramidalis' performed significantly better in shredded firbark than in sawdust. Azalea 'Mother's Day' showed no preference.

One application of 18-16-12 fertilizer, resin coated for controlled release, and 12 applications of liquid whale formulation 6-2-1 gave the same results and were best for juniper, *Thuja*, and azalea. For rhododendron, the liquid whale formulation was best. For *Erica* × *darleyensis*, one-application, controlled-release forms of resin-coated 18-6-12 and coarse granular 7-40-6+12 Mg proved equal and best.

Growth retardants for production of forcing 1-yr-old rhododendrons. The retardants B-9 (Alar), chlorphonium (Phosfon), and chlormequat (Cycocel), were tested intensively for 8 yr. The chemicals, particularly the first two, demonstrated a capacity for restricting growth of rhododendron, initiating flower buds in the first season of growth from rooted cuttings when normally none are produced, and increasing the number of

flower buds on plants of bearing age. However, no reliable recommendations can be made because of inconsistency of results and an insufficiently high percentage of uniformly budded 1-yr-old plants.

Weed control in English holly. In a 5-yr comparison, sprays to control weedy growth in a young holly orchard showed several advantages over cultivation. Spray treatments of simazine at 3.36 kg/ha plus paraquat at 2.24 kg/ha were applied each

spring, with later applications, as required, of paraquat alone at the same rate. Five combination sprays plus seven follow-up sprays gave better control of quack grass and other weeds than 24 hoeings during the same period. Other benefits from spraying were increased shoot growth, darker and denser foliage, lower maintenance costs, and the increase in marketable holly, both branched and unbranched, harvested at the end of the experiment.

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Research Station Summerland, British Columbia

PROFESSIONAL STAFF

D. V. FISHER, B.S.A., M.S.A., Ph.D., F.A.S.H.S.	Director
E. F. BELL	Administrative Officer
J. C. LAVERY, B.Sc., B.L.S.	Librarian

Agricultural Engineering Section

A. D. McMECHAN, B.A.Sc.	Head of Section; Sprayer and fruit-handling equipment
P. PARCHOMCHUK, B.A.Sc., M.S.	Harvesting equipment

Animal Science Section

J. M. McARTHUR, B.A., M.A., Ph.D.	Head of Section; Bloat research in cattle
R. E. HOWARTH, ¹ B.S.A., M.S., Ph.D.	Biochemist

Entomology Section

H. F. MADSEN, B.A., Ph.D.	Head of Section; Integrated control
F. L. BANHAM, B.A.	Stone-fruit insects
R. S. DOWNING, B.A., M.S.	Control of mites
A. P. GAUNCE, B.Sc., M.Sc., Ph.D.	Pesticide and environmental chemistry
R. D. McMULLEN, B.Sc., M.Sc., Ph.D.	Bionomics of pear psylla
J. D. MACNEIL, B.Sc., M.Sc., Ph.D.	Pesticide and environmental chemistry
C. V. G. MORGAN, B.S.A., M.Sc.	Control of grape insects and mites
M. D. PROVERBS, B.Sc., M.Sc., Ph.D.	Control of codling moth by the sterility method

Food Processing Section

J. A. KITSON, B.A., M.S.	Head of Section; Process and product development
J. F. BOWEN, B.S.A., M.S.A., Ph.D.	Microbiology
D. BRITTON (Miss), Dip. H.Ec.	Home economist
D. R. MACGREGOR, ² B.S.A., M.S., Ph.D.	Biochemistry and microbiology

Soil Science Section

J. L. MASON, B.S.A., M.Sc., Ph.D.	Head of Section; Plant nutrition
F. M. CHAPMAN, B.S.A.	Cereals, forage crops
D. S. STEVENSON, B.S.A., M.S., Ph.D.	Soil physics and irrigation

Plant Pathology Section

M. F. WELSH, B.S.A., Ph.D.	Head of Section; Virus diseases of pome fruits
A. J. HANSEN, Dip. Agr., M.Sc., Ph.D.	Virus diseases of stone fruits and grapes
L. E. LOPATECKI, ³ B.A., B.S.A., M.S.A., Ph.D.	Parasitic tree-fruit diseases
D. L. MCINTOSH, B.S.A., Ph.D.	Parasitic tree-fruit diseases
R. M. ROSHER, B.A., M.A.	Parasitic tree-fruit diseases

Pomology Section

S. W. PORRITT, B.S.A., M.S., Ph.D.	Head of Section; Fruit harvesting and storage
L. G. DENBY, B.S.A., M.S.A., F.R.H.S.	Rootstocks—grapes, peaches
K. O. LAPINS, Agr., M.S.A., Ph.D.	Fruit breeding and hardiness
N. E. LOONEY, B.S., M.S., Ph.D.	Agrometeorology, growth regulants
M. MEHERIUK, B.Sc., B.Ed., M.Sc., Ph.D.	Postharvest physiology, biochemistry

Departure

A. W. MOYLS, B.S.A. Retired April 4, 1972	Fruit and vegetable processing
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VISITING SCIENTISTS

National Research Council postdoctorate fellows, 1972-73

A. S. ROBINSON, Ph.D.

Insect genetics

S. K. SARKAR, Ph.D.

Biochemistry, animal nutrition

¹On work transfer from Research Station, Saskatoon, Sask., from June 1972.

²On two-year loan to CIDA, as head of Food Science Department, University of Ghana, from October 1971.

³On one-year transfer of work to Department of Scientific and Industrial Research, Auckland, N.Z., from September 1972.

INTRODUCTION

The Research Station at Summerland, B.C., places special emphasis on the problems of the fruit and vegetable industry in the region, and also carries national projects that have wide application to the industry throughout Canada. It is mainly concerned with solving problems for the fruit industry of the British Columbia interior, which has an F.O.B. product value of \$60 million. The Station also carries national programs for the Research Branch in research areas such as trickle irrigation, grape and sweet cherry breeding, codling moth control by use of sterile insects, development of certain fruit products, and control of fruit tree root rots.

In the past year the Station has benefited from the presence of three National Research Council postdoctorate fellows, and our program in environmental chemistry was further strengthened by the addition to our staff of Dr. J. D. MacNeil, a pesticide chemist. Dr. Looney has returned from a one-year work transfer to CSIRO, North Ryde, Australia, and Dr. Lopatecki left in September for a one-year work transfer to the Department of Scientific and Industrial Research, Auckland, N.Z.

The Animal Science program, which is due to be transferred in 1973 to the Research Station at Saskatoon, has benefited from the secondment of Dr. R. E. Howarth from Saskatoon, who has helped complete the Summerland program.

During the year, members of the professional staff participated in various national and international conferences, and published many articles and papers to serve both industry and science.

For more information, correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Summerland, B.C.

D. V. Fisher
Director

AGRICULTURAL ENGINEERING

Sprinkler Application of Pesticides

Application of pesticides by overtree sprinklers was much less effective than application by air-blast sprayers. During the season three sprays of azinphos-methyl were applied for control of the codling moth and one spray of endosulfan for control of the white apple leafhopper in an orchard of mature, semi-dwarf apple trees. Two days after the endosulfan application, counts showed 100% mortality of leafhoppers in the plots sprayed by air-blast sprayer and less than 50% mortality in the plots sprayed by overtree sprinklers. Codling moth infestation at harvest averaged 1.2% in plots sprayed by air-blast sprayers and 1.9-4.2% in plots sprayed by overtree sprinklers.

Orchard Air-blast Sprayer Development

An experimental air-blast sprayer that directs the spray-laden airstream horizontally through the trees again gave more uniform spray deposits than a good conventional sprayer. The spray was applied from the bottom to the top of trees in a hedgerow

planting on M 7 rootstocks. At both the recommended insecticide rate and three-quarters of this rate, the experimental sprayer gave somewhat better codling moth control than the conventional sprayer.

New Apple-harvesting Aid

A small, self-propelled catching frame with conveyor and bin filler was constructed and evaluated as an apple-harvesting aid. When the pickers tossed the apples onto the catching frame, the picking rate was the same as when they used picking bags and ladders, but damage to the fruit was slightly higher.

ANIMAL SCIENCE

Bloat Research

Survey of Fraction 1 protein content of alfalfa. Thirty established alfalfa varieties were surveyed for Fraction 1 protein content. No variety contained less than 2% Fraction 1 protein based on dry matter, the threshold below which bloat has not occurred. Second-cut alfalfa at Summerland and Creston had

significantly lower Fraction 1 protein content than first or third cuttings. No significant differences among cuttings were obtained in alfalfa grown at Kamloops. The screening of plants in a breeding nursery was continued and selections of "low" and "high" lines were made.

Soluble leaf proteins. Molecular weights of Fraction 1 proteins from alfalfa, white clover, and red clover were 542,000, 515,000, and 545,000. Fraction 1 protein from alfalfa was dissociated into two subunits, which were characterized by their molecular weights and peptide maps.

A rapid analytical procedure for determining total soluble protein content of alfalfa was devised. The correlation coefficient between Fraction 1 protein content and total soluble protein content was 0.68.

Phenolic constituents. Concentrations of total phenols, tannins, and nontannin phenols were measured in bloating legumes (alfalfa, red clover, and white clover) and nonbloating legumes (birdsfoot trefoil, crownvetch, and sainfoin). Levels of total phenols and tannins were generally higher in bloating legumes than in nonbloating legumes. There were no differences between the two groups in amounts of nontannin phenols. The stage of growth, environment, and analytical procedure affected the concentration of phenolic compounds.

ENTOMOLOGY

Codling Moth

Autocidal control. For the 4th consecutive year, gamma-irradiated moths dosed at 30–35 krad were released by helicopter three times a week from time of bloom through late September in a 40.5-ha block of apple and pear trees. At harvest, the percentage of fruit injured by codling moths was 0.0005 compared with 0.007 in 1971. Moths were released in another 121.5 ha consisting of 18 orchards. There was larval injury along the eastern border of four of the orchards; one spray against the codling moth was applied in three of these orchards. In two others, growers applied a spray unnecessarily. At harvest, apples injured by codling moths in the remaining orchards amounted to 0.3% in 1 orchard, 0.03% in 2 orchards, and 0.01% in 10 orchards.

During the period of sterile moth release, 10.3 million moths were reared on an artificial diet, an increase of 22% over the number reared in 1971.

Sex attractant. Six apple orchards were monitored with traps containing Codlemone (Zoëcon Corp.), a synthetic codling-moth sex attractant. By spraying only when moth captures exceeded two per week or when larval entries were found, the number of sprays needed was reduced by two in one orchard and by one in three orchards. The other two orchards received a normal three-spray program.

Fruittree Leafrollers

Sex attractants. Two species of leafroller, the fruittree leafroller and the European leafroller, are common in British Columbia apple orchards. Field tests with synthetic sex attractants showed that fruittree leafroller males responded to a combination of *cis*-11-tetradecenyl acetate and dodecyl acetate, but the mixture was not as attractive as virgin females. Males of the European leafroller were attracted to a combination of *cis*-11-tetradecenyl acetate and *cis*-11-tetradecen-1-ol and the synthetic lure was far more attractive than virgin females.

Cherry Fruit Flies

Traps and attractants. Of four trap types and 14 colors tested, Sectar 1 daylight yellow traps (3M Co.) and Pherotrap 1C-Y yellow traps (Zoëcon Corp.) were the most attractive to cherry fruit flies. Seclure bait increased the attractiveness of Sectar traps, and Maggottrack 11 increased the effectiveness of Pherotrap traps. The new traps and baits were more attractive to black cherry fruit flies and western cherry fruit flies than the standard yellow sticky-board trap.

Chemical control. Dimethoate at 4.1 litres/ha applied 7 days after the first cherry fruit fly was trapped or at 7 days and again 15 days later gave excellent control for the season. A 1:1 dilution of dimethoate brushed in 15.2-cm bands on branches of cherry trees showed systemic action against eggs and adults of the western cherry fruit fly. Peak mortality was obtained 28 days after application and effectiveness dropped sharply after 42 days.

FOOD PROCESSING

Thrips

Pansy spot on apples. Apple blossoms attracted adult thrips as soon as the petals opened. Flowers of McIntosh, Spartan, and Red Delicious were equally attractive and more so than Golden Delicious. Eggs were found in the following flower parts in descending order of frequency: sepals, style, peduncle, filament, hypanthium, and petals. Pansy spot resulted from oviposition in the hypanthium. Not all the oviposition marks produced pansy spot and the symptom persisted to harvest on only two varieties, McIntosh and Spartan.

Bruce Spanworm

Chemical control. The Bruce spanworm caused widespread but light damage to apples and cherries in 1972. This pest had not been present in sufficient numbers to be of concern to growers for almost 40 yr. In orchard field plots, azinphos-methyl, diazinon, or endosulfan applied at the early-cluster stage killed all the larvae. In commercial orchards, sprays of azinphos-methyl or diazinon at the pink stage for fruittree leafroller control prevented damage by the spanworm.

Orchard Mites

Biological control. An organophosphate-resistant strain of the predacious phytoseiid *Amblyseius fallacis* (Garman) was reared in the laboratory and compared with an organophosphate-resistant strain of *Typhlodromus occidentalis* Nesbitt. *A. fallacis* reproduced faster and consumed more prey than *T. occidentalis*, and both species were equally resistant to sprays of diazinon. *A. fallacis* was released in an orchard and increased initially to high numbers, but populations declined drastically by August.

Chemical control. Triazid (Upjohn Canada) and formetanate hydrochloride gave excellent initial and residual control of the European red mite but were toxic to predacious phytoseiids. Plictran (Dow Canada) gave excellent control of phytophagous mites, was not toxic to predacious mites, and was an excellent selective acaricide in an integrated mite-control program.

Pilot Plant Vacuum Aroma Concentrator

A 10-cm (4-in.) diam vacuum aroma concentration column has been installed and is undergoing testing and modification in the pilot plant. The column, built by the Engineering Research Service, Ottawa, is fed with 150-fold apple essence at a maximum rate of 16 litres/h and produces from this approximately 100 ml of 25,000-fold essence. Without further scale-up, the unit can concentrate the essence output from an apple juice plant that presses 3,200 kg of fruit/h. The column is one of the essential stages in scale-up of the patented Sugisawa process for manufacture of fruit aromas in dry powdered form.

Canned Fruit Puddings

Canned fruit puddings are a new type of single-serving fruit dessert intended for lunch-box or dispenser use. The product contains approximately 35% crushed or pureed fruit set into a bright stable gel with a stabilizer system consisting of modified starch, xanthan, and locust bean gums. The product has a pH of 3.5 and could thus be hot-filled and sealed without further processing. However, to minimize loss of fruit aroma, it was found preferable to heat the product rapidly to 82°C before filling, and then to process sealed cans in boiling water to gelatinize the starch. Twenty varieties of fruit puddings have been made from berries, soft fruits, and rhubarb.

Apple "Snaps," a New Snack Food

A crisp, light-colored, fruit-flavored snack food has been made from apples. As a first stage in manufacture, slices 1.9–2.6 mm thick are cut from peeled, cored fruit. To remove intracellular gases, slices are held for 5 min at 50-mm pressure or lower in a vacuum chamber. The vacuum is then released with a 40% solution of maltodextrin, which saturates the slices and reduces fat absorption during the frying process. The maltodextrin-saturated slices are vacuum-fried for 15 min at 104°C and 50-mm pressure, and then removed from the fat before the vacuum is released. By this technique the fat content may be kept below 30%. The crisp finished slices have a moisture content of 2% and storage life in air similar to that for potato chips. Storage life of 6 mo or more may be achieved by packing in inert gas.

Grape Cultivars for Wine

Of 40 grape cultivars processed in the 1971 season the most outstanding red wines were made from Vincent, Schuyler, Baco Noir, Seibel 13053, Foch, and Seibel 9549. The best white wines were made from Pinot Gris, Auxerrois, Hungarian Riesling, and Perle von Alzey. Illinois 172-8 and the Vineland varieties 37031, 37034, and 35122 also gave good white wines.

The Russian cultivars Svernyi and Michurinets, which produced excellent red wines in 1970, failed to yield a crop in 1971.

PLANT PATHOLOGY

Crown Rot of Apple Trees

The survival of propagules of *Phytophthora cactorum* (Leb. & Cohn) Schroet. in the soil is affected by soil temperature and moisture. Mycelium, sporangia, and zoospore cysts of *P. cactorum* did not survive in air-dry soil, or in wet soil below freezing. Hyphae were lysed in 3 days in wet soil at 29°C, but survived for at least 45 days in wet soil at 4°C.

Oogonia can be freed from mycelium fragments for laboratory studies by homogenizing colonies, exposing the homogenate to a mixture of cellulase and hemicellulase for 2 days, and filtering the suspension through polyester bolting cloth. There is evidence that oospores will germinate in soil that has 5 bars of suction pressure.

P. cactorum can be isolated from soil on dilution plates by using a simple nutrient medium supplemented with benomyl at 20 ppm active ingredient, and by adding pimarinic acid to the dilution plates after *Phytophthora* propagules have germinated, i.e., 48 h after plating the dilution.

Four rootstocks in the Ottawa clonal series, two resistant to *P. cactorum* and two susceptible, have been studied in an attempt to determine the factors involved in the resistance mechanism. The main amino acids in the stem bark of all four selections have been identified as alanine, aspartic acid, glutamic acid, asparagine, and tryptophan. The level of total amino acids was higher in the resistant selections than in the susceptible selections at the June (168%), July (244%), and August (119%) sampling dates, but in September no difference was evident.

Corticium Rot of Apple

A fungus tentatively identified as *Corticium centrifugum* (Lév.) Bres. was isolated from Spartan and Golden Delicious apples held in cold storages during the 1971-72 season. The fungus produced a surface rot resembling bull's-eye rot in both cultivars, and also a core rot of Spartan. All isolates appeared identical in agar culture, but mycelium of some lacked clamp connections. These presumably haploid strains produced oidia in agar culture; those with clamp connections did not. Thiabendazole and benomyl, the fungicides that most strongly inhibit the bull's-eye rot fungus, *Gloeosporium perennans* Zeller & Childs, gave poor control. The fungicide Geigy 20072 (8-hydroxy quinoline) strongly inhibited both fungi.

Apple Virus Indexing on Virginia Crab

There is considerable scope for improving the procedures for indexing apple viruses. Progress has been made in differentiating the viruses for which Virginia crab serves as an indicator. This crabapple originally entered the indicator range specifically for detection of the causal agent of apple stem pitting. It is now apparent that it reacts to infection by a number of viruses, or virus strains, or both, which fall into at least two main groupings. One of these is of "stem pitting" isolates that induce pits in the woody cylinder matching necrosis-free bark pegs. The other is of "junction brown line" isolates that induce pits or encircling depressions in the wood at the stock-scion junctions accompanied by necrosis in the matching bark protrusions. Recent studies have shown that among stem pitting isolates some invariably induce severe reticulated wood pitting within 3 yr, whereas others, over much longer periods, induce only sparse small pits. All stem pitting isolates have induced fruit fluting. The causal agent has not been juice-transmitted or characterized and is merely assumed to be a virus.

The junction brown line isolates have shown similar diversity; some have caused only junction abnormalities, whereas others have also induced long grooves in the wood of the trunk above, with necrosis in the corresponding bark ridges. Trees affected with necrotic brown line may bear fruits with small ring depressions or may have normal fruit. Apple stem grooving virus has been juice-transmitted from some trees with

brown line symptoms, but precise correlations have not been established. Stem pitting and brown line have been eliminated from apple clones by heat therapy, but when they occur together, the brown line more often persists after the treatment.

Cherry Rasp Leaf Virus Indigenous to British Columbia

Host range studies and serological comparisons of virus isolates from cherry trees affected by cherry rasp leaf virus, from orchard weeds, and from wild balsamroot, *Balsamorhiza* sp., have shown that all isolates are closely related or identical. This indicates that the virus came originally from wild balsamroot or other plants of the native vegetation, and that it can survive in orchards in the absence of cherry trees. It also explains the erratic occurrence of the disease in Western North America.

POMOLOGY

Controlled-atmosphere Storage of Newtown Apples

In controlled-atmosphere (CA) experiments Newtown apples kept in excellent condition for 8 mo in 3% carbon dioxide and 2–3% oxygen at 1.7°C. In comparison with similar fruit stored in air at -1.1°C, CA fruit was 1.63 kg (3.6 lb) firmer and had 24% higher acid content. There was no scald or breakdown, and incidence of core or flesh browning was negligible. In contrast, two-thirds of the control fruit had core browning and one-third had flesh browning.

Effects of Handling on the Quality of Starking Delicious Apple

Regular cold storage, CA storage of 2% CO₂ + 2% O₂ (2+2) and 0% CO₂ + 3% O₂ (0+3), delayed storage of 48 h at 21°C prior to cold or CA storage, and temperatures of 1°C and -1.1°C were the treatments used. Storage temperatures had little effect on firmness, acidity, soluble solids, and internal disorders. CA storage markedly reduced the incidence of scald at -1.1°C. Apples stored in the 2+2 atmosphere had more core browning than fruit stored in the 0+3 atmosphere. The more mature fruit had less core browning when stored in the 2+2 atmosphere. Delayed storage reduced firmness of fruit stored in the 2+2 atmosphere.

Comparison of Grape Training Systems

In 1971, De Chaunac (S-9549) grape trained to the Geneva Double Curtain system (GDC) produced 28.98 t/ha (12.93 tons/ac), whereas identical plants on the two-wire Kniffin system produced only 16.34 t/ha (7.29 tons/ac). Soluble solids at harvest, on October 28, were 16.8% for GDC and 18.7% for Kniffin.

In 1972 all plots were moderately injured in winter, and the yields were closely proportionate to the 1971 tonnages. The GDC planting yielded 14.39 t (6.42 tons) and the Kniffin 12.01 t (5.36 tons). Despite a late season, however, the harvest was advanced to October 12, soluble solids amounting to about 18.3% for both training methods. These data also suggest that tonnage and quality could be maintained with a vigorous cultivar such as De Chaunac by reducing the bearing surface and increasing the number of plants per hectare.

Storage Disorders of Cherries

Controlled bruising tests showed that mechanical injury incurred by normal harvesting and handling procedures could be responsible for much of the skin marking that develops after a period of cold storage. Seasonal differences in susceptibility to damage were apparent and less mature fruit was more readily marked than that picked later. Cooling in ice water before cold storage increased the number of defects visible after cold storage.

Performance of Spur-type Delicious

Starkrimson Delicious and Starkspur Golden Delicious were planted in 1966, on M 26, M 7, MM 111, and seedling rootstocks. Alternate rows were McIntosh frames. The delay in bearing caused by frameworking reduced cumulative yield by 35% in Starkrimson and 39% in Starkspur. Frameworking has reduced tree growth of Starkrimson, but not of Starkspur.

Compact-growth Types in Seedling Progenies of Apple

Thirteen different measurements were used to identify compact growth types in 2-yr apple seedlings from 16 families. Eleven crosses had Golden Delicious or one of its compact mutants (spur types) as one parent. The other parent was a compact-growth cultivar or its mutant. Three crosses, Golden

Delicious (GD) Goldspur × Alkmene, GD Goldspur × McIntosh (Wijcik), and GD Goldspur × McIntosh (10C-6-48-1) segregated compact or spurred seedlings in 15–50% of the progeny.

Accessory Buds in Sweet Cherry

Accessory buds, located in the axils of the outermost bud scales, represent a less differentiated and simpler structure than the main bud and thus desirable tissue for induction of mutants. Accessory buds, which normally remain dormant, were forced to grow by removal of the main bud. Treatment of the cut surface with 6-benzylamino purine (BAP) plus adenine, or with BAP, adenine, and indoleacetic acid in lanoline paste, promoted growth of irradiated or nonirradiated accessory buds.

Growth Regulators Influence Peach Fruit Ripening

A study was made of the effects of Alar (UniRoyal Chemicals) and ethephon on the physiology of fruit ripening of peaches. Of particular interest were the effects of these chemicals on ethylene production and fruit growth at the time of transition from Growth Stage II (the midseason lag phase) to the final fruit swell known as Growth Stage III. Although both regulators advanced the date of commercial harvest, neither altered the time of the Stage II to Stage III growth transition. Both Alar and ethephon increased ethylene production by Stage III fruits, which probably explains their effect on date of harvest. Alar reduced ethylene production by peach fruit just before Stage III, whereas ethephon increased ethylene at this time. It was concluded that ethylene does not trigger Stage III in peaches. Endogenous levels of abscisic acid, another natural plant growth regulator, rose just before Stage III, which may indicate a triggering role for this hormone.

Spartan Breakdown

Soil Ca:Mg ratio. Analysis of soil samples has shown relationships between the soil and breakdown in Spartan apples. Eight orchards that had an average of 3% breakdown had a pH of 7.0 and a Ca:Mg ratio of 0.63. Another eight orchards that averaged 27% breakdown had a pH of 6.8 and a Ca:Mg ratio of 0.47. A further 11 orchards that averaged 58% breakdown had a pH of 5.9 and a Ca:Mg ratio of 0.42.

Number of sprays. Calcium sprays were applied by concentrate sprayer at 2-wk intervals. The unsprayed trees had 34% breakdown. Trees receiving one spray just before harvest had 25% breakdown. Trees receiving three sprays, the last spray just before harvest, had 13% breakdown. Trees receiving seven sprays, the last spray just before harvest, had only 8% breakdown. The optimum number of sprays was five or six.

Preventive dips in calcium chloride. Fruit from 29 growers' orchards was dipped in calcium chloride solution (4 kg/litre) at harvest. Dipped fruits from 18 orchards had no breakdown, but where dipping was not practiced fruit from only five orchards showed no breakdown. In 27 of the 29 orchards, the dipped fruit had 0–3% breakdown, but the nondipped fruit had 0–25% breakdown. The other two orchards showed a large amount of breakdown (45%), which was reduced by dipping (32%). This process costs only 60 c per bin. It has been adopted for trial operations by the packinghouses.

Trickle Irrigation for Apples and Grapes

Trickle irrigation is apparently an effective method for irrigating high-density orchards and vineyards. A semidwarf orchard is in excellent condition after 2 yr, and a dwarf tree orchard is in good condition after 1 yr of trickle irrigation. A vineyard under trickle irrigation in 1972 yielded the same as in 1971 under sprinkler irrigation (6.4 kg grapes per vine). Under sprinkler irrigation, the yield was lower when a cover crop was used than when the plots were cultivated; under trickle irrigation, the yields were similar.

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Research Station Vancouver, British Columbia

PROFESSIONAL STAFF

M. WEINTRAUB, B.A., Ph.D., F.N.Y.A.S.	Director
R. N. MACK, B.S.A.	Administrative Services Officer

Scientific Support

H. M. CABALLERO (Mrs.), B.A., B.L.S.	Library Coordinator, Pacific Area
J. D. ANASTASIOU (Mrs.), B.A., M.A., B.L.S.	Librarian

Entomology Section

H. R. MACCARTHY, B.A., Ph.D.	Head of Section; Virus vectors
W. T. CRAM, B.S.A., M.S., Ph.D.	Strawberry insects; ecology
D. G. FINLAYSON, ¹ B.A., M.A., Ph.D.	Root maggots; toxicology
A. R. FORBES, B.A., M.S., Ph.D.	Aphids; morphology
B. D. FRAZER, B.Sc., Ph.D.	Aphid ecology
J. RAINE, B.S.A., M.S.	Berry insects; leafhopper vectors
A. T. S. WILKINSON, B.S.A.	Soil insects
I. H. WILLIAMS, B.A., M.S.	Pesticide chemistry
P. ZUK, B.A.	Stored-product insects

Pedology Section

L. FARSTAD, B.S.A., M.S.A.	Head of Section; Soil classification and soil correlation
A. J. GREEN, B.S.A., M.Sc.	Soil survey party leader
L. LESKIW, B.Sc., M.Sc.	Soil survey party leader
T. M. LORD, B.S.A.	Soil survey party leader
J. I. SNEDDON, B.S.A., M.Sc.	Soil survey party leader
K. W. G. VALENTINE, ² B.A., M.A., M.Sc.	Soil survey party leader

Plant Pathology Section

N. S. WRIGHT, B.S.A., M.S.A., Ph.D.	Head of Section; Potato diseases; serology
-------------------------------------	---

F. D. MCELROY, B.S., Ph.D.	Nematology
F. C. MELLOR (Miss), B.S.A.	Strawberry viruses; thermotherapy
H. S. PEPIN, B.S.A., M.A., Ph.D.	Root rots; red stele of strawberry
R. STACE-SMITH, B.S.A., Ph.D.	Raspberry viruses; virus characterization
H. N. W. TOMS, B.A.	Mycology; potato diseases

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.	Virology; virus interactions and seed transmission
G. G. JACOLI, B.A., Ph.D.	Biochemical virology
J. H. TREMAINE, B.Sc., M.Sc., Ph.D.	Biophysical virology

Departure

R. E. FITZPATRICK, B.S.A., Ph.D. Retired June 27, 1972	Virus characterization
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VISITING SCIENTISTS

D. G. WALKEY, B.Sc., Ph.D. On leave from National Vegetable Research Station, Wellesbourne, Warwick, England	Plant virology
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National Research Council postdoctorate fellows

H. O. AGRAWAL, B.Sc., M.Sc., M.S., D.Sc., 1970-72	Virology
J. A. FROWD, B.Sc., M.Sc., Ph.D., 1972-73	Plant virology

Postgraduate students

G. A. DODDS, B.Sc., M.Sc.	Plant virology
A. F. YANG, B.Sc.	Plant virology

¹On transfer of work at Wellesbourne, Warwick, England.

²On educational leave, University of Reading, Reading, England.

INTRODUCTION

This report, the 10th from the Research Station, Vancouver, outlines briefly the main areas of progress in our research. This station is the national center for research on plant viruses; this field of study includes work in several disciplines, involving entomologists, plant pathologists, and virologists. The program ranges from background to applied research aimed at solving current problems of plant virus diseases. We are pleased to congratulate the team of scientists on our staff that was given the highest merit award of the Public Service Commission, for the development of virus-free seed potatoes.

The research continues on control of pests, diseases, and weeds by chemical and biological agents in an integrated program, with emphasis on biological control.

Correspondence or requests for reprints may be directed to individual scientists, or addressed to: Research Station, Research Branch, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver 8, B.C.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Physical and chemical properties of viruses in vitro. The action of trypsin on cowpea chlorotic mottle virus (CCMV) at pH 7.4 caused the release of 25 amino acid residues from the N-terminal of the protein. The separation of released peptides on cation exchange resins and the determination of their N-terminals yielded six major peptides: the N-terminal peptide $\text{CH}_3\text{-C(=O)-NH-}$ (Lys, Thr₂, Ser, Gly₂, Val₂); Ala-Ala-Ala-Arg; Asn-Thr-Arg; Ala-Gln-Arg; Leu-Thr-Arg; and Lys-Asn-Lys-Arg. Some of these peptides were cleaved by nontryptic enzymes in the digestion. Peptides cleaved by trypsin from chymotrypsin-treated virus were Lys, Arg, and Asn-Thr-Arg.

From these data and the isolation of peptides containing more than one arginine, we propose the following partial sequence of 25 residues in the N-terminal of CCMV protein:

$\text{CH}_3\text{-C(=O)-NH-}$ (Thr, Ser, Gly, Val, Val)-Thr-
6
Gly-Lys-Leu-Thr-Arg-Ala-Gln-Arg-Ala-Ala-
7 8 9 10 11 12 13 14 15 16
Ala-Arg-Lys-Asn-Lys-Arg-Asn-Thr-Arg-
17 18 19 20 21 22 23 24 25
COOH

Evidence was obtained for the action in vitro of plant proteases on potato virus X (PVX), when protein prepared from specially purified virus showed two components in sodium dodecyl sulfate (SDS) polyacrylamide gel electrophoresis. The molecular

weights of the major and minor components were 27,000 and 29,000. When PVX purified by other procedures was incubated with trypsin, 19 amino acid residues were cleaved from the virus without disassembling the particle. The resulting protein had a mol wt of 27,000.

The physical, chemical, and serological properties of cucumber necrosis virus (CNV) and an associated top component were investigated. Partly purified preparations of CNV had two components. The major component, 35 nm in diam, was infectious, and had a sedimentation coefficient of 136 S. The minor component, 20 nm in diam, was not infectious, was serologically related to the virus, and had a sedimentation coefficient of 50 S.

The purified virus contained 1.77% P and 18.5% RNA. The nucleic acid consisted of 25.8% adenylic acid, 28.8% guanylic acid, 20.2% cytidylic acid, and 25.2% uridylic acid. The protein had a molecular weight of 40,400, consisted of 356 amino acids, and did not contain cysteine. The molecular weight of the virus calculated from the sedimentation and diffusion coefficients was 9.3×10^6 .

Virus infection. The action spectrum of the virus inhibitor from carnation, *Dianthus caryophyllus* L., was found to include some of the unusual viruses, such as tomato spotted wilt virus (TSWV), potato spindle tuber virus (PSTV), and cauliflower mosaic virus (CauMV). The effect of the virus

inhibitor on CauMV was the first record of this inhibitor acting against a DNA virus.

To obtain and preserve concentrated and biologically active material, large-scale purification attempts including freeze drying the partly purified inhibitor were continued. Preliminary studies have shown that highly purified inhibitor preparations, which had resisted all attempts at concentration, can now be concentrated by a freezing technique, without loss of activity. In order to determine the nature and mode of action of the inhibitor, purified preparations of the inhibitor were used in experiments with the unusual viruses and in analytical and preparative procedures.

Virus synthesis. Investigations are continuing on mixed infection of barley, *Hordeum vulgare* L., by tobacco mosaic virus (TMV) and barley stripe mosaic virus (BSMV) or bromegrass mosaic virus (BMV). TMV inoculated into barley plants during the first leaf stage at 30°C could rarely be detected by infectivity assays in leaves produced after inoculation; analytical gradient centrifugation of concentrated preparations from the second, third, and fourth leaves mixed together showed that the concentration of TMV was between 2 and 20 µg/g of tissue. When BSMV or BMV was inoculated into plants at the same time as inoculation with TMV, systemic infection developed in all the inoculated plants and the concentration of TMV was 4–7 mg/g tissue. TMV can be found in association with BSMV or BMV in the same cell by examining thin sections of doubly infected leaves in the electron microscope. However, the proportion of doubly infected cells has not been determined.

Cytology and physiology of virus-infected plants. Mitochondrial preparations were made from healthy and TMV-infected leaves of *Nicotiana glutinosa* L. at five different times after inoculation, representing progressive stages in local lesion infection. Statistical analyses of counts of mitochondria per

electron microscope field with isolated, embedded, and sectioned material showed that up to 37 h after inoculation little change had occurred; at 39 and 42 h, about 50% more mitochondria were in the preparations from infected leaves than were in those from healthy material; at 45 h, infected preparations contained slightly fewer mitochondria; and at 48 h, the mitochondrial content had decreased to almost half of that from healthy leaves. The maximum increases in numbers of mitochondria are greater than the numbers signify, because only a portion of each inoculated leaf was infected. These results substantiate earlier findings from this Station that, at certain stages of localized virus infections, increases in mitochondrial enzymes and mass are responsible for the observed increase in respiration of the infected tissues.

Exudates and purified preparations of leaves infected with *Datura* shoe-string virus (DSV) contained particles 720–750 × 16 nm in size. Examination of DSV-infected leaves of *Datura metel* L. by means of light microscopy showed that the infected parts consisted mainly of midrib, with the tissues arranged as in healthy leaves, but without a lamina. Ultrathin sections of tissue showing shoe-string effects from infected leaves of *D. metel*, and of laminae from infected leaves of *D. metel*, *N. glutinosa*, and *N. debneyi* Domin. contained cytoplasmic lamellar inclusions as dense bands and pinwheels in all parenchymatous tissues and often in X-bodies. Long, rod-shaped particles were frequently arranged in regular array along the arms of the lamellar inclusions. Structures composed of ribosomelike particles were often found arranged regularly and alternately in an undulating double row in the cytoplasm. Nuclei contained tubular inclusions with an outside diameter of 35–40 nm. As a result of these findings with DSV, which is not serologically related to potato virus Y (PVY), it is misleading to classify in the PVY group any virus that induces forma-

tion of lamellar inclusions, regardless of size or serological relationships. Instead, for descriptive purposes only, all such viruses should be called Lamellar Inclusion Forming (LIF) viruses.

Cellular ultrastructure. In order to establish the possible nature of ectodesmata, the structure and macromolecular composition of leaf-epidermal outer cell walls were investigated by means of electron microscopy, with the use of chemically pretreated and post-stained ultrathin sections. Wounds caused by mechanical inoculation of leaves that resulted in successful virus establishment were also examined.

The cytopathic effects of potato spindle tuber virus (PSTV) in tomato were found to be both limited and late. No evidence was found for the intracellular accumulation of the infectious entity of relatively low molecular weight, nor of a possible labile precursor of higher molecular weight.

PLANT PATHOLOGY

Potatoes

Virus-free program. Treatment of 21 potato selections for virus eradication by means of heat therapy and nutrient culture of excised buds brought to 109 the number of selections treated since the virus-free potato program began in 1966. Recent virus-free accessions include from 1 to 10 selections of 30 cultivars that are licensed for certification in Canada, and 29 other selections. These selections are propagated in isolated plots and are subjected to regular inspections and laboratory tests for virus.

Approximately 61 ha (150 ac) of 10 cultivars derived from the virus-free potato program were planted by seed growers in British Columbia in 1972.

Small Fruits

Control of mummy berry of highbush blueberry. In the search for a chemical control for *Monilinia vaccinii-corymbosi* (Reade) Honey, split-schedule sprays were applied during April, May, and June of benomyl (Benlate, DuPont of Canada Ltd.) at 0.56 kg active ingredient/ha; Cela W524 (Cela Landwirtschaftliche Chemikalien Gesellschaft MBH) at 0.28, 0.56, and 1.12 kg; Cela W524 at 0.56 kg plus benomyl at 0.56 kg; ferbam at 2.24 kg; and EL273 [Eli Lilly

and Co. (Canada) Ltd.] at 0.022, 0.044, and 0.088 kg.

Treated plots were examined for ascospore infections of leaf and flower clusters and conidial infections resulting in mummied fruits. Fruit yields were recorded. Cela W524 alone and with benomyl effectively controlled ascospore infection. Benomyl gave the best control of conidial infections. Cela W524 at 0.56 kg applied twice for control of ascospore infections followed by benomyl at 0.56 kg applied twice for conidial infections gave the best overall control and significantly increased the yields.

Morphology of raspberry vein chlorosis virus. Raspberry vein chlorosis virus is transmitted by *Aphis idaei* van der Goot, but it has not been sap-transmitted, nor has the morphology of the particle been investigated. Red raspberry plants infected with the virus exhibit some chlorosis along the veinlets of their leaves. Infected leaf tissue was fixed, embedded, sectioned, and examined in the electron microscope. A few parenchyma cells, either within or adjacent to the veinlets, contained bacilliform particles that were rounded at both ends. They occurred singly or in groups of 2–14 particles enclosed in a vesicle with a membranous border. The particles varied somewhat in size, but the mean dimensions were 530 × 82 nm.

Nematodes

Nematode vector of cherry rasp leaf virus. Bioassays confirmed that *Xiphinema americanum* Cobb, which is common in soil under cherry trees infected with cherry rasp leaf virus in the Okanagan Valley of British Columbia, is responsible for transmitting the pathogen.

Control of lesion nematodes in raspberry root cuttings. *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. in dormant raspberry root cuttings was not controlled without plant injury when the bare roots were dipped in Nematicur (Chemagro Corp.), Vydate (DuPont Chem. Co.), or Zinophos (Cyanamid of Canada). Treatment of similar cuttings in water at 47°C for 15 min reduced the number of nematodes to less than 10/g of root. All nematodes were killed in cuttings treated at 48°C for 15 min. Four raspberry cultivars withstood this treatment without injury, but one was killed.

ENTOMOLOGY

Vectors

Mycoplasma-like bodies. Small mycoplasma-like bodies were found repeatedly in the extruded saliva of newly hatched nymphs of the aster leafhopper, *Macrostelus fascifrons* (Stal), the principal vector of aster yellows disease. These bodies were observed also in membrane-enclosed sacs of Type III acini of the posterior lobes in the salivary glands of unfed nymphs that had been newly hatched from eggs laid in agar by nontransmitting females of *M. fascifrons*.

Morphology and fine structure. Innervation was demonstrated and described in the mandibular stylets of three more species of aphids: the raspberry aphid, *Amphorophora agathonica* Hottes; the woolly apple aphid, *Eriosoma lanigerum* (Hausm.); and the English grain aphid, *Macrosiphum avenae* (F.). All have two dendrites in the central ducts of the mandibular stylets. Each dendrite is closely surrounded by a cuticular sheath enclosing a membrane, two neurotubules, and a structureless matrix, probably a fluid in life. Examination of the mandibular stylets with the aid of the scanning electron microscope did not show the receptor sites of the mandibular nerves.

In the stylets of the aster leafhopper, *M. fascifrons*, the dendrites narrow as they leave the nerve cell body and for a short distance have the structure of a typical cilium, surrounded by sheath cells. Beyond the ciliary region, the dendrites consist of fibrillar tubular bodies surrounding a cuticular sheath, which encloses from 4 to 10 neurotubules in the mandibular stylets and from 3 to 37 in the maxillary stylets. The dendrites do not branch. Receptor sites for the three mandibular and five maxillary nerves have not been located.

A study was started on the asymmetrical mouthparts of the onion thrips, *Thrips tabaci* Lindeman, a vector of tomato spotted wilt virus.

Potato Flea Beetles

Chemical control. In a coastal climate in silt loam and in a semiarid climate in sandy loam, three insecticides were tested as possible controls for the tuber flea beetle, *Epitrix tuberis* Gentner. Also included in the tests were the current recommendations: carbaryl or endosulfan applied every 10 days during

the growing season, starting when 75% of the potatoes had emerged. Carbofuran and fensulfothion were tested as sprays, starting when 75% of the potatoes had emerged and repeating three, four, or five times at 15-day intervals. Carbofuran and fensulfothion were also applied as a band before planting, followed by two or three sprays at 15-day intervals. AC92100 (Cyanamid of Canada) was applied in a band before planting. Analyses of the tubers showed that residues of carbofuran were ≤ 0.5 ppm and of fensulfothion were ≤ 0.1 ppm. All the treatments reduced the number of unmarketable tubers to below 7%; the untreated plots in silt loam yielded 21% unmarketable tubers, and those in sandy loam 50%.

Wireworms

Chemical control. Several chemicals were tested in sandy loam in the dry climate of the interior of the province for control of the Pacific Coast wireworm, *Limonium canus* LeConte. Granules of fonofos and AC92100 incorporated into the soil reduced wireworm damage to Netted Gem potatoes by 93%. Granules of carbofuran, including an acidified formulation, and fensulfothion gave inadequate control, as shown by yields of 14-24% unmarketable tubers. In the untreated plots, 31% of the potatoes were unmarketable.

Leatherjackets

Chemical control. On grassland infested at 365/m² with the European crane fly, *Tipula paludosa* Meigen, one spray application in April of pirimiphos-ethyl, diazinon, chlorfenvinphos, and encapsulated parathion reduced the populations by more than 80%.

Biological control. The tachinid parasite *Siphona geniculata* DeGeer, imported from Germany and released in the lower Fraser Valley in 1968 to reduce the population of *T. paludosa*, was recovered in 1972 from the release site. The first recovery was from field collections made in April. The highest degree of parasitism was found in July, when 3.6% of the leatherjackets examined were parasitized.

A New Pest

In 1972, for the first time in North America, a restricted but severe infestation of the strawberry tortrix, *Acleris comariana* (Zeller), was discovered in strawberry plantings at

Richmond, near Vancouver. This small bivoltine moth is a native of Northern Europe and the Palearctic, where the larvae seriously damage strawberries. Studies are under way on the biology of this pest and its control by chemical, cultural, and natural means.

Residue Chemistry

Organophosphate and carbamate residues. The effect of storage at 5°C on residues of fensulfothion, chlorfenvinphos, zinophos (Cyanamid of Canada), and carbofuran in field-treated carrots was studied. Except for chlorfenvinphos, which degraded from 0.37 ppm to 0.07 ppm, no degradation was detected over a period of 90 days.

A study was completed on the distribution of fensulfothion residues in field-treated carrots. The peel was found to contain approximately five times as much residue as the pulp, and the top 3 cm of the roots contained three times as much as the lower part.

Analytical methods were developed for detecting residues of chemical compounds in potatoes. Residues of fonofos and its oxygen analogue, fensulfothion and its sulfone, and carbofuran and its 3-hydroxy metabolite were found in potatoes that had been field-treated by two methods for control of the tuber flea beetle, *Epitrix tuberis* Gentner. The highest residues found were 0.20 ppm of combined carbofuran and 3-hydroxy carbofuran, and 0.18 ppm of combined fensulfothion and its sulfone.

The method for detecting residues of carbofuran and its 3-hydroxy metabolite in strawberries was improved and extended to include raspberries, blueberries, and cranberries. Field-treated samples of the four fruits were analyzed. The blueberries contained more than four times as much carbofuran in the waxy outer layer as in the pulp, whereas 3-hydroxycarbofuran was absent in the wax but present in the pulp.

Electron-capturing impurities in hexane. The cause of a buildup of electron-capturing impurities in pesticide grade hexane was examined. These impurities tended to interfere with early elution peaks during the analysis of samples for organochlorine pesticides. The impurities were found to be caused by the photooxidation of certain hexane isomers. Because some isomers are much more susceptible to oxidation than

others, the formation of impurities can be avoided by using hexane that is free from these isomers.

Root Weevils

Strawberry cultivars and barriers. Barri-erred microplots started in 1970 were continued through 1972. In spite of many adult black vine weevils that emerged in 1971 there was no apparent buildup in the infested plots. The barriers remained serviceable. No significant differences in yield were found between plots with two or eight adults of *Otiorhynchus sulcatus* F., *O. ovatus* L., *Nemocestes incomptus* (Horn), or *Sciopithes obscurus* Horn, nor did the cultivars Northwest, BC-25, Cheam, Totem, or Shuksan differ in susceptibility. In these plots, Shuksan was more acceptable than the other cultivars to adults of *N. incomptus*. In the laboratory, *O. sulcatus* produced significantly more eggs when fed on Shuksan foliage than when fed on the other cultivars, and preferred Shuksan to Totem foliage in choice tests. In greenhouse tests, the heaviest larvae fed on roots of Shuksan.

Entomophagous fungi. In 1971, the fungi *Beauveria bassiana* (Bals.) Vuill. and *Metarrhizium anisopliae* (Metch.) Sorokin were discovered attacking *N. incomptus*. The fungi were plated on potato dextrose agar (PDA) and subcultured on the eggs, larvae, and adults of *O. sulcatus*. The fungi did not attack cranefly larvae. Both organisms grew on bran, which was used to inoculate a barriered strawberry plot infested with adult weevils. In 1972, dry weather from mid-July until September appeared to be unfavorable for weevil inoculation, because no adults died from fungi, although many died from heat. Fungi have not been observed before on root weevils.

Spores of both organisms were inoculated on PDA containing 0, 10, 100, and 1,000 ppm of the fungicide captan. Both fungi grew well at 0 and 10, less well at 100, and only slightly at 1,000 ppm. To control fruit rot in commercial plantings, captan is recommended at 3,000 ppm at weekly intervals, starting near the time the adult weevils emerge from soil. These soft, teneral adults are highly susceptible to the fungi in laboratory cultures, but in the field, where captan has been used, they emerge into a nearly fungi-sterile environment.

Aphid ecology. Work was started on the development of a predictive model of population dynamics of the pea aphid, *Acyrtosiphon pisum* (Harris), on alfalfa. Three submodels were prepared and integrated into a simulation model. The aphid submodel was derived from life-table data gathered during the rearing of groups of aphids at five temperatures in the laboratory. A parasitization submodel was derived from similarly produced life tables. The predation submodel was derived from field data. The simulation model allowed comparisons to be made between the population trends predicted by the model and the actual events that occurred in the field, thus indicating any errors in the model.

Predators accounted for low numbers of aphids in spring near Vancouver; the equally low numbers at Kamloops were due to an introduced pea aphid parasite, *Aphidius smithi* Sharma & Subba Rao. Published models of predation were not useful for our purpose. We found that, although the densities of prey and predators were important, the distribution of aphids in the field was as important in determining the numbers consumed by predators. Experiments are planned to develop a better predation model.

PEDOLOGY

Classification and Mapping

About 2.4 million ha of land in the central interior of the province was surveyed at the reconnaissance level, and soil capabilities for agriculture and forestry were assessed for the preparation of soil capability maps.

A generalized soil map was made of the Capital Regional District, Victoria, and of

several islands in the Gulf of Georgia, with the use of abstractions from mapping units from the original soil surveys and reconnaissance field work. Generalized maps are an integral part of the inventory required by planners to formulate guides for development of areas on the urban fringe. To facilitate the use of these maps, careful study was given to such features as steep slopes, floodplains, organic deposits, bedrock outcroppings, and soil stability and permeability.

Soil Characterization

Soil-vegetation relationships and patterns of groundwater movement were studied on three types of bedrock in the Nimpkish Valley, Vancouver Island. This study was part of a pilot project in cooperation with the Canada Land Inventory, the British Columbia Forest Service, and Canadian Forest Products Limited.

On transects of granitic and basaltic bedrock, three vegetative subzones and corresponding soils were observed. Groundwater was shown to flow mostly through the B horizon with smaller amounts moving through the basal till and bedrock. On the transect of limestone bedrock, observations indicated that water moves mainly downward through the soil into the underlying fractured, cavernous bedrock. Soil and water samples were collected for analysis.

To determine the distribution of volcanic ash and the amount present in the soils of the area, a study was conducted throughout the Canadian Cordillera.

The geneses of soils developed from a local source of volcanic ash were investigated to determine the effects of a thin layer of ash over a wide area.

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INDEX OF PROFESSIONAL STAFF AND VISITING SCIENTISTS

- Aalders, L. E., 20
 Acton, C. J., 176
 Acton, D. F., 176
 Adams, (Mrs.) J. B., 29
 Adamson, R. M., 327
 Agrawal, H. O., 344
 Ainsworth, L., 118
 Aitken, J. R., 118
 Ali-Khan, S. T., 219
 Allan, J. R., 300
 Allen, H. T., 289
 Allen, W. R., 109, 110
 Allen, W. R., 225
 Anand, I. J., 260
 Anastasiou, J. D., 343
 Anderson, C. H., 271
 Anderson, D. T., 300
 Anderson, L. J., 81
 Anderson, R. V., 143
 Andison, H., 327
 Andrews, J. E., 299
 Andrews, W. C., 131
 Anstey, T. H., v
 Armstrong, K. C., 93
 Arnason, S. B., 299
 Arnold, J. W., 144
 Arnold, (Mrs.) R., 163
 Arthur, A. P., 260
 Atkinson, R. G., 327
 Atkinson, T. G., 300
 Atwal, A. S., 119
 Aubé, C., 52
 Ayers, G. W., 8
 Aylesworth, J. W., 81, 82
 Ayre, G. L., 226
 Ayres, K. W., 176
- Baenziger, H., 94
 Bagnall, R. H., 29
 Baier, W., 163
 Bailey, C. B. M., 299
 Bailey, L. D., 211
 Baker, R. J., 225
 Balba, M. H., 260
 Ballantyne, A. K., 176
 Ballantyne, H. R., 243
 Banham, F. L., 331
 Banting, J. D., 251
 Barker, P. S., 225
 Barnett, G., 52
 Barr, D. J. S., 163
 Barr, G. R., 117
 Barran, L. R., 131
 Barron, J. R., 144
 Bassett, I. J., 164
 Basu, P. K., 93
 Baum, B. R., 164
 Beacom, S. E., 243
 Beaulieu, A. A., 65
 Becker, E. C., 143
 Bedwany, T., 177
- Behki, R. M., 131
 Beke, G. J., 176
 Bell, E. F., 331
 Bellamy, R. E., 260
 Belzile, L., 52
 Bendelow, V. M., 225
 Bender, F., 156
 Berck, B., 225
 Berkenkamp, B. B., 289
 Bernard, C. S., 45
 Bernier, R., 65
 Bertoia, D. R., 327
 Best, K. F., 251
 Bickis, M. G., 205, 226
 Bickle, A., 205
 Biederbeck, V. O., 272
 Binns, M. R., 205
 Bisal, F., 272
 Bishop, C. J., viii
 Bishop, R. F., 19
 Black, W. N., 7
 Blakeley, P. E., 299
 Blatt, C. R., 19
 Boch, R., 94
 Bodnaryk, R. P., 226
 Boivin, B., 164
 Bolduc, R., 51
 Bole, J. B., 300
 Bolton, A. T., 93
 Bolton, E. F., 82
 Bond, E. J., 189
 Bonin, S. G., 283
 Bonneau, Y., 65
 Bordeleau, L., 52
 Botten, (Mrs.) M. G., 131
 Bouchard, R., 45
 Boughton, G. R., 251
 Bourget, S. J., 51
 Bowden, D. M., 299
 Bowen, J. F., 332
 Bowes, G. G., 251
 Bowman, B. T., 189
 Bowren, K. E., 243
 Bowring, (Mrs.) M., 109
 Boyer, J. C., 259
 Brach, E. J., 197
 Bracken, G. K., 226
 Bradley, G. A., 145
 Bradley, J. A., 289
 Bradley, R. H. E., 29
 Bright, D. E., 143
 Britton, (Miss) D., 332
 Bronskill, (Miss) J. F., 132
 Brown, B. E., 189
 Brown, W. J., 143
 Brydon, J. E., 175
 Buchannon, K. W., 226
 Bucher, G. E., 226
 Buckley, A. R., 164
 Buckley, D. J., 197
 Buglass, E., 239

Bullen, M. R., 51
 Burgess, L., 260
 Burgess, P. L., 29
 Burnett, P. A., 227
 Burnett, T., 94
 Burrage, R. H., 259
 Burrows, V. D., 93
 Butler, K. P., 19
 Buttery, B. R., 81
 Byers, J. R., 143
 Buzzell, R. I., 81

Caballero, (Mrs.) H. M., 343
 Cairns, R. R., 289
 Calder, F. W., 20
 Callbeck, L. C., 8
 Cameron, B. H., 176
 Cameron, C. D. T., 45
 Campbell, A. B., 225
 Campbell, C. A., 272
 Campbell, C. G., 219
 Campbell, J. M., 143
 Cannings, (Miss) E. J., 301
 Carefoot, J. M., 300
 Carter, K. M., 19
 Cartier, J. J., viii
 Casserly, L. M., 94
 Castell, A. G., 243
 Chan, A., 163
 Chancey, H. W. R., 1
 Chaplin, C. E., viii
 Chapman, F. M., 332
 Chapman, R. A., 189
 Charnetski, W. A., 300
 Chefurka, W., 189
 Chen, (Mrs.) F., 259
 Cheng, H. H., 75
 Cheng, K.-J., 299
 Chi, C. C., 94
 Chiang, M., 65
 Chiasson, T. C., 30
 Chiba, M., 109
 Chiko, A. W., 226
 Childers, W. R., 94
 Chinn, S. H. F., 260
 Chipman, E. W., 20
 Chisholm, D., 19
 Chiykowski, L. N., 132
 Chow, P. N. P., 211
 Christie, P., 177
 Chubb, W. O., 219
 Chubey, B. B., 219
 Church, N. S., 260
 Ciperia, J. D., 118
 Clark, D. J., 205
 Clark, J. S., 175
 Clark, M. C., 29
 Clark, R. V., 93
 Clarke, J. M., 284
 Clarke, M. F., viii, 315
 Clayton, J. S., 177
 Cliplef, R. L., 211
 Cody, W. J., 164

Coen, G. M., 177
 Collins, W. B., 29
 Comeau, A., 51
 Comeau, J. E., 52
 Cooke, D. A., 243
 Cooper, D. J., 197
 Cordukes, W. E., 164
 Corlett, M. P., 163
 Costescu, (Mrs.) L. M., 178
 Coulombe, L. J., 65
 Cox, A. C., 20
 Craig, C. H., 260
 Craig, D. L., 20
 Cram, W. T., 343
 Crête, R., 65
 Crookston, R. K., 301
 Crossley, J. H., 327
 Crosson, L. S., 176
 Crowe, A. D., 20
 Crowle, W. L., 259
 Crown, P. H., 177
 Cumming, W. A., 219
 Cutcliffe, J. A., 7
 Czarnecki, E. M., 225
 Darisse, J. P. F., 52
 Darwent, A. L., 283
 Daubeny, H. A., 315
 Davidson, T. R., 110
 Davies, H. T., 29
 Davis, G. R. F., 260
 Davis, W. E. P., 315
 Dawley, W. K., 283
 Day, J. H., 175
 Dean, P. R., 21
 De Jong, H., 29, 219
 De Kimpe, C., 52
 de la Roche, I., 93
 Denby, L. G., 332
 De Pauw, R., 227
 Depner, K. R., 301
 Deschênes, J. M., 51
 Desjardins, R. L., 163
 Dessureaux, L., 94
 Dew, D. A., 289
 Dhanvantari, B. N., 82
 Dias, H. F., 110
 Dionne, J.-L., 45
 Doane, J. F., 260
 Dodds, G. A., 344
 Dodds, M. E., 271
 Dondale, C. D., 143
 Donovan, L. S., 94
 Doornenbal, H., 289
 Dormaar, J. F., 300
 Dorrell, D. G., 219
 Downes, J. A., 144
 Downey, R. K., 259
 Downing, C. G. E., viii, 197
 Downing, R. S., 331
 Dryden, R. D., 211
 Dubetz, S., 301
 Dubuc, J. P., 51
 Dueck, J., 82

- Dufour, J., 45
 Dumanski, 175
 Dumas, T., 189
 Dunkelgod, K. E., 271
 Dupré, M., 41
 Durkee, A. B., 155
 Dyck, F. B., 272
 Dyck, G. W., 211
 Dyck, P. L., 225
- Eaves, C. A., 21
 Edey, S. N., 163
 Elliot, J. M., 75
 Elliott, C. R., 283
 Elliott, J. A., 155
 Elliott, (Miss) J. E., 118
 Elliott, (Miss) M. E., 163
 Elliott, W. M., 81
 Emmond, G. S., 251
 Emmons, D. B., 155
 Enns, H., 219
 Erfle, J. D., 118
 Evans, G., 82
 Everett, C. F., 29
 Ewen, A. B., 260
- Fahmy, M. H., 45
 Faris, D. G., 283
 Farstad, L., 177, 343
 Fedak, G., 93
 Fejer, S. O., 93
 Feldman, M., 197
 Ferguson, W. S., viii
 Findlay, W. I., 82
 Finlayson, D. G., 343
 Fisher, D. V., 331
 Fisher, J. C., 82
 Fisher, J. E., 93
 Fisher, L. J., 118
 Fisher, R. W., 109
 Fitzpatrick, R. E., 344
 Fleischmann, G., 131, 226
 Fleming, A. C., 284
 Flipot, P., 45
 Folkins, L. P., 289
 Foott, W. H., 81
 Forbes, A. R., 343
 Ford, R. J., 260
 Forest, J., 66
 Forrest, R. J., 315
 Forsyth, F. R., 20
 Foster, J. R., 239
 Foster, T. S., 118
 Fowler, D. B., 95
 Frappier, J. R., 51
 Frazer, B. D., 343
 Fredeen, F. J. H., 260
 Fredeen, H. T., 289
 Freeman, J. A., 315
 Freyman, S., 300
 Friend, D. W., 118
 Friesen, H. A., 289
 Frowd, J. A., 344
- Fulcher, R. G., 133
 Fulton, J. M., 82
- Gagnon, C., 51
 Gallagher, J. R., 301
 Gamble, D. S., 132, 175
 Gammon, D. B., 29
 Gardiner, E. E., 299
 Gasser, H., 51
 Gates, L. F., 82
 Gaunce, A. P., 331
 Gavora, J. S., 117
 Gayed, S. K., 75
 Gaynor, J., 175
 Gazeley, (Mrs.) J. E., 117
 Généreux, H., 52
 Genest, J., 45
 Gerber, G. H., 226
 Gibson, D. R., 94
 Giesbrecht, J. E., 219
 Gill, C. C., 226
 Gillespie, J. E., 176
 Gillett, J. M., 164
 Ginns, J. H., 163
 Gochnauer, T. A., 94
 Goplen, B. P., 259
 Gorby, B. J., 211
 Gorrill, A. D. L., 29
 Gourley, C. O., 20
 Gowe, R. S., 117
 Graham, L. M. A., 205
 Granger, R. L., 65
 Grant, E. A., 29
 Grant, M. N., 300
 Green, A. J., 177, 343
 Green, D. G., 271
 Green, G. J., 225
 Greenhalgh, R., 132
 Greenshields, J. E. R., 259
 Gross, A. T. H., 211
 Grover, R., 251
 Grunder, A. A., 117
 Gubbels, G. H., 219
 Guitard, A. A., 271
 Guppy, J. C., 94
 Gupta, U. C., 7
- Haas, J. H., 82
 Hache, B. J., 205
 Hagborg, W. A. F., 226
 Haggis, G. H., 132
 Hagley, E. A. C., 109
 Hall, (Miss) D., 163
 Hall, I. V., 20
 Halstead, R. L., viii, 177
 Hamill, A. S., 81
 Hamilton, D. G., v
 Hamilton, H. A., 65
 Hamilton, K. G. A., 143
 Hamilton, M. D., 283
 Hamilton, R. I., 211
 Hamilton, R. I., 344
 Hampson, M. C., 1

Hanna, M. R., 300
Hannay, C. L., 189
Hanneman, R. E., 30
Hansen, A. J., 332
Harcourt, D. G., 94
Harding, H., 260
Hardwick, D. F., 144
Harper, A. M., 300
Harper, F. R., 300
Harris, C. R., 189
Harris, K. F., 30
Harris, P., 251
Harris, R. E., 283
Harwalkar, V. R., 156
Haufe, W. O., 301
Hawn, E. J., 300
Hay, J. R., 251
Hayhoe, H. N., 163
Heaney, D. P., 118
Heapy, L. A., 289
Heeney, H. B., 94
Hegdekar, B. M., 226
Heinrichs, D. H., 271
Helson, V. A., 93
Hennig, A. M. F., 283
Herbert, (Miss) H. J., 19
Heringa, P. K., 1, 176
Herne, D. H. C., 109
Hickman, C. G., 117
Hidiroglou, M., 118
Hill, A. T., 315
Hinks, C. F., 144
Hinman, W. C., 272
Hironaka, R., 299
Hobbs, E. H., 301
Hobbs, G. A., 300
Hodgson, W. A., 29, 30
Hoes, J. A., 219
Hogue, E. J., 65
Holland, G. P., 143
Hollands, K. G., 117
Holliday, W. B. G., 323
Holmes, D. P., 93
Holmes, N. D., 300
Hope, G. W., 155
Hope, H. J., 51
Hopkins, J. F., 82
Hopper, B. E., 145
Hore, F. R., 197
Hosono, A., 156
House, H. L., 94
Howarth, R. E., 259, 331
Howes, N. K., 227
Hoyt, P. B., 283
Huang, H.-C., 260
Hubbard, W. A., 323
Hudon, M., 65
Hudson, (Miss) B. N. A., 144
Hughes, S. J., 163
Humphrey, S. E., 176
Hunsaker, W. G., 118
Hunt, J. R., 118
Hunter, J. H., 251

Hurd, E. A., 271
Hurtig, H., viii
Hutchinson, D. A., 7

Ihnat, M., 132
Ivany, J. A., 8
Ivarson, K. C., 175

Jablonski, B. W., 163
Jackson, H. A., 197
Jackson, L. P., 20
Jacoli, G. G., 344
James, W. C., 93
Janzen, W. K., 176
Jaques, R. P., 81
Jasmin, J. J., 65
Jenkins, K. J., 118
Joanisse, J., 155
John, M. K., 315
Johnson, P. W., 81
Johnston, A., 300
Johnston, F. B., 156
Johnston, G. R., 94
Johnston, H. W., 7
Jones, J. D., 156
Jordan, W. A., 118

Kajiwara, T., 190
Kalab, M., 156
Kaldy, M. S., 300
Kashi, K. P., 190
Kasting, R., 300
Kaufmann, M. L., 289
Kavanagh, G. P., 117
Kayler, W. E., 82
Kelton, L. A., 143
Kemp, G. A., 300
Kemp, J. G., 29
Kemp, W. G., 109, 110
Kenaschuk, E. O., 219
Kerber, E. R., 225
Kerley, G. E., 271
Kevan, P. G., 164
Keys, C. H., 259
Khan, M. A., 301
Khan, S. U., 251
Kiehn, F. A., 227
Kilcher, M. R., 271
Kim, W. K., 225
Kimpinski, J., 7
Kinsman, D. R., viii
Kitson, J. A., 332
Kjearsgaard, A. A., 177
Klassen, A. J., 259
Klein, K. K., 299
Kloosterman, B., 177
Knowles, R. P., 259
Kocaoglu, S. S., 177
Kodama, H., 175
Korven, H. C., 271
Kosmolak, F. G., 227
Kozub, G. C., 299
Kozumplik, V., 41

- Kramer, J. K. G., 118
 Kristjansson, F. K., 93
 Krogman, K. K., 301
 Krupka, R. M., 189
 Kunelius, H. T., 7
 Kwok, J., 205
- Laflamme, L., 45
 Laird, (Mrs.) A. K., 271
 Lajoie, P. J., 176
 Lalande, G., 45
 Lamarre, M., 41
 Langille, J. E., 20
 Langmaid, K. K., 176
 Lantagne, M., 29, 30
 Lapins, K. O., 332
 Lareau, M., 65
 Larmond, (Mrs.) E., 156
 Larson, D. J., 301
 Larson, (Miss) R. I., 300
 Last, K. B., 117
 Laverdière, M., 52
 Lavery, J. C., 331
 Lawrence, C. H., 30
 Lawrence, T., 271
 Lawson, J. E., 299
 Layne, R. E. C., 82
 Lebeau, J. B., 300
 Lebeau, J. V., 52
 Ledingham, R. J., 260
 Lee, C. R., 30
 Lee, D. H., 81
 Lee, T. T., 189
 Lee, Y. W., 260
 Leech, R. E., 145
 Leefe, J. S., 19, 20
 Lees, D. H., 155
 Lefkovitch, L. P., viii, 205
 Leger, D. A., 117
 Leisle, D., 225
 LeLacheur, K. E., 7
 Lentz, W. E., 117
 LeRoux, E. J., v
 Leskiw, L., 177, 343
 Lesley, S. M., 131
 Lessard, J. R., 118
 Leuty, S. J., 94
 Levesque, M., 175
 Lievers, K. W., 197
 Lilly, C. E., 300
 Lin, C. S., 205
 Lindquist, E. E., 143
 Lindwall, C. W., 301
 Lister, E. E., 118
 Loan, C. C., 144
 Lockhart, C. L., 20
 Lodge, G. A., 118
 Lodge, R. W., 271
 Loiselle, J. G. R., 93
 Looman, J., 271
 Looney, N. E., 332
 Lopatecki, L. E., 332
 Lord, T. M., 177, 343
- Loschiavo, S. R., 225
 Lovering, J. H., 7
 Ludwig, R. A., v, viii
 Lukosevicius, P. P., 41
 Lutwick, L. E., 301
 Lyall, L. H., 93, 94
- Maas, E. F., 315
 MacCarthy, H. R., 343
 MacDonald, M. D., 300
 MacDougall, J. I., 176
 MacDowall, F. D. H., 131
 MacEachern, C. R., 19
 MacGillivray, (Mrs.) M. E., 30
 MacGregor, D. R., 332
 MacIntyre, T. M., 20
 Mack, A. R., 175
 Mack, R. N., 343
 MacKay, D. C., 300
 MacKay, (Miss) M. R., 145
 MacKinnon, J. P., 30
 MacLean, A. A., 29
 MacLean, A. J., 175
 MacLellan, C. R., 19
 MacLeod, J. A., 7
 MacLeod, L. B., 7
 MacMillan, K. A., 65
 MacNaughton, W. N., 211
 MacNeil, J. D., 331
 MacPhee, A. W., 19
 MacVicar, R. M., 95
 Madhosingh, C., 131
 Madsen, H. F., 331
 Magee, A. I., viii
 Mahadevan, S., 118
 Mailloux, M., 66
 Malloch, D. W., 163
 Mallough, E. D., 251
 Marks, C. F., 109
 Marriage, P. B., 81
 Martel, P., 65
 Martel, Y., 52
 Martens, J. W., 225
 Martin, A. H., 289
 Martin, J. E. H., 143
 Martin, R. W., 93
 Masner, L., 144
 Mason, J. L., 332
 Mason, W., 45
 Mason, W. R. M., 144
 Mathur, S. P., 175
 Matsuda, R., 144
 Matthews, G. B., 117
 Maurer, A. R., 315
 Maw, M. G., 251
 McAipine, J. F., 144
 McArthur, J. M., 331
 McBean, D. S., 271
 McBeath, D. K., 289
 McClanahan, R. J., 81
 McCurdy, E. V., 239
 McDonald, H., 260
 McDonald, S., 300

McDonald, W. C., 225
 McElgunn, J. D., 271
 McElroy, F. D., 344
 McGinnis, A. J., 109, 226
 McGregor, D. I., 259
 McGuffin, W. C., 144
 McGugan, W. A., 155
 McIntosh, D. L., 332
 McIntyre, G. I., 251
 Melsaac, J. A., 7
 Melver, R. N., 239
 McKeague, J. A., 176
 McKeen, C. D., 82
 McKenzie, A. R., 30
 McKenzie, H., 300
 McKenzie, J. S., 283
 McKenzie, R. I. H., 225
 McKillican, (Miss) M. E., 155
 McKinlay, K. S., 260
 McLaughlin, N. B., 300
 McLean, A., 323
 McLeod, D. G. R., 189
 McLintock, J. J. R., 260
 McMahan, H., 260
 McMechan, A. D., 331
 McMullen, R. D., 331
 McNeill, J., 164
 McPherson, (Miss) A. E., 259
 Meheriuk, M., 332
 Mellor, (Miss) F. C., 344
 Menzies, D. R., 109
 Merritt, E. S., 117
 Metcalfe, D. R., 226
 Michalyna, W., 176
 Michaud, R., 51
 Migicovsky, B. B., v
 Miles, J. R. W., 190
 Miller, C. D. F., 81
 Miller, D. M., 190
 Miller, R. W., 131
 Miller, S. R., 95
 Milliron, H. E., 144
 Mills, J. T., 225
 Milne, (Miss) H. K., 259
 Miltimore, J. E., 323
 Minshall, W. H., 189
 Misener, G. C., 30
 Miska, J. P., 299
 Mitchell, K. B., 197
 Moen, H., 271
 Mohr, W. P., 95
 Molberg, E. S., 251
 Molnar, J., 164
 Monteith, L. G., 95
 Montgomery, G. F., 197
 Moore, R. J., 164
 Morgan, C. V. G., 331
 Morita, H., 175
 Morley, H. V., viii, 132
 Morris, R. F., 1
 Morrison, J. W., viii
 Morse, (Ms.) P. M., 205
 Mortimore, C. G., 81
 Mosquin, T., 164
 Mountain, W. B., 143
 Moyls, A. W., 332
 Mudryj, G. J., 227
 Mukerji, M. K., 94
 Mukhoty, H. M., 119
 Mulligan, G. A., 164
 Mulvey, R. H., 143
 Munro, D. C., 8
 Munroe, D. D., 145
 Munroe, E. G., 144
 Murray, (Miss) B. E., 94
 Murray, W. J., 289
 Mutuura, A., 144
 Myhr, P. I., 271
 Nagai, J., 117
 Nagai, T., 189
 Nass, H. G., 7
 Nathan, (Mrs.) V., 189
 Neal, J. L., 301
 Neilson, W. T. A., 19
 Nelson, D. L., 283
 Nelson, G. A., 300
 Nelson, W. A., 301
 Newman, J. A., 289
 Nicholaichuk, W., 272
 Nicholson, J. W. G., 29
 Nielsen, J. J., 226
 Nishida, A., 290
 Northover, J., 109
 Nowland, J. L., 176
 Nunes, A. C., 155
 Nuttall, V. W., 82
 Nuttall, W. F., 243
 O'Brien, C. P., 117
 Oliver, D. R., 143
 Oliver, K. D., 225
 Olthof, T. H. A., 109
 Ortiz De Serra, M., 177
 Osgood, C. E., 226
 Osman, A. A., 110
 Osoro, M. O., 227
 Ouellet, C. E., 163
 Paliwal, Y. C., 132
 Pankiw, P., 283
 Paquin, R., 51
 Paradis, R. O., 65
 Parchomchuk, P., 331
 Parent, B., 65
 Parmelee, J. A., 163
 Parups, E. V., 164
 Paton, D., 156
 Paulhus, D. L., 205
 Pawlowski, S. H., 259
 Peck, O., 144
 Pelletier, G., 45
 Pelletier, G., 51
 Pelletier, G., 52
 Pelton, W. L., 272
 Penney, B. G., 1

Pepin, H. S., 344
 Perron, J. P., 66
 Pesant, A., 45
 Peschken, D. P., 251
 Peters, H. F., 117
 Peters, T. W., 177
 Peterson, B. V., 144
 Peterson, D. G., v, viii
 Peterson, E. A., 131
 Petrie, G. A., 260
 Pettapiece, W. W., 177
 Phillips, J. H. H., 109
 Phillips, P. A., 197
 Pickford, R., 260
 Piening, L. J., 289
 Pieuk, (Mrs.) K. C., 299
 Pigden, W. J., viii
 Piloski, A. P., 211
 Pirozynski, K. A., 163
 Pittman, U. J., 301
 Plessers, A. G., 93
 Poapst, P. A., 20
 Pohjakas, K., 301
 Pomeroy, M. K., 131
 Pond, D. D., 30
 Porritt, S. W., 332
 Porteous, R., 175
 Potter, J. W., 109
 Povilaitis, B., 75
 Pree, D. J., 19
 Presant, E. W., 176
 Price, K. R., 205
 Pringle, R. B., 131
 Pringle, W. L., 283
 Proudfoot, F. G., 20
 Proudfoot, K. G., 1
 Proverbs, M. D., 331
 Puri, S., 205
 Purkayastha, R., 132
 Putnam, L. G., 260
 Putt, E. D., 219

 Quamme, H. A., 82
 Quinn, J. R., 156

 Ragab, M. T. H., 19
 Ragetli, H. W. J., 344
 Rahnefeld, G. W., 211
 Raine, J., 343
 Rajhathy, T., 93
 Rakow, G., 261
 Randall, C. J., 156
 Rayment, A. F., 1
 Read, D. C., 8
 Read, D. W. L., 281
 Reid, W. S., 197
 Reimer, (Mrs.) E. H., 289
 Reiser, B., 205
 Reyes, A. A., 109
 Ricard, P., 65
 Rice, W. A., 283
 Rich, G. B., 323
 Richards, W. R., 143

 Richardson, L. T., 190
 Riffaldi, R., 177
 Rioux, R., 52
 Rivard, I., 65
 Roberts, D. W. A., 300
 Roberts, J. G., 177
 Robertson, G. W., 272
 Robertson, H. A., 118
 Robertson, J. A., 243
 Robertson, R. H., 301
 Robertson, R. W., 94
 Robinson, A. S., 333
 Robinson, J. R., 189
 Robinson, P., 205
 Rohleder, H., 133
 Rohringer, R., 225
 Rola-Pleszczynski, S. A., 45
 Romanow, W., 225, 226
 Ronald, W. G., 219
 Rosa, N., 75
 Rosher, R. M., 332
 Roslycky, E. B., 189
 Ross, G. J., 175
 Ross, R. G., 20
 Ross, W. B., 143
 Rostad, H. P. W., 176
 Rouatt, J. W., 131
 Rousselle, G. L., 65
 Roy, G., 45
 Roy, R., 163
 Russell, G. C., 81
 Russell, K. D., 299
 Russell, W. A., 219
 Ryan, J. E., viii
 Ryan, L. P., 109

 Sabourin, L., 66
 Saha, J. G., 260
 Sahasrabudhe, M. R., 155
 Saidak, W. J., 81
 Saini, G. R., 29, 30
 St-Pierre, C. A., 51
 St-Pierre, J. C., 51
 Salam, M. A., 260
 Salkeld, (Miss) E. H., 144
 Salmon, R. E., 271
 Samborski, D. J., 225
 Sampson, D. R., 93
 Sanford, K. H., 19
 Santerre, J., 51
 Sanwal, K. C., 8
 Sarkar, N. K., 118
 Sarkar, S. K., 333
 Sauer, F. D., 118
 Savile, D. B. O., 163
 Schmid, F., 144
 Schneider, E. F., 131
 Schnitzer, M., 175
 Schoening, C. G., 299
 Schori, A., 1
 Scott, W. A., 81
 Seaman, W. L., 93
 Sehgal, O. P., 133

- Sévigny, L. M., 45
 Sexsmith, J. J. P., 300
 Shearer, D. A., 132
 Sheidow, N. W., 75
 Shemanchuk, J. A., 301
 Shewell, G. E., 144
 Shields, J. A., 176
 Shih, C. S., 205
 Shoemaker, R. A., 163
 Sibbald, I. R., 118
 Siddiqui, I. R., 155
 Siemens, B., 284
 Siminovitch, D., 131
 Simpson, C. M., 109
 Simpson, W. G., 19
 Sims, R. P. A., 155, 156
 Singh, R. P., 30
 Singh, S. S., 175
 Sinha, R. C., 132
 Sinha, R. N., 226
 Sinha, R. P., 155
 Sirois, J. C., 131
 Skipp, R. A., 227
 Slen, S. B., 299
 Sly, W. K., 163
 Slykhuis, J. T., 93
 Small, E., 164
 Smeltzer, G. G., 20
 Smetana, A., 144
 Smith, A. D., 301
 Smith, A. E., 251
 Smith, B. C., 81
 Smith, D. S., 300
 Smith, J. D., 260
 Smith, L. B., 226
 Smith, R. E., 176
 Smoliak, S., 300
 Sneddon, J. I., 177, 343
 Soehngen, U., 301
 Sommerfeldt, T. G., 301
 Sonmor, L. G., 259
 Sonntag, B. H., 299
 Sowden, F. J., 175
 Spangelo, L. P. S., 283
 Specht, H. B., 19
 Spencer, E. Y., 189
 Spratt, E. D., 211
 Spurr, G. T., 117, 205
 Stace-Smith, R., 344
 Stanfield, B., 7
 Staple, W. J., 175
 Stark, R., 19
 Starratt, A. N., 189
 Sterling, J. D. E., 7
 Stevenson, A. B., 109
 Stevenson, I. L., 132, 299
 Stewart, D. K. R., 19
 Stewart, D. W., 272
 Stewart, W. W. A., 260
 Stoessl, A., 190
 Stonehouse, H. B., 177
 Stothart, J. G., 289
 Strain, J. H., 211
 Stringam, G. R., 259
 Struble, D. L., 300
 Sugiyama, J., 164
 Sussmann, (Mrs.) N. B., 143
 Sutherland, (Miss) K. M., 81
 Suzuki, M., 7
 Svec, H. H., 190
 Svejda, (Miss) F. J., 164
 Swailes, G. E., 300
 Swierstra, E. E., 211
 Symko, S., 93
 Tai, G. C. C., 30
 Tape, N. W., viii
 Tarn, T. R., 30
 Tarnocai, C., 176
 Taylor, D. K., 315
 Taylor, M. E., 259
 Tekauz, A., 110
 Teskey, H. J., 144
 Thomas, P. L., 226
 Thompson, B. K., 205
 Thompson, J. L., 272
 Thompson, L. S., 7
 Thorlacius, S. O., 243
 Thorn, G. D., 190
 Thottappilly, G., 133
 Timbers, G. E., 197
 Tingle, J. N., 284
 Tinline, R. D., 260
 Tomlin, A. D., 190
 Toms, H. N. W., 344
 Tonks, N. V., 327
 Topp, G. C., 175
 Torfason, W. E., 300
 Towill, W. B., 95
 Townley-Smith, T. F., 271
 Townsend, L. R., 19
 Townshend, J. L., 109
 Tremaine, J. H., 344
 Troelsen, J. E., 272
 Trottier, R., 109
 Tsang, C. P. W., 118
 Tu, C. M., 190
 Turnbull, J. E., 197
 Turner, R. C., 175
 Turnock, W. J., 226
 Ukrainetz, H., 259
 Valentine, K. W. G., 177, 343
 Vandenheuvel, F. A., 118
 Vanderlee, J., 225
 van Ryswyk, A. L., 323
 van Schaik, J. C., 301
 van Ysselstein, M., 189
 Vardanis, A., 189
 Venne, P., 51
 Vesely, J. A. P., 299
 Vickery, L. S., 75
 Vockeroth, J. R., 144
 Voisey, P. W., 197
 Voldeng, H. D., 94

Volk, B. G., 178
 von Stryk, F. G., 81

 Waddington, J., 243
 Waldern, D. E., 315
 Walker, D. R., 289
 Walker, E. K., 75
 Walker, P. H., 299
 Walkey, D. G., 344
 Walkof, C., 219
 Wall, G. J., 176
 Wallace, H. A. H., 226
 Wallen, V. R., 93
 Walley, G. S., 144
 Walsh, (Mrs.) D. S., 118
 Wang, C., 176
 Ward, E. W. B., 190
 Ward, G. M., 81
 Warder, F. G., 272
 Warren, F. S., 94
 Watson, M. C., 75
 Watt, W., 177
 Watters, F. L., 225
 Wauthy, J. M., 94
 Weaver, G. M., 29
 Webber, M. D., 175
 Webster, D. H., 20
 Weintraub, J., 301
 Weintraub, M., 343
 Weiss, G. M., 289
 Wells, S. A., 300
 Welsh, M. F., 332
 Wensley, R. N., 82
 Weresub, (Miss) L. K., 164
 Westdal, P. H., 226
 Whelan, E. D. P., 219
 White, F. H., 75
 White, G. A., 190

 White, R. P., 7
 Whitfield, D. H., 299
 Whitten, F. J., 29
 Wilkes, A., 144
 Wilkinson, A. T. S., 343
 Wilkinson, P. R., 301
 Willemot, C., 51
 Williams, G. D. V., 163
 Williams, I. H., 343
 Willis, C. B., 7
 Wilner, J., 164
 Wilson, D. B., 300
 Wilson, G., 176
 Winter, K. A., 7
 Wolfe, R. I., 211
 Wood, D. M., 144
 Wood, G. W., 30
 Wood, P. J., 155
 Wressell, H. B., 81
 Wright, J. R., 19
 Wright, L. M., 271
 Wright, N. S., 343
 Wu, (Miss) L.-Y., 143
 Wylie, H. G., 226

 Yang, A. F., 344
 Yates, A. R., 155
 Yoo, J. Y., 261
 Yoshimoto, C. M., 144
 Young, D. A., 29
 Young, J. C., 132

 Zarkadas, C. G., 156
 Zawalsky, M., 117
 Zentner, R. P. J., 299
 Zilkey, B. F., 75
 Zimmer, R. C., 219
 Zuk, P., 343

SUBJECT INDEX

- Acaricides (*see also* insecticides) 112, 113
Acclimation 136
Acid soils (*see also* soil chemistry) 48, 179, 183
Acleris comariana (Zeller) 348
Actinomycetes 279
Aerial photography 37, 99
Agrometeorology 165
Aleurode des serres 62
Alfalfa breeding and varieties 4, 55, 98, 241, 263, 275
Alfalfa chemistry 53, 134, 263, 334, 335
Alfalfa diseases 99, 267, 276, 305
Alfalfa infestation 11, 102, 304
Alfalfa management 12, 13, 59, 124, 245, 248, 286
Altai wild ryegrass 275, 276, 277
Alternaria 267, 305
Aluminum 179, 183
Amino acids 161, 337, 345
Aphids 35, 37, 86, 101, 303, 317, 348, 349
Apple diseases 112, 336, 337
Apple maggots 24, 104, 113
Apple minerals 183, 339
Apple products 200, 336
Apple stocks 68, 100, 329
Apples 23, 60, 67, 104, 338
Apricots 88
Aquatic insects 146
Aquatic weeds 308
Arachnida 148
Arboretum 223
Armyworms 24, 192, 264
Aroma concentrator 336
Arthrobacter 136
Aspens 254
Aster yellows 232
Autocidal control 335
Avoine (*V. aussii* oats) 56
Bacillus thuringiensis 24, 192
Bactericidal dip 89
Bacteriophage 159
Barley 9, 57, 62, 97, 285
Barley genetics 214, 229
Barley jointworm 9
Barley production 9, 10, 33, 295
Barley viruses 10, 56, 57, 232, 346
Barnyard grass 38
Barrows 161, 292
Beans 16, 84, 86, 222, 307, 309
Beef cattle (*see* meat, steers, feedlot)
Beef feeding 31, 246, 248, 325
Beef muscle 161, 292
Beef nutrition 16, 124, 212, 303
Beef production 32, 213
Bees 103, 138, 244, 286
Béliers (*V. aussii* rams) 47
Bioassays 206, 231
Biosystematics 148, 149
Birdsfoot trefoil 12, 286, 293
Biting flies 149, 310, 335
Black spot 267
Blackleg 5
Blé (*V. aussii* wheat) 57
Blight resistance 34, 37
Blight, potato 15, 207
Bloat 263
Blood cholesterol levels 303
Blood pressure, poultry 121
Blow flies 4
Blueberries 22
Boars 213, 292
Boron compounds 12, 15, 16, 305
Botrytis 318
Brassica glycosides 158
Breeder seed 255
Broccoli 15, 316
Broiler breeder stock 122
Bromegrass 12, 13, 14, 98, 101, 245, 276, 277
Bromegrass fertilizer 214
Bromegrass mosaic virus 346
Brown soils 279
Brulures foliaires 70
Buckwheat 220
Building plan service 199
Bulls 291
Burley tobacco 78, 84
Cabbage looper 24
Cabbage maggots 4, 192, 304
Cabbages 3, 85, 307
Cadmium 316
Calculi 302
Calcium sprays 339
Calve milk diets 124
Calve weight gain 212
Calves 26, 291
Canadian collection, insects 146
Cankers of blueberry 24
Cannabis 169
Capsidiol 194
Caractérisation des sols 57, 58
Carbohydrates 157
Carbon dioxide flux 165
Carcass quality 161, 213, 246, 291, 292, 303
Carnations 345
Carottes (*V. aussii* carrots) 68
Carrot rust fly 113
Carrot storage rot 25
Carrot virus 115
Carrot weevil 71, 113, 192
Carrots 23, 70, 316, 317
Cartography 186
Cauliflowers 15, 316, 345
Cell components 135, 194
Cellulases 337
Cephalosporium 2
Cereal crops (*see also specific cereal*) 60, 214, 241, 280
Cereal diseases 56, 102, 293
Cereal leaf beetle 83
Cereal physiology and nutrition 48, 285
Cereal protein 10
Cereal silage 32, 286

- Cereal soils 263
 Céréales (*V. aussi* cereals) 48
 Cereals (*see also* wheat, barley, oats, corn or rye) 9, 96, 277
 Chalcides 67
 Champignons du sol (*V. aussi* fungi) 56
 Charolais bulls 212
 Charolais crosses 246, 247, 291
 Charançon de la carotte (*V. aussi* carrot weevil) 71
 Charançon de la prune (*V. aussi* plum weevil) 68
 Charbon de l'oignon (*V. aussi* smut) 70
 Chaulage (*V. aussi* liming) 48
 Cheese flavor 159
 Chemistry, analytical 138, 139
 Cherries 335
 Cherry buds 339
 Cherry rasp leaf virus 338, 347
 Cherry storage 339
 Chick feeding 214
 Chickens (*see also* poultry) 121
 Chironomidae 208
 Chlamydozoospores 135
 Choline additive 32
 Chou fourrager 61
 Choux (*V. aussi* cabbages) 71
 Chromatography 35, 36, 53, 126, 134, 138, 158, 159, 180, 223
 Chrysanthemums 223
 Chrysomelid beetles 324
 Clays 181, 192, 255
 Clover 11, 55, 137, 215, 244, 286
 Clubroot 15, 71, 115
 Cochenille virgule 67
 Codling moth 23, 24, 112, 113, 335
 Cold-hardening 167, 306
 Cold hardiness 53, 54, 88, 136, 213
 Cold tolerance 274
 Coleoptera 148
 Colorado potato beetle 103
 Colostrum 47
 Companion crops 245
 Concombres (*V. aussi* cucumbers) 62
 Copper 208
 Corn 47, 62, 71, 86, 98, 99, 220, 222, 247, 317
 Corn breeding 71, 83, 306
 Corn fertilizer 12, 72, 84, 215
 Corn insects 83, 85, 86, 101, 192
 Corn maturity 294, 326
 Corn production 99, 214
 Corn seeding dates 13
 Corn silage 215, 318
 Corn spurry 16
 Cow wintering 26
 Cowpea virus 345
 Crabapples 337
 Cranberries 22
 Crested wheatgrass 262
 Croissance de veaux (*V. aussi* calves) 46
 Crop density 114, 115, 207
 Crop losses 207
 Crop rotations 240, 248
 Cross pollination 199
 Crossbreeding 46, 120, 122, 246, 291, 303
 Crown rot 293, 305, 337
 Crown rust (*see also* rust) 231
 Crufomate 324
 Cucumber virus 87, 345
 Cucumbers 62, 85, 87, 222, 294, 328
 Cultivar stocks 103, 104
 Cultivation des céréales 60
 Cutworms 16, 24, 33, 79, 192, 233, 235, 304
 Cytogenetics 228
 Dairy cattle breeding 120
 Dairy cattle nutrition 32, 124, 303
 Damping off 78
 Deer 325
 Dietary fat 123, 274
 Diethylstilbestrol 247
 Diptera 148, 335
 Diseases (*see* plant diseases)
 Dormoats 137
 Dormancy 13, 136, 137
 Drageons du tabac 44
 Drainage 3, 57, 309
 Dryland cereals 308
 DDT uptake 77
 DNA viruses 346
 Ecology 170, 207, 234
 Economic return 274
 Egg yield 25
 Egg-laying 127
 Eggshell formation 122
 Electron microscope 139, 232
 Electrophoresis 99
 Embryo transplants 291
 Entomologie 67, 69
 Entomology (*see also* insects) 4, 67, 69, 146, 233, 264, 303, 310, 324, 335, 348
 Entomophagus fungi 349
 Environment 254, 278, 285, 304, 310
 Environment, controlled 95
 Environmental quality 31, 194
 Enzymes 37, 134, 135, 159, 306, 337, 345
 Equipment, farm 199, 274, 280
 Equipment, research 279, 280
 Equipment, sprinkling 334
 Ergot 102
 Esterases 121, 149
 Estrolide diglycerides 192
 Estrus, ewe 127
 Ethylene 167
 European corn borer 85, 192
 European red mite 113, 193, 336
 Euxoa 149
 Experimental design 207
 Eyespot 267
 Fababeans 222, 247
 Fat content 303
 Fat deposition 293
 Fat reduction 303
 Fatty acids 274
 Fatty aldehydes 275
 Faunal surveys 146
 Faunistics 148

- Feed additives 275
 Feed choice 123
 Feed form 124, 247, 302
 Feedlot steers 303
 Feedlots 291, 302, 310
 Fern taxonomy 169
 Fertilisants des céréales 59, 60
 Fertilité des sols (*V. aussi* soil fertility) 58, 72
 Fertilizers 3, 10, 105, 167, 207, 214, 215, 241, 248, 263
 Fiber content 307
 Field crops (*see also* tobacco, peas, buckwheat, beets, beans, corn) 23
 Finishing steers 247
 Finnish Landrace 122
 Finnish Ayrshires 120
 Fir cuttings 328
 Fire blight 89
 Fish protein 32, 215
 Flax 220, 221, 253
 Flétrissure (*V. aussi* blight) 60
 Flooding tolerance 276
 Floristic surveys 169
 Fly parasites 235
 Foot rot 268
 Forage (*see specific legume or grass*)
 Forage breeding 275, 286, 293
 Forage cereals 12, 33
 Forage diseases 265, 293
 Forage handling 165, 198, 307
 Forage mixtures 13, 105, 240, 242, 319
 Forage nutrition 12, 48, 59, 215
 Forage weed control 245
 Forage yield 12, 241, 244, 277, 286
 Formic acid 13
 Formaldehyde treatment 31
 Fossil insects 148
 Fourragères (*V. aussi* forage) 48
 Fraction 1 protein 263, 334
 Fraisiers (*V. aussi* strawberries) 60, 69
 Frost control 76
 Frost seeding of cereals 105
 Fruit (*see also specific fruit*) 60
 Fruit diseases 114, 318
 Fruit flies 335
 Fruit puddings 336
 Fruit stock program 114, 115
 Fulvic acid 181
 Fumigation 11, 193
 Fungi 11, 12, 24, 56, 134, 168, 180, 267, 337, 349
 Fungicides 68, 69, 85, 111, 112, 193, 233, 305, 306, 347
 Fusarium 11, 15, 99, 102, 134, 135, 268, 305, 328
 Geese 127
 Genetics 71, 228
 Génétique 71
 Genisser croisées (*V. aussi* heifer crosses) 46
 Gibberellin 77, 104, 137
 Gilts 123, 292
 Glucosinolates 157, 159
 Grain insect control 233, 234, 235
 Grain yield 10, 105
 Graminées (*V. aussi* grasses) 54
 Grapes 114, 337, 338
 Grasses 3, 54, 169, 262, 275, 276, 319
 Grasshoppers 233, 265, 304
 Grasslands 62, 308
 Grazing stock 26
 Greenhouse whitefly 62, 87, 329
 Greensprouting 38
 Growth regulators 68, 104, 137, 166, 194, 328, 329, 339
 Hardiness 53, 54, 88, 136
 Harvesting 245, 277
 Hay stacking 33, 198, 245, 325
 Hay yields 277, 286
 Hedge shrubs 166
 Heifer crosses 46, 303
 Hemiptera 148
 Hemolymph 192, 235
 Herbicide residues 14, 88, 255
 Herbicides 3, 24, 38, 60, 70, 84, 194, 215, 221, 245, 248, 252, 264, 294, 308, 317, 330
 Herbarium 170, 223
 Hernie (*V. aussi* clubroot) 71
 Highland cattle 303
 Hivernement de la luzerne 59
 Hog grades 293
 Holly 329, 330
 Honey bees 103, 138
 Horizons indurés 58
 Horizontal silos 33
 Hormone implants 247, 319
 Horticultural crops (*see also* fruits, vegetables and ornamentals) 14
 Host pathology 311
 Humic substances 181, 255
 Hybrides de tabac 42
 Hydroxyquinoline 167
 Hymenoptera 150
 Ice cream 200
 Information retrieval 200
 Insect morphology 146, 148
 Insect population dynamics 102
 Insect traps 4, 199, 233, 335
 Insecticide metabolism 16, 193, 234
 Insecticide residues 4, 86, 126, 138, 349
 Insecticides (*see also* pesticides) 4, 24, 37, 86, 112, 191, 233, 266, 304, 311, 324, 329, 335, 348
 Insects (*see also specific orders, insecticides, entomology*) 4, 16, 23
 Instruments, data 199
 Ion binding 181
 Iron micronutrients 23
 Irrigation 5, 86, 278, 309, 339
 Isoelectric focusing 160
 Kaemferol glucosides 158
 Ketogenesis 124
 Knapweed 169
 Lactating cows 124, 318
 Lamb meat 161
 Lamb rearing 26, 123
 Larvicides (*see also* insecticides) 266

- Laying hens 214
 Leaching 254
 Lead 25, 316
 Leaf diseases 70, 84, 85, 230, 306
 Leaf decomposition 77, 180
 Leafhoppers 113, 138, 208, 335, 348
 Leafcutter bees 244, 286
 Leatherjackets 348
 Légumes 11, 54, 62, 263
 Légumineuse (*V. aussi* legumes) 54
 Lepidoptera 150
 Lettuce 3, 316
 Light regimes 127
 Liming 15, 16, 48
 Limousin cattle 212, 291
 Lindane 264
 Lipides 53, 136
 Luzerne 53, 55, 59
 Lysimeters 280
 Magnesium 12, 58
 Maïs (*V. aussi* corn) 47, 62, 71
 Maladies de fraisiers 69
 Maladies des céréales (*V. aussi* cereal diseases) 56
 Manganese micronutrients 2, 10, 23, 36, 76, 183
 Manure (*see also* fertilizers) 125, 182, 240, 248
 Marek's disease 121
 Meadow foxtail 286
 Meat 25, 160, 292, 303
 Membrane lipids 136
 Mercury contamination 183
 Metabolism 54, 125, 126
 Methyl bromide 193
 Microbiology (*see also specific microflora*) 134, 192
 Mildew 11, 221
 Milk coagulation 159
 Milk processing 160, 200, 303
 Milk replacers 27, 32, 46, 123, 124, 161
 Milkvetch 324
 Mineral soils 3, 76, 181, 255
 Minerals 255, 296, 316, 317, 325
 Miserotoxin 325
 Mite predators 112
 Mites 24, 67, 112, 193, 234, 336
 Mitochondria 191, 346
 Model building, statistical 207
 Mosquitoes (*see also* biting flies) 266, 310
 Moths 252, 348, 349
 Mouche de la pomme (*V. aussi* apple maggots) 67
 Mouse research 120
 Mulch 76, 87, 294, 328
 Muscular dystrophy 125, 325
 Muskmelons 85
 Mustard 157, 268
 Mycoplasma 348
 Mycology (*see also* fungi) 167, 168
 Myrosinase 159
 Nematicides (*see also* insecticides) 4, 12, 114
 Nematodes 4, 11, 37, 44, 54, 55, 87, 113, 147, 235, 276, 347
 Neurotransmitters 191
 Nitrogen (*see also* fertilizers) 12, 277, 295, 308
 Noctuids 149
 Nucleic acids 36, 136, 231, 345
 Numerical taxonomy 208
 Nursery stock 167
 Nutrient density 275
 Oat breeding and genetics 101, 208, 230
 Oat diseases 102, 231, 232
 Oat flour 160
 Oat silage 105, 246
 Oat taxonomy 168
 Oats 9, 56, 96, 97, 247, 316
 Oignons (*V. aussi* onions) 69
 Oil contamination 14, 183
 Oilseed content 14, 249
 Oilseeds (*see also* rapeseed, mustard, soybeans, sunflowers) 157
 Onions 70, 192, 317
 Onosmodium occidentale Mackenz. 215
 Orchardgrass 12, 13, 96
 Orchards 24, 88, 336
 Organic soil 72, 179, 181, 248, 309, 325
 Orge (*V. aussi* barley) 57
 Ornamental plants 166, 223, 329
 Oxidases 194
 Parasites 2, 26, 235, 311
 Parasitism 150, 231
 Paraquat 15
 Parsnips 307
 Pastures 26, 61, 245, 246, 276, 286, 307
 Pathogenic fungi 134
 Pathology (*see* plant diseases)
 Paturage de graminées 61
 Pea diseases, fusarium 102
 Peach insects 88
 Peach X-disease 114
 Peaches 88, 339
 Pears 23, 25, 89
 Peas 102, 220, 316
 Peat soil 2, 23
 Pepper insects 192
 Pepper virus 115
 Peppers 85
 Pesticide residues 14, 25, 125, 139, 140, 194
 Pesticide sprinkling 334
 Pesticides (*see also* fungicides, herbicides, insecticides) 57, 191
 Phenolics 158, 180, 335
 Pheromones 68, 103, 104, 112, 138, 192, 304, 335
 Phosphine 193
 Phosphorus 76, 316
 Photoperiod 166
 Phytic acid 158
 Phytopathology (*see also* plant diseases) 68
 Phytotoxins 305
 Pig rations 249
 Piglet nutrition 123
 Plant breeding (*see also specific plant*) 5, 293
 Plant density 285
 Plant diseases (*see* nematodes, fungicides, viruses, mycoplasma, fungi, blight, rot, wilt, rust)

- Plant nutrition (*see also* fertilizers) 38
 Plant taxonomy 168
 Plantes fourragères 59, 61
 Plasma estrogen levels 126
 Pole rot 78
 Plum weevil 68
 Poinsettia 329
 Poisoning 324
 Pollen morphology 169
 Pollination 244, 304
 Pollution (*see also* environment) 125, 194
 Polyoxin D 232
 Pommes (*V. aussi* apples) 60, 67
 Pommes de terre (*V. aussi* potatoes) 60, 72
 Pomology 338
 Population dynamics 207
 Population microbienne (*V. aussi* soil microbes) 59
 Pork musele 292
 Pork taste 161
 Porte-greffes de pommier (*V. aussi* apple stocks) 68
 Potato chips 222
 Potato disease 5, 15, 34, 37, 60, 102, 306, 345
 Potato genetics 33, 34
 Potato insects 37, 304, 348
 Potato seed production 33, 36
 Potato top killers 14, 38
 Potato virus 35, 36, 345
 Potato yield 31, 37, 294
 Potatoes 14, 16, 60, 72, 86, 100, 222, 317, 347
 Poultry 25
 Poultry meat 121
 Poultry nutrition 122, 214
 Poultry selection 122
 Poultry tests 208
 Powdery mildew 102
 Predators 148
 Pregnancy physiology 126
 Pregnant ewes 123
 Proline 54
 Proteases 345
 Protein quality 123
 Punaise terne (*V. aussi* tarnished plant bug) 67, 69
 Pyrale du maïs (*V. aussi* corn borer) 71
 Pyralids 150
 Quack grass 14, 38, 295, 307
 Quarantine 329
 Radishes 316
 Radioimmunoassay 126
 Ralgro 247
 Rams 47, 122
 Range cattle 325
 Rape diseases 267, 294, 305
 Rape residues 305
 Rapeseed 31, 157, 247, 255, 262, 309
 Rapeseed insects 264, 304
 Rapeseed weeds 295
 Rapeseed white rust 267
 Raspberries 100, 317
 Raspberry fungus 24
 Raspberry sprays 25
 Raspberry viruses 317, 347
 Red fescue 267
 Reed canarygrass 13, 26, 286
 Régulateurs de croissance (*V. aussi* growth regulators) 68, 69
 Remote sensing (*see also* aerial photography) 184, 200
 Rendement des carcasses (*V. aussi* carcass yield) 46
 Rennin 159
 Reproductive physiology 126, 213
 Residue analysis 139, 193, 349
 Respiration 136, 191
 Rhagoletis 67
 Rhizobium 55
 Rhizosphere 308
 Ring rot 306
 Roots 276, 328
 Root maggot 4, 235, 304, 305
 Root rot (*see also* fusarium) 78, 99, 102, 135, 266, 293
 Roses 166, 223
 Rot disease control (*see also* fungicides) 84, 193, 305, 337
 Roughages 247
 Ruminant nutrition 123, 303, 318
 Runoff water 125, 278
 Russian wild ryegrass 275, 276, 277, 307, 326
 Rust 167, 267, 293, 305
 Rust fungus analysis 231
 Rust resistance 228
 Rust virulence 230
 Rutabagas 3, 14, 15, 192
 Rutin 158
 Rye breeding 273
 Rye hardiness 9
 Rye stalk smut 305
 Ryegrass mosaic virus 137
 RNA 231, 345
 RNA virus fractionation 36
 Sagebrush defoliation 324
 Sainfoin 244
 Salt intake 302
 Sap beetles 86
 Sawdust packing 329
 Sawdust-sand mulch 328
 Sawfly 304
 Scab resistance 104
 Scald 305, 306, 338
 Scales 67
 Sclerotinia 24, 85
 Scours 291
 Sedge stands 325
 Seed treatments 233
 Seed yield 255, 262, 277, 286
 Seeding equipment 199, 215, 274, 279
 Seeding rates 10, 240, 317
 Selenium 16, 125, 138, 180, 325
 Selection du tabac 43
 Semen characteristics 212, 213
 Senescence 95
 Septoria 57, 102
 Serology 137, 159, 311

- Sex attractant (*see also* pheromones) 335
 Sheep 26, 249
 Sheep breeding 26, 122, 303
 Sheep nutrition 123
 Shelterbelts 285
 Shepherd's-purse 17
 Shikimates 231
 Shorthorn calves 212
 Silage 13, 26, 32, 33, 124, 125, 246, 286
 Silt loam 348
 Simmentals 212, 291
 Siphonaptera 148
 Skim milk 160
 Smuts 70, 167, 194, 232, 305
 Snow drifting 285
 Snow mold 267, 305
 Soil analysis 38, 179, 182, 349
 Soil bacteria 194
 Soil classification 58, 184, 349
 Soil contaminants 316
 Soil fertility 58, 72, 76, 240, 286, 308
 Soil incubator 280
 Soil information 184
 Soil insecticides 192
 Soil insects 17
 Soil inventory 2, 184, 185
 Soil management 114
 Soil mapping 184, 349
 Soil microbiology 278
 Soil moisture 166, 179, 278, 279, 309, 349
 Soil phosphorus 310
 Soil pollution 182
 Soil structure 309
 Soil sulfur 295
 Soil temperature 276, 277
 Soilless culture 328
 Sol organique (*V. aussi* organic soil) 72
 Solonetzic soil 296
 Sols acides (*V. aussi* acid soils) 48
 Sophorosides 158
 Sow crosses 47
 Sow nutrition 123
 Soybeans 32, 84, 97
 Spaghetti 160, 200
 Spanworm 336
 Spartan apples 183
 Sperm reserves 212
 Spiders 24
 Sporangia germination 5
 Spotted wilt virus 137
 Spraying 109, 334
 Spring wheat yield 9
 Spur blight tolerance 317
 Starter rations 246
 Statistical science 206
 Steers 16, 26, 246, 291, 303, 307, 325
 Stemphylium 56
 Stem rust (*see also* rust) 230
 Steroid hormones 126
 Steroid implants 247, 319
 Sterol biosynthesis 134
 Stinkweed 254
 Storage pests 234
 Stored products 233
 Strawberries 22, 318, 349
 Strawberry *Botrytis* 111
 Strawberry hardiness 286
 Stubble burning 267
 Succédané de lait (*V. aussi* milk replacers) 46
 Suckers 77, 88
 Sugar beets 233
 Sugarbeet insects 305
 Sulfur 215, 295
 Summerfallow (*see also* zero tillage) 240, 248, 254, 273, 279
 Sunflowers 221
 Surfactants 296
 Swine crossbreds 292
 Swine nutrition 123, 125, 208, 213
 Synovex 319
 Tabac (*V. aussi* tobacco) 42
 Tabanids 149
 Tache zonée 56
 Tachinid parasites 348
 Taille de pommier 68
 Tannins 335
 Tapeworms 2
 Tarnished plant bug 67, 103, 112
 Tavelure du pommier (*V. aussi* scab, apple) 68
 Tétranique rouge (*V. aussi* mites) 67, 69
 Thrips 336
 Tillage, corn 15
 Tiller growth 285
 Timothy 12, 13, 98, 100, 286
 Titrations 181
 Tobacco 16, 42, 76, 77, 78, 79
 Tobacco breeding 42, 78
 Tobacco content 76, 78
 Tobacco drying 200
 Tobacco mosaic virus 346
 Tobacco pests 44, 235
 Tobacco selection 43
 Tobacco suckers 44
 Tolérance au froid (*V. aussi* cold tolerance) 53, 54
 Tomato breeding 104, 294
 Tomato peeling 200
 Tomato spotted wilt virus 345
 Tomatoes 86, 87, 100, 223, 328
 Toxicology 135, 311, 324
 Trace elements (*see also specific elements, minerals*) 2, 125
 Transpiration 194, 279
 Transplanting 76
 Tree bark fertilizer 38
 Tree fruits 88
 Trèfle rouge (*V. aussi* clover) 55
 Trialeurodes 62
 Trichoptera 150
 Trifluralin 87
 Triticales 94
 Truies croisées (*V. aussi* sow crosses) 47
 Tuber lesions 36
 Tubers 5, 15
 Turfgrass 167, 319
 Turkey nutrition 161, 274

- Turnip seed 4
 Turnip-rutabaga hybrid 15
 Urea 14, 318
 Urea phytotoxicity 263
 Veal 161
 Vegetable mycology 115
 Vegetable virology 115
 Vegetables (*see also specific vegetable*) 23, 62, 222, 317
 Vers gris 44
 Verticillium wilt 15, 85, 86, 221
 Vetches 324
 Virgin females 335
 Virology 345
 Virus infection physiology 346
 Virus inhibitor 345
 Virus spreading 35
 Virus-free potatoes 34, 347
 Viruses, barley 232, 346
 Viruses, bromegrass 346
 Viruses, cauliflower 345
 Viruses, cherry 338, 347
 Viruses, cucumber 345
 Viruses, DNA 346
 Viruses, oat 232
 Viruses, potato 34, 35, 345
 Viruses, raspberry 347
 Viruses, strawberry 318
 Viruses, tobacco 346
 Viruses, tomato 345
 Warble flies 310
 Wart resistance 5
 Water quality 31
 Weaning 125
 Weathering 182
 Webworms 264
 Weed biological control 169, 252
 Weed control (*see also herbicides and growth regulators*) 3, 308
 Weed herbarium 84
 Weed taxonomy 169
 Weevils 68, 252, 265, 349
 Western false gromwell 215
 Wethers 249
 Wheat 9, 57, 96, 247, 309
 Wheat acclimation 136
 Wheat breeding 228, 273, 306
 Wheat cold tolerance 274
 Wheat hardening 274
 Wheat protein yield 10
 Wheat rust (*see also rust*) 230
 Wheat seeds 255
 Wheat spindle streak mosaic virus 83, 96
 Wheat straw 97, 274
 Wheat striate mosaic virus 137
 Wheat yield 240, 278, 306
 Wheatgrass 275, 276, 307, 326
 Whey 275
 Whitefly (*see also greenhouse whitefly*) 329
 Whitlon grass 169
 Wildlife 265
 Wild oats 216, 253, 294, 295
 Wilt (*see also fusarium*) 328
 Wine 337
 Winter injury 10
 Winterhardiness (*see also cold hardiness*) 9, 94
 Winterhardiness freezer 199
 Winterkill 326
 Wireworms 37, 264, 348
 Woody plants 328
 Worm burdens 26
 Yeast 275
 Yellow leaf blotch 267
 Yellows 221
 Zero tillage (*see also summerfallow*) 309
 Zinc micronutrients 23

